Unofficial translation

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The technical requirements and the prequalification process of Fast Frequency Reserve (FFR)

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1 Introduction

This document describes the prequalification process for the Reserve Units offered for the maintenance of the Fast Frequency Reserve (FFR) and the verification of compliance with the technical requirements that apply to the Reserve Units. The general requirements concerning Balancing Service Providers have been described in Fingrid's document "Terms and conditions for providers of Fast Frequency Reserve (FFR)".

The purpose of the Fast Frequency Reserve (FFR) is to ensure that the loss of an individual electricity production unit or HVDC link will not cause the frequency to fall below 49.0 Hz. The Fast Frequency Reserve is needed for managing low-inertia situations in the power system and it is procured at times when the amount of inertia so requires.

2 Subjecting a Reserve Unit for prequalification

2.1 Prequalification process

The process illustrated in Figure 2.1 is followed in the prequalification of a Reserve Unit. A Balancing Service Provider is responsible for carrying out the prequalification tests in accordance with Chapter 4 of this document and for delivering the required information (see section 2.2) within the prescribed deadlines. The prequalification test record shall be submitted within a year of the measurement date.

Fingrid is responsible for the verification of the information and measurement results within the deadline prescribed in the process chart and for informing the Balancing Service Provider of the result of the prequalification process.

Fingrid has the right to send its representative to the prequalification tests. The Balancing Service Provider is responsible for the costs caused by the carrying out of the tests and Fingrid only for its own personnel costs.

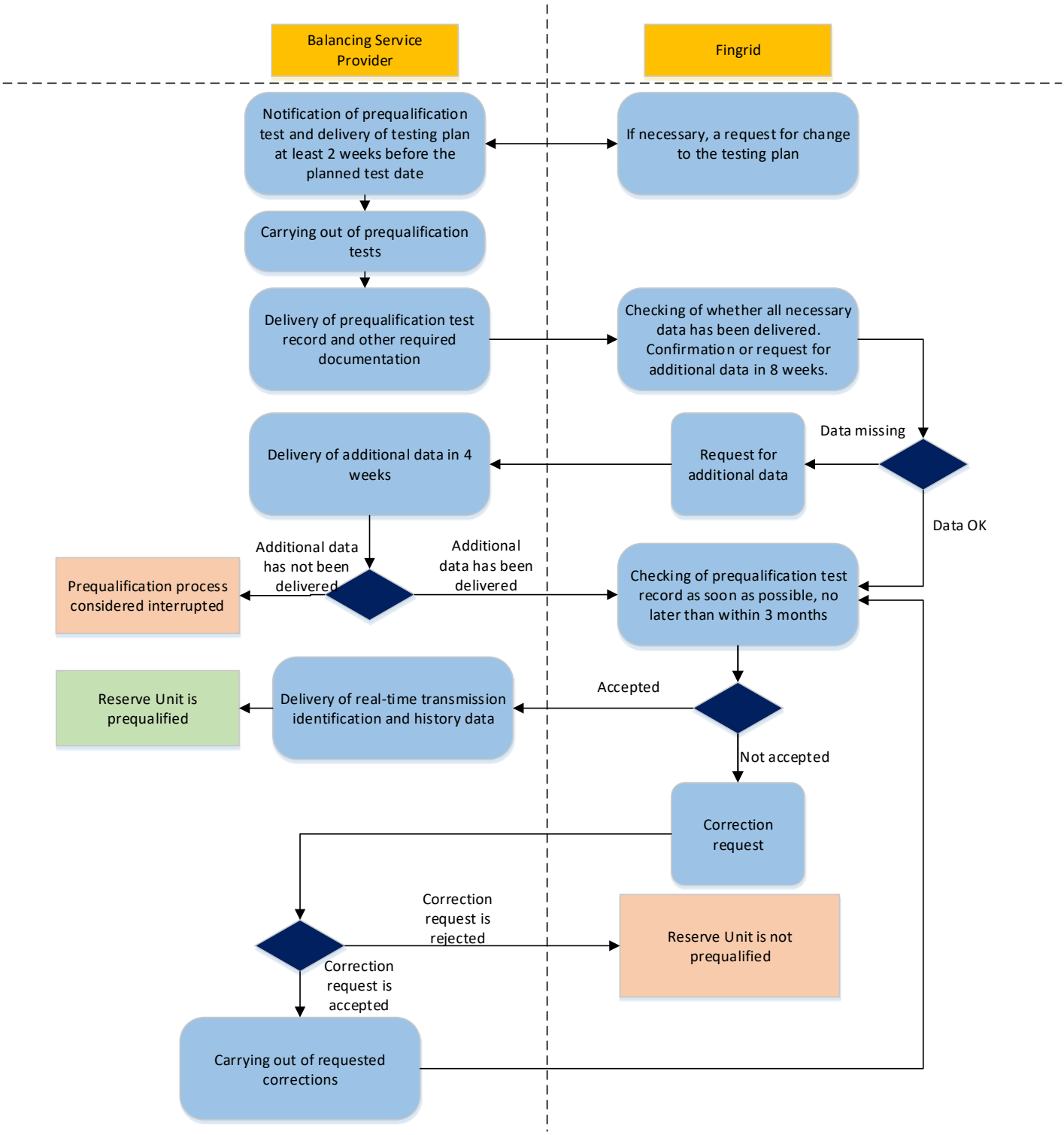

Figure 2.1 Progress of prequalification process

2.2 Necessary documentation

The prequalification test results shall be documented in a prequalification test record (see item 4.5), which shall be delivered to Fingrid after the prequalification tests.

Moreover, the following information shall be delivered of new Reserve Units, depending on the type of the unit:

Power plants:

- maximum power (MW)
- nominal apparent power (MVA) and inertia constant *H* (MWs/MVA)
- technical description of the functioning of the control system.

Consumption:

- type of load such as industrial process (what kind of process?), lighting, heating
- maximum power (MW)
- technical description of the functioning of the control system.

Energy storage facilities:

- rated power (MW)
- energy capacity (MWh)
- upper and lower limit of charge level (MWh or %)
- technical description of the functioning of the control system.

For aggregated Reserve Units, the provider must submit a technical description of the implementation of the aggregation, the control system and data transfer between the control system and reserve resources.

It is recommended that the above information be delivered before the prequalification test in so far as it is available.

The requirements concerning the reporting and follow-up of reserves have been described in Fingrid's document "Terms and conditions for providers of Fast Frequency Reserve (FFR)". A description of the calculation of real-time data and the identifier used in the sending of the real-time data shall be delivered in connection with the prequalification process of the Reserve Unit. The appropriate saving of history data shall be indicated by delivering history data for a period of at least one hour, during which the Reserve Unit has participated in the maintenance of the Fast Frequency Reserve.

For Reserve Units whose prequalification test is renewed, the provider must submit the prequalification test record, a sample of the history data and any information that has changed.

2.3 Validity period of prequalification test

The validity period of prequalification tests is 5 years. A prequalification test shall be renewed before the ending of the validity period. A prequalification test shall also be renewed whenever changes influencing reserve operation are carried out on the Reserve Unit, such as renewal of control equipment or change of control parameters.

3 Technical requirements

3.1 Activating the Fast Frequency Reserve

The Fast Frequency Reserve is activated as up-regulation by increasing the delivery of power to the grid or by reducing the consumption of power. When the frequency reaches the threshold, the reserve capacity shall be activated in full within the required activation time. The Fast Frequency Reserve has three alternative combinations of activation frequency and activation time, of which the Balancing Service Provider selects one. The options are presented in Table 3.1.

Table 3.1 Activation frequency and activation time of the Fast Frequency Reserve

Activation frequency (Hz)	Activation time (sec)
≤ 49.70	≤ 1.30
≤ 49.60	≤ 1.00
≤ 49.50	≤ 0.70

For example, the option ≤ 49.60 Hz and ≤ 1.00 sec means that the reserve must be fully activated in a maximum of one second, if the power system frequency is 49.60 Hz or below. The activation of the reserve must be monotonically increasing, for example, one or several steps or a ramp.

The power change of the Reserve Unit resulting from the activation may exceed the capacity approved for Fast Frequency Reserve by no more than 35%. Figure 3.1 shows an example of a permissible power curve. The overdelivery is calculated from the largest measured value of the power change during the duration of the activation of the Fast Frequency Reserve.

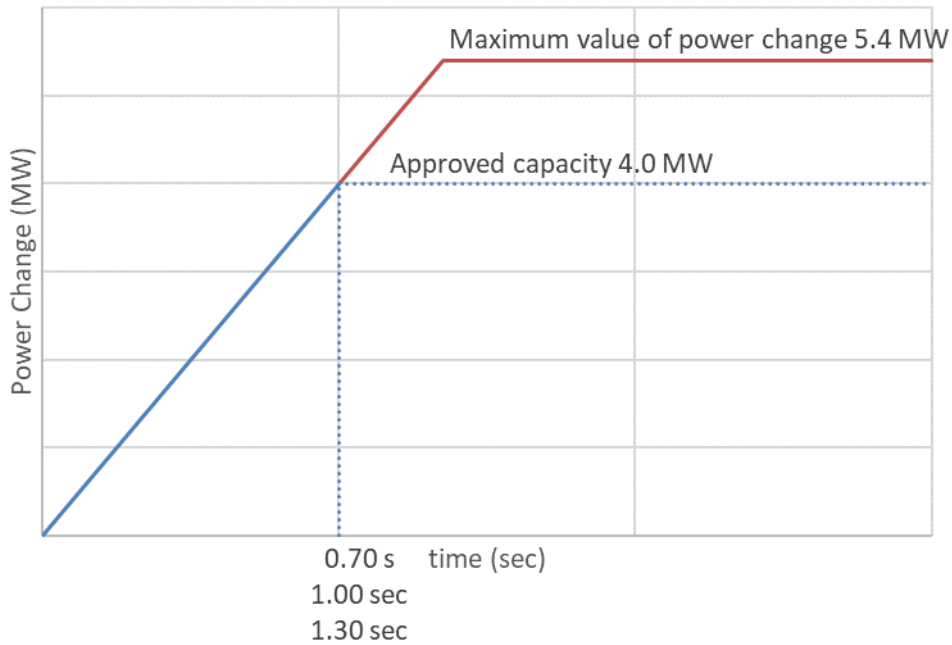

Figure 3.1 Maximum permitted activated power in relation to the approved capacity

3.2 Duration of the activation, deactivation and recovery

There are two options for the minimum duration of the activation of the Fast Frequency Reserve, depending on the speed of the deactivation of the Reserve Unit. Deactivation means restoring the power of the Reserve Unit back to a state where the reserve capacity is not activated. The options are described in Table 3.2. The reserve must remain activated for the minimum duration regardless of the frequency. After the minimum duration, deactivation is permissible regardless of the frequency.

Table 3.2 Minimum duration of activation of the Fast Frequency Reserve

Minimum duration of activation (s)	Speed of deactivation
30 sec	not limited
5 sec	up to 20% of the reserve capacity per second

The Reserve Unit must be able to reactivate after 15 minutes have passed since the last activation. However, the Reserve Unit may remain activated for as long as the frequency is below 49.8 Hz and start deactivation only when the frequency exceeds 49.8 Hz.

The Reserve Unit is allowed to recover subject to certain conditions. Recovery means taking power from the grid, for example, to raise the state of charge of an energy storage or to restore the nominal rotational speed of a converter-connected generator. The recovery power may not exceed 25% of the Reserve Unit's Fast Frequency Reserve capacity. The recovery may start no earlier than 10 seconds after the end of deactivation. An example of the recovery of a Reserve Unit is shown in Figure 3.2.

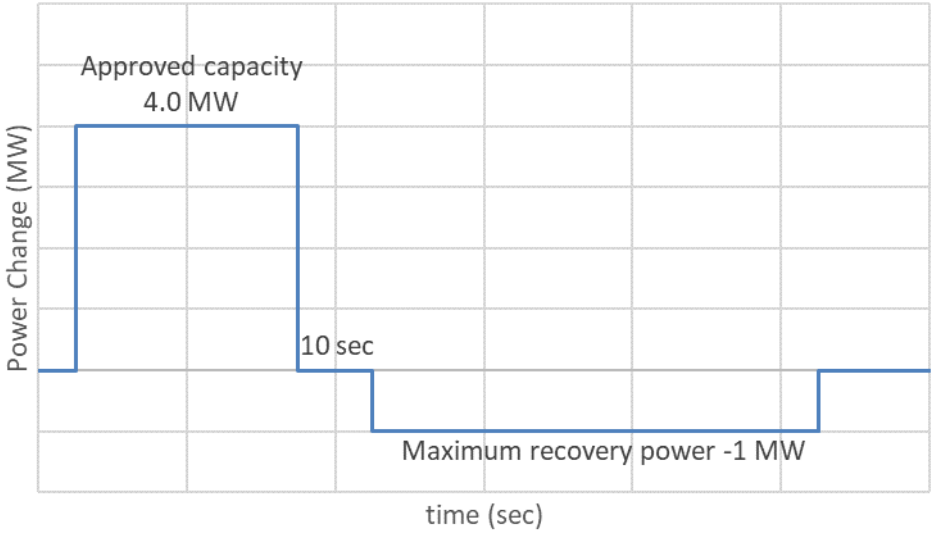

Figure 3.2 Recovery of a Reserve Unit

3.3 Measurement of frequency

The Balancing Service Provider can measure the frequency used in the control from a point of its choice in the Electricity system of Finland. The accuracy of the frequency measurement must be at least 10 mHz and the sampling interval not more than 0.1 seconds.

4 Verification of the Fast Frequency Reserve

The Balancing Service Provider shall ensure that a Reserve Unit that contributes to the maintaining of the Fast Frequency Reserve fulfils the technical requirements laid down in this document. The fulfilment of the requirements shall be verified by means of prequalification tests that shall be carried out in a normal operating situation of the Reserve Unit. A number of control settings can be specified for the Reserve Unit, and the functioning of all of these shall be verified by means of prequalification tests.

The requirements and guidelines given in this document shall be followed in the execution of the prequalification tests. If the execution of the prequalification test or its part in the manner specified is not possible due to the properties of the Reserve Unit, the Balancing Service Provider and Fingrid can agree on an alternative method.

4.1 Specification of reserve capacity

The prequalification tests are used for specifying the maximum volume of Fast Frequency Reserve that the Reserve Unit can provide for the reserve market. The active power activated in the time specified in table 3.1 shall be calculated as the reserve capacity. The reserve capacity is determined at an accuracy of 0.1 MW.

4.2 Performing the prequalification test

The Reserve Unit shall be connected to the electricity system during the prequalification test. Other controls potentially affecting the active power or the activation of the reserve, such as FCR-N or FCR-D and the automatic frequency restoration reserve (aFRR), shall not be in use.

A synthetic frequency signal is produced for testing the Fast Frequency Reserve. The test signal is primarily produced by an external source, from which the signal is fed into the frequency-measuring device.

Alternatively, the test signal can be generated programmatically in a controller. Since in the latter option the frequency-measurement device is bypassed, the activation of the reserve must additionally be verified on the basis of grid frequency. For the supplementary test, the activation frequency is set close to the nominal frequency so that the reserve is activated by the normal variation of the frequency.

The synthetic test signal can be a frequency ramp or stepwise frequency changes. The principle of a frequency ramp is shown in Figure 4.1. The ramp starts at 50.0 Hz and ends at 49.40 Hz. The ramp speed shall not exceed 0.2 Hz/s in order for the measurements to indicate the moment when the activation frequency is reached.

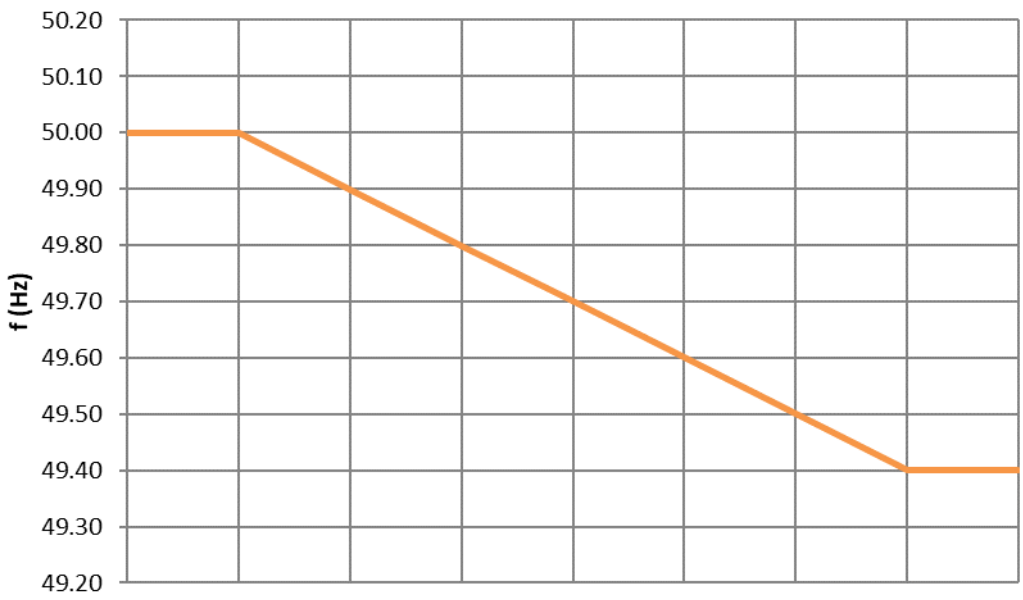

Figure 4.1 Frequency ramp as a test signal

If stepwise frequency changes are used for the test, use the test sequence shown in Figure 4.2. In the first step, the frequency stays no more than 0.05 Hz above the activation frequency of the Fast Frequency Reserve. The reserve must not activate. The frequency is then lowered to the activation frequency or no more than 0.05 Hz below it. The reserve must activate in accordance with the requirements. If desired, the test signal can also be reverted to 50 Hz between the steps.

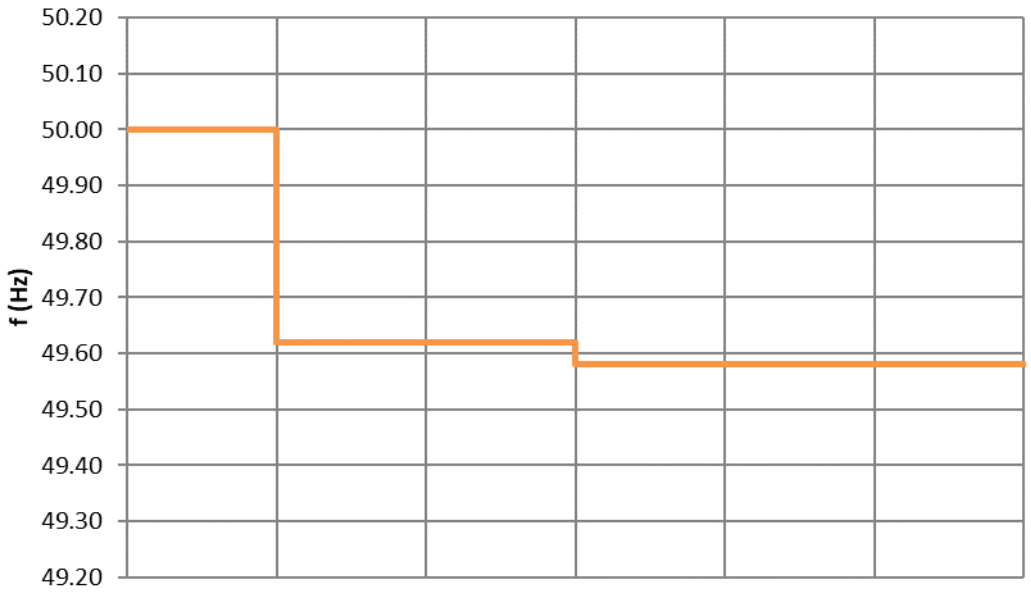

Figure 4.2 Stepwise frequency changes as a test signal when the activation frequency is 49.6 Hz.

The measurement continues until the deactivation and potential recovery of the Reserve Unit is completed. If, in addition to the required minimum duration, the Reserve Unit is set to remain activated for as long as the frequency is below 49.8 Hz, then it is restored to over 49.8 Hz in order to test the deactivation.

4.3 Accuracy requirements concerning measuring and registering equipment

The resolution of the active power measurement shall be 0.01 MW. The required accuracy, in relation to the rated power of the Reserve Unit, is dependent on the measurement system and on the rated power of the Reserve Unit according to Table 4.1.

Table 4.1 Accuracy requirement of the active power measurement

Category	Description	Max. inaccuracy
1	no current and voltage transformer	± 5 %
2	current transformer, no voltage transformer	± 2 %
3	rated power < 2 MW, current and voltage transformer	± 2 %
4	rated power 2–10 MW, current and voltage transformer	± 1 %
5	rated power > 10 MW, current and voltage transformer	± 0,5 %

The frequency signal fed in the tests shall be measured at a resolution of 10 mHz, and the measuring accuracy shall be 10 mHz or better.

The sampling interval of registration devices shall not exceed 0.1 seconds.

4.4 Prequalification tests of aggregated Reserve Units

Individual Reserve Resources can be made into an aggregated Reserve Unit. Fingrid has a right to request real-time data and history data separately of the individual resources of

an aggregated unit. The rules of the participation of aggregated Reserve Units in the market have been described in the document, “Terms and conditions for providers of Fast Frequency Reserve (FFR)”.

Three different methods can be applied to the verification of the control capability of aggregated Reserve Units. The method of execution of the prequalification test shall be agreed upon with Fingrid in advance.

1. Testing the aggregated unit as a whole

   The test signal shall be fed into the upper-level control system, and the activating power shall be calculated as the sum total of the powers of all resources. The Balancing Service Provider shall indicate that the aggregated unit in full fulfils the technical requirements. Adding new resources requires that new prequalification tests be conducted either to the new resources or again to the entire unit.

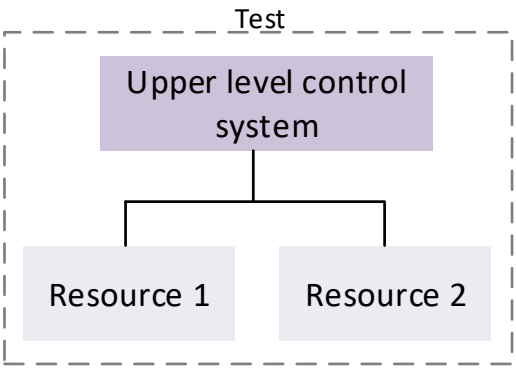

Figure 4.3 Testing of aggregated Reserve Unit as a whole

2. Testing of individual resources separately

   Each resource is tested separately. The Balancing Service Provider shall demonstrate that each aggregated resource fulfils the technical requirements independently. The Balancing Service Provider shall also demonstrate that the functioning of the upper-level system fulfils the requirements (for example verification of data transfer delays).

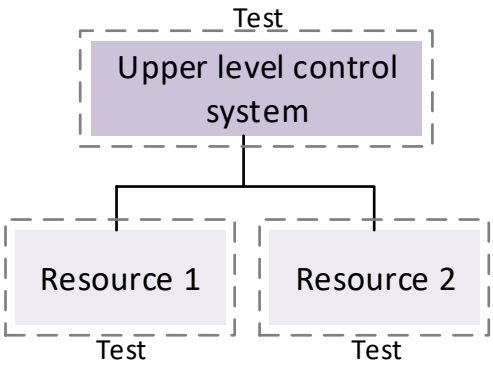

Figure 4.4 Testing of individual resources

3. Type approval

   Type approval may be used for identical resources if the Fast Frequency Reserve capacity of a single resource does not exceed 0.1 MW. The Balancing Service Provider must demonstrate that the resources operate identically. New similar resources can then be added to the aggregated Reserve Unit without prequalification tests. However, increasing the approved capacity of the Reserve Unit requires a notification to Fingrid.

4.5 Documentation of prequalification test results

A free-format prequalification test record shall be delivered of the results of a prequalification test. The following information shall be recorded in the record:

- Measurement date
- Reserve Unit Name
- Activation frequency of the Fast Frequency Reserve

The measurement results shall be plotted on a graph that shows the test frequency and the active power of the Reserve Unit over time. If a supplementary test is performed on the basis of the actual network frequency, its results shall be shown in a separate graph. The activation frequency temporarily set for the frequency is documented.

The time-stamped frequency (depending on the test, a synthetic frequency signal or the network frequency) and the active power shall also be provided as an appendix to the record in the same format as the history data (see “Terms and conditions for providers of Fast Frequency Reserve (FFR)").

5 Maintaining the Frequency Containment Reserve for Disturbances (FCR-D) and the Fast Frequency Reserve (FFR) with the same Reserve Unit

A single Reserve Unit can be used for maintaining both the Frequency Containment Reserve for Disturbances and the Fast Frequency Reserve simultaneously. However, the same capacity can only participate in one reserve market at a time, i.e. if part of the capacity

is sold to the Fast Frequency Reserve, the capacity of Frequency Containment Reserve for Disturbances decreases.

The requirements of the Frequency Containment Reserve for Disturbances are described in the document, “The technical requirements and the prequalification process of Frequency Containment Reserves (FCR)”. 50% of the reserve capacity must activate in 5 seconds and 100% in 30 seconds when the frequency drops stepwise from 50.0 Hz to 49.5 Hz. The proportion of the Frequency Containment Reserve for Disturbances that activates during the first seconds in a monotonically increasing way can be offered for the Fast Frequency Reserve. In such a case, the requirements in sections 3.1 and 3.2 and the instructions on the prequalification test in section 4.2 shall not be applied.

Figure 5.1 illustrates the determination of reserve capacity. The graph shows the power change of the Reserve Unit when the frequency drops stepwise from 50 Hz to 49.5 Hz. The red part of the curve illustrates the capacity accepted for Fast Frequency Reserve (C_{FFR}), which is calculated as follows:

$$C_{\text{FFR}} = \Delta P_{1\text{s}} = 2\ \text{MW}$$

When calculating the capacity of the Frequency Containment Reserve for Disturbances $C_{\text{FCR-D}}$, the volume of the Fast Frequency Reserve is subtracted from the value of active power measured at 5 and 30 seconds:

$$C_{\text{FCR-D}} = \min(2 \cdot (\Delta P_{5\text{s}} - C_{\text{FFR}}), \Delta P_{30\text{s}} - C_{\text{FFR}}) = 8\ \text{MW}$$

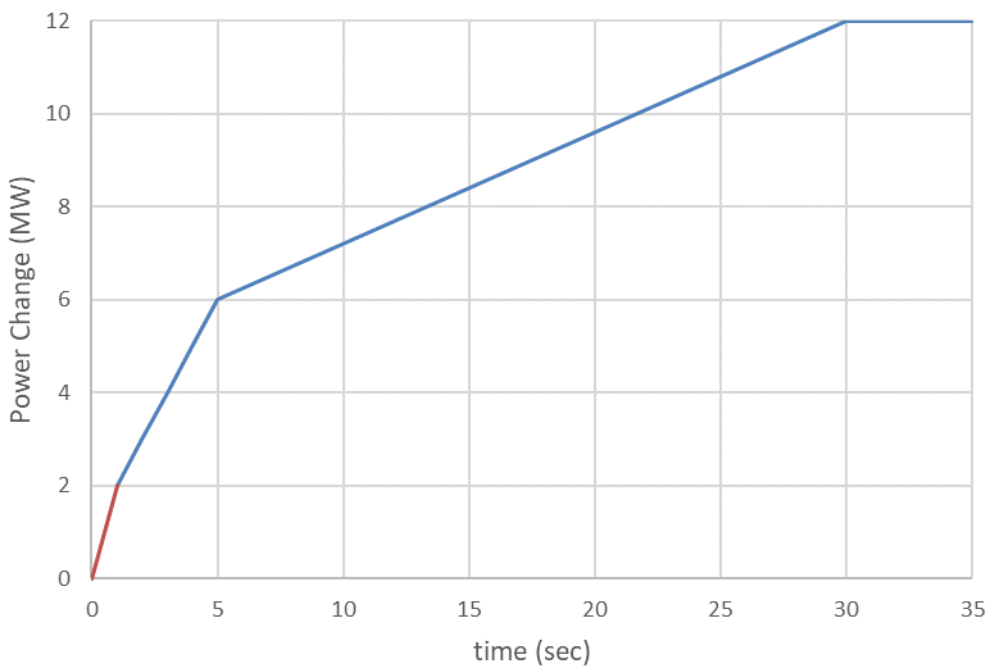

Figure 5.1 Frequency Containment Reserve for Disturbances and Fast Frequency Reserve in the same Reserve Unit

The following can be sold from the example unit:

a) 2 MW of Fast Frequency Reserve and 8 MW of Frequency Containment Reserve for Disturbances, or

b) 0 MW of Fast Frequency Reserve and 12 MW of Frequency Containment Reserve for Disturbances.