Le réseau
de transport
d'électricité

Annex 15:
Template for certification
of qualification for primary frequency control
"Aggregates" or "Storage Only"

SUMMARY

SUMMARY 2
1. Purpose of document 4
2. Definitions 4
2.1 Electrical specifications 4
2.2 System states 4
2.3 Characteristics of frequency control 5
2.4 Decentralised Reserve Providing Group 6
2.5 Limited Energy Reservoir 6
3. Primary frequency control (FSM mode) 7
4. Frequency measurement 9
4.1 Frequency for Primary Frequency Control 9
4.2 Large seperate networks detection (split system) 10
4.3 Summary 10
5. Dimensioning and stock management 10
5.1 Service availability and stock dimensioning 11
5.2 Active stock management 12
5.3 Management of stock depletion and saturation 13
5.3.1 Mode Réserve 13
5.3.2 Stock renewal after depletion or saturation 15
5.4 Optional: Case of units with implementation of LFSM-O and LFSM-U/UI modes 15
6. Nature of the exchanged information 16
7. Additional requirements in the case of connection to the Public Distribution System 18
8. Certification control files 19
9. References 20
10. List of annexes 21
ANNEX 1: Information and simulations to be provided by the Customer (Step 1) 22
INFORMATION File n°1: List of data 22
INFORMATION File n°2: Compliance of systems dedicated to information exchange 27
SIMULATION file n°1 : Dynamic behaviour of frequency control and reserve availability 28
ANNEX 2: Tests to be carried out by the Customer (Step 2) 31
TEST file no. 1: Tests of systems dedicated to information exchange 31
TEST file no. 2: Primary frequency control –FSM mode 32
TEST file no. 3: Frequency control – FSM mode 39
ANNEX 3: TEMPLATE for returning digital data 41
ANNEXE 4 : Frequency time series at 10 S intervals 1 bis 44

Figure 1: Insensitivity 5
Figure 2: Dead band 6
Figure 3: Control law for FSM (Frequency Sensitive Mode) 8
Figure 4: Activation delay and response time at one step 9
Figure 5: State of charge thresholds 12

Annex 15:
Template for certification
of qualification for primary frequency control

1. PURPOSE OF DOCUMENT

The purpose of this document is to define the expected performance for the Reserve Providing Group's (RPG) participation in primary frequency control [name of RPG] of the Reserve Provider [Customer name], for a maximum Frequency Containment Reserve volume FCR_{max} of [FCR_{max}value]. The Reserve Providing Group consists of [a list of consumption sites or power generating modules or storage units by type, indicating the connection location (municipality for PDS and the HV-B station for PTS) as well as the Metering code of each of the sites (to be requested if required from the site system operator) and their distribution in the SEs or Consumption SEs making up the Reserve Providing Group. For each unit or site specify according to the type:

- storage unit (Pmax_unit, total stock capacity (E))
- consumption sites
- decentralised consumption sites (specify number and geographical distribution),
- power generating module (Pmax_unit, primary energy type)

The performance requirements requested by RTE are consistent with the Frequency Ancillary Services Terms and Conditions [1] and the experimental framework provided in these, the Technical Reference Documentation [2], the System Operation Guideline (SOGL) [3] and the Demand Connection Code (DCC) [4].

The document describes the simulations and tests to be carried out to establish the Qualification Certificate for primary frequency control.

2. DEFINITIONS

2.1 Electrical specifications

The maximum injection power of the Reserve Providing Group (**Pmax_inj**) is the sum of the maximum powers of the units or sites at injection (**Pmax_inj_unit**) measured.

The maximum extraction power of the Reserve Providing Group (**Pmax_extr**) is the sum of the maximum powers of the units or sites at extraction (**Pmax_extr_unit**) measured.

2.2 System states

The **Normal State** of the system frequency is declared when:

- the absolute value of the frequency deviation is not greater than 200 mHz;

And

- the absolute value of the frequency deviation is not greater than 50 mHz for more than 15 min or is not greater than 100 mHz for more than 5 minutes

Reference: Article 18 of [3]

The **Alert State** of the system frequency is declared when:

- the absolute value of the frequency deviation is not greater than 200 mHz;

And

- the absolute value of the frequency deviation is not greater than 50 mHz for more than 15 min or greater than 100 mHz for more than 5 minutes

Coming out of the Alert State, i.e.: returning to a Normal State, occurs as soon as the absolute value of the frequency deviation is less than 50 mHz if the absolute value of the frequency deviation was greater than 50 mHz for more than 15 minutes or as soons as the absolute value of the frequency deviation is less than 100 mHz if the absolute value of the frequency deviation was greater than 100 mHz for more than 5 minutes.

Frequency deviations are calculated in relation to the nominal frequency f_n = 50.00 Hz
Reference: Article 18 of [3]

The **Emergency State** of the system frequency is declared when:

- the absolute value of the system frequency deviation is greater than 200 mHz; Coming out of the Emergency State, i.e.: returning to a Normal State, occurs as soon as the absolute value of the frequency deviation is less than 50 mHz.

Coming out of the Emergency state, i.e. returning to a Normal state, occurs as soon as the absolute value of the frequency deviation is less than 50 mHz.

2.3 Characteristics of frequency control

Accuracy:

The accuracy of a measurement is the maximum permissible error of the measurement. Measurement error is the difference between the value given by the measurement and the exact value of the physical quantity.

Resolution:

The resolution of a measurement is the smallest variation between two different values of that measurement**.**

Insensitivity:

The inherent feature of the control system specified as the minimum magnitude of change in the frequency or input signal that results in a change of output power or output signal when the signal changes direction

Figure 1: Insensitivity

Dead band:

Interval intentionally used to "neutralize" the frequency control

Figure 2: Dead band

Centralised frequency control:

Frequency control is said to be centralised when the frequency control of at least one unit or site is not done based on a local frequency measurement.

2.4 Decentralised Reserve Providing Group

Decentralised Reserve Providing Group:

RPG built up exclusively of sites whose maximum Frequency Containment Reserve and/or Automatic Frequency Restoration Reserve frequency control capacity is less than or equal to 250 kW.

Administrative Region:

Administrative division of France which groups several departments.

2.5 Limited Energy Reservoir

LER (Limited Energy Reservoir):

Reserve Providing Group for which a continuous activation of the full reserve for two hours in the positive or negative direction could, without taking into account the effect of active management of the reservoir, lead to a limitation of its capacity to provide full activation of the Frequency Containment Reserve due to the depletion of its energy reservoir(s), taking into account the energy of the reservoir actually available.

Characterisation time LER (T_{LER}):

This duration is set to 2 hours in accordance with the definition above.

Useful Capacity (E_{useful})

Useful capacity is the amount of energy, expressed in MWh, made available to perform Primary Frequency Control.

For storage units, by agreement in this document, useful capacity is the capacity to provide system frequency control and not the total capacity of the unit.

This concept is generalisable to any unit with a limited amount of energy to participate in frequency control. Useful capacity is the sum of the upward energy available and the downward energy available.

State of charge (SoC):

The State of charge is the instantaneous value of the amount of energy available for frequency control expressed as a percentage of the useful capacity.

This concept is generalisable to any unit with a limited amount of energy to participate in regulation according to the ratio between the downward energy available and the useful capacity of the unit.

$$SoC_{unit}(t) = \frac{E_{downward}(t)}{E_{useful}}$$

For an LER type RPG consisting of an aggregation of units, the stock of the aggregate is defined as the useful capacity-weighted sum of the stocks:

$$SoC_{LER} = \frac{\sum_{i \in LER} SoC_i \times E_{useful_i}}{\sum_{i \in LER} E_{useful_i}}$$

Units that do not have energy limitation constraints are not included in the calculation of the RPG's stock.

For RPGs comprising LER and non LER type entities, RTE needs to maintain the need for observability of SoC. Therefore, the E/FCR ratio cannot be viewed. The only real stock (in the sense of limited energy quantity) is the stock of the LER. In this logic, the RPG's stock is the LER stock (Euseful_LER). However, it cannot be compared directly with FCR because the link between Euseful_LER and FCR depends on the power distribution in the RPG.

3. PRIMARY FREQUENCY CONTROL (FSM MODE)

Applicable to all

The Reserve Providing Group must have a primary frequency control ability (FSM mode) characterised by:

- A volume of active power reserve, called "Frequency Containment Reserve, FCR" that can be made available to RTE upwards or downwards.
- A control law defining the actual supply of this reserve in response to a frequency variation.
- A temporal dynamic (activation time for the provision of this reserve, and the duration of the maintenance of supply of this reserve)

Operation in primary frequency control must be possible during set point power variation slopes.

Frequency Containment Reserve volume (FCR)

The maximum frequency containment reserve FCR_{max} is specified in Information file No. 1.

Control law (frequency variation response characteristics)

The Reserve Providing Group must be equipped with a primary frequency controller ensuring the following control law:

$$P - P_c = -K.(f - fn)$$

with:

P [MW]: actual power provided by the Reserve Providing Group in quasi-steady state mode

P_c [MW]: setpoint power of the Reserve Providing Group at reference frequency f_n

f [Hz]: frequency measured on the network

f_n [Hz]: nominal frequency (50 Hz)

K [MW/Hz/): gain of the Reserve Providing Group

The sign convention used is the generator convention, i.e. a positive P value corresponds to a power injection and a negative value corresponds to an extraction.
The K gain of the Reserve Providing Group can be adjustable. For FCR, it cannot be greater than K_{max} = 25 FCR MW/Hz and cannot be less than K_{min} = 5 FCR MW/Hz.

In operation, the upward and downward gain values may be different, the value of each of the gains must:

- Guarantee the release of the entire reserve made available to RTE for any frequency deviation of amplitude greater than or equal to 200 mHz regardless of the setpoint power,
- When $f > f_n$ or when $f < f_n$
    - Be constant at minimum over a period of 15 min[1] and consistent with setpoint power changes
    - Be independent of frequency variation.

An intentional dead band can be defined in the frequency regulation, provided that it can be adjusted, including setting to 0 (inactive) if the unit participates in primary frequency control.

Figure 3: Control law for FSM (Frequency Sensitive Mode)

Δf: frequency variation measured on the network
ΔP: active power variation

<u>Temporal Dynamic</u>

For any frequency variation $\Delta f = f - f_n$ between 0 and +/- 200 mHz from 50 Hz, the activation of the Reserve Providing Group's response must not be unduly delayed: the activation time (t1) is to be specified in file 1 (if t1 is greater than 500 ms, technical justification must be provided, in all cases t1 must be less than or equal to 2s).

For any frequency step $\Delta f = f - f_n$ between 0 and +/-200 mHz from 50 Hz, the Reserve Providing Group must be able to activate the active power response (ΔP1) on or above the solid line of the curve below. This includes providing the entire expected FCR power reserve in less than 30 s (t2).

The expected power reserve is equal to the smaller of the following two values:

- the frequency containment reserve FCR defined above,
- the K gain multiplied by the value of the frequency step, i.e. -K.Δf.

This power reserve must be able to be delivered for at least 15 minutes (t3).

[1] 15 min: this value corresponds to the duration of the future imbalance settlement period scheduled to date for early 2025, and is consistent with the minimum reserve maintenance time.

Figure 4: Activation delay and response time at one step

The resolution of the frequency measurement used for frequency control must be less than or equal to 1 mHz.
The frequency measurement accuracy used for frequency control must be as good as possible and in all cases less than or equal to 10 mHz.
The insensitivity of the primary frequency control must be less than or equal to ±10 mHz. The insensitivity is specified in information file No. 1.

The implementation of the FSM must be transmitted to RTE through remote signalling. When the Reserve Providing Group is not in a position to contribute to primary frequency control (unit not connected, default affecting regulation), the signalling must then be positioned in out-of-service state "PART.FSM HS". The return to service of the FSM is accompanied by the transmission of the "PART.FSM ES" signalling.

The following telemetry data must also be transmitted to RTE:

- Actual power provided by the Reserve Providing Group in quasi-steady state mode
- Setpoint power of the Reserve Providing Group at reference frequency f_n
- Frequency measured on the network

4. FREQUENCY MEASUREMENT

4.1 Frequency for Primary Frequency Control

Applicable to all

Each unit or site with a primary control capacity greater than or equal to 1MW must have either a HV-A or HV-B local frequency measurement.

The acquisition time of the frequency measurement used for the frequency control (consolidated frequency in the case of central control or local measurement in the case of local control) is less than or equal to 0.2s in accordance with Article 29 f of [4].

For Reserve Providing Group units or sites that provide frequency control proportional to the frequency deviation, the frequency used must be measured locally.

Applicable to decentralised RPGs

For centralised frequency control, the frequency used to ensure frequency control must be derived from 3 frequency measurements over separate administrative regions in France.

The frequency measurement is considered consolidated when 2 or more measurements are equal to the nearest resolution. The processing of the different frequency measurements will be described in Information File No. 1.

The acquisition time of the consolidated frequency measurement is less than or equal to 0.2s.

4.2 Large-scale seperate networks detection (split system)

Centralised management should enable the detection of large-scale, separate networks.

In the case of sites connected to the PDS, without local frequency measurement, once a volume of more than 1.5 MW of primary control capacity has been reached in an administrative region, 3 frequency measurements are required in that region.

Two networks are considered to be separated if the difference between frequency measurements is greater than 100 mHz for 1 second. The frequency measure should be consolidated in the case of centralised management.

If large-scale seperate networks are detected, only units or sites with local frequency measurement and performing a power variation proportional to a frequency deviation continue to participate in primary frequency control. The other sites stop controlling unless they can react according to the frequency of their administrative region.

4.3 Summary

	Centralised RPG control	Decentralised RPG control
Decentralised RPG	Case 1	Case 2
non-Decentralised RPG	Case 3	Case 4

Case 1:
Consolidated frequency measurement from 3 frequency meters in France in separate administrative zones.
If the primary frequency control capacity of the RPG is greater than 1.5 MW in an administrative area: 3 frequency meters in this area.

Case 2:
Each unit or site of the RPG has a local measurement and regulates in relation to this measurement.

Case 3:
Each unit or site controlling proportionally to the frequency deviation has a HV-A or HV-B local measurement.
Each HV-B connected unit or site has a local measurement (regardless of its participation in frequency control or in setpoint tracking).
Each HV-A connected unit or site with primary frequency control capacity greater than 1 MW has a local measurement (regardless of its participation in K.Δf or in set point tracking).
The participant must state in file E1 how local frequency measures are taken into account to consolidate the frequency used for centralised control.

Case 4:
Each unit or site of the RPG has a local measurement and regulates in relation to this measurement.

5. DIMENSIONING AND STOCK MANAGEMENT

Applicable to LER

5.1 Service availability and stock dimensioning

Applicable to LER

The Reserve Providing Group must provide primary frequency control service continuously and permanently in the Normal State.

In an Alert or Emergency State, the Reserve Providing Group must provide primary frequency control service and be able to maintain full activation of the frequency containment reserve (outside of operation in reserve mode) corresponding to a deviation of +200 mHz or greater (less than or equal to -200 mHz, respectively), for a period of t3 (15 minutes) or the equivalent in energy in case of a frequency deviation of less than 200 mHz (greater than -200 mHz, respectively). This duration is counted from the time of entry into the Alert State or entry into the Emergency State when it is not directly preceded by an Alert State.

To guarantee an energy reserve maintaining t3 (15 minutes) of the full activation of the upward and downward primary frequency control, the Reserve Providing Group, if it is composed exclusively of limited energy units, must have a useful energy (E_{useful}) to FCR_{max} ratio greater than 0.5.

The table below summarises the different concepts of stock levels:

Acronym	Definition
SoC	State of Charge, level of stock at one time
SoC_{upper}	Upper state of charge threshold in normal operation, guaranteeing the availability of 15 min maintenance (t3) of downward frequency containment reserve in power and energy
SoC_{lower}	Lower state of charge threshold in normal operation, guaranteeing the availability of 15 min maintenance (t3) of the upward frequency containment reserve in power and energy
SoC_{max}	Upper limit state of charge threshold, corresponding to a security constraint for the RPG
SoC_{min}	Lower limit state of charge threshold, corresponding to a security constraint for the RPG
$SoC_{reserve\ upper}$	The threshold above which Reserve Mode is activated to manage stock saturation
$SoC_{reserve\ lower}$	The threshold below which Reserve Mode is activated to manage stock depletion
E_{useful}	The usesful capacity of the stock

The useful capacity of the stock is expressed in MWh.

Stock levels are expressed as % of useful capacity. By convention in this document, useful capacity is the capacity to provide frequency control *[case of non-synchronous stationary storage units]* and not the total capacity of the battery.

Applicable to non-synchronous Storage Units

The useful capacity can be defined on the DC or AC side. This choice will be specified in file 1.

Applicable to LER

The diagram below provides a graphical representation of these thresholds and stock intervals corresponding to the Reserve Providing Group's modes of operation.

Figure 5: State of charge thresholds

The Frequency Control Provider must continue to provide primary frequency control service until the energy supply is exhausted or saturated (see § 5.3).

5.2 Active stock management

Applicable to LER

An active stock management process must be implemented at the Reserve Providing Group level to ensure continuity of service and availability of energy reserves.

The setpoint power must not limit participation in frequency containment reserve.

[Case of non-synchronous stationary storage units] To actively and simultaneously manage stock and frequency containment reserve, the maximum power P_{max} must be greater than 110% of the frequency containment reserve FCR_{max}.

The maximum setpoint power P_{cmax} should be less than or equal to P_{max}-FCR.

The active stock management process may change the setpoint power Pc to maintain the normal state of charge (SoC) between SoC_{lower} and SoC_{upper} or have a state of charge to provide FCR upwards or downwards during t3 (15 minutes).

The active storage management process must not be based on an overactivation.

The active stock management process must not have an impact on the primary frequency control service provided (for example, the reserve volume provided must not be reduced due to a change in the setpoint power).

The variation in the setpoint power must take place by step, the duration of the step must be configurable with a minimum duration of 15 minutes[2]. The ramps (MW/min) for step changes must be configurable (if RTE imposed ramps in the future). The hourly timing of the steps must be configurable.

In an Alert State or Emergency State and outside of operation in reserve mode, the change in the setpoint power must be frozen if this change is contrary to the requirements of the power system (for example it is forbidden to modify the setpoint power downwards towards extraction if the frequency is below 50 Hz). The setpoint power must remain frozen as long as the network is not out of Alert State or Emergency State.

The principle of the active stock management process including the chosen settings and the method of estimating the state of charge will be described in detail in information file 1. RTE must be kept informed of any change to the active stock management process, and may request additional information.

5.3 Management of stock depletion and saturation

5.3.1 Mode Réserve

Applicable to non-synchronous Storage Units or aggregates of non synchronous Storage Units LER

The depletion or saturation of the stock is managed by activating Reserve Mode [5], when the state of charge is less than $SoC_{reserve\ lower}$ or greater than $SoC_{reserve\ upper}$.

These thresholds are defined by the amount of energy required to provide FCR for a time interval equal to the full activation time of the aFRR:

- $SoC_{reserve\ inf} = \frac{RP \cdot \Delta t_{FAT}}{E_{utile}}$
- $SoC_{reserve\ sup} = 1 - SoC_{reserve\ inf}$

Where Δt_{FAT} is the complete activation time of the aFRR, Δt_{FAT} = 300 sec or 1/12th hour.

In established reserve mode, outside of the transition period, the unit must follow the following frequency control law:

$$P - P_c = -K.\overline{\Delta f_{zero_{mean}}(t)}$$

- The set-point power may be reduced to 0 if it is not favourable for stock replenishment so as to ensure continuous operation in reserve mode until the conditions for exiting reserve mode are met (see below); otherwise, it must be maintained.

- The K gain [MW/Hz] remains the same in all modes: normal, reserve and in the transitions.

- $\overline{\Delta f_{zero_{mean}}(t)}$ is the short-term frequency deviation from the average frequency: $\overline{\Delta f_{zero_{mean}}(t)} = \Delta f(t) - \frac{1}{N}\sum_{i=0}^{N-1} \Delta f\left(t - \frac{i}{N}\Delta t_{FAT}\right)$

  With N = the number of frequency measurements taken over a period of time Δt_{FAT} according to the sampling frequency.

Following a long-term operation in reserve mode, if the SoC no longer allows this operation to be performed (saturation or total depletion), the Reserve Providing Group will switch to a downgraded reserve mode. Thus, an asymmetric reserve mode, only in the direction favourable to the SoC, will be used for the time to reconstitute stock allowing the return to nominal (symmetric) reserve mode.

[2] 15 min: this value corresponds to the duration of the future imbalance settlement period scheduled to date for early 2025, and is consistent with the minimum reserve maintenance time

During the transition from Normal to reserve mode and vice versa, the Reserve Providing Group must follow the following frequency control law:

$$P - P_c = -K.\Delta f_{reaction}(t)$$

$\Delta f_{reaction}(t)$ is a combination of the normal frequency deviation and the short-term frequency deviation as described by the following equation:

$$\Delta f_{reaction}(t) = \overline{\Delta f_{zero_{mean}}(t)} \cdot T + (1 - T) \cdot \Delta f(t)$$

where T is the transition function defined as follows:

Figure 6: Transition function

- Transition direction from Normal to Reserve mode:

$$T = \begin{cases} 0 & t < t_{start} \\ \dfrac{t - t_{start}}{\Delta t_{FAT}} & for\ t_{start} \leq t < t_{start} + \Delta t_{FAT} \\ 1 & t \geq t_{start} + \Delta t_{FAT} \end{cases}$$

  Where t_{start} is the time at which the upper ($SoC_{reserve\ upper}$) or lower ($SoC_{reserve\ lower}$) limits of the state of charge are exceeded.

- Direction of transition from Reserve to Normal mode:

$$T = \begin{cases} 1 & t < t_{restore} \\ \dfrac{t_{restore} - t}{\Delta t_{FAT}} + 1 & for\ t_{restore} \leq t < t_{restore} + \Delta t_{FAT} \\ 0 & t \geq t_{restore} + \Delta t_{FAT} \end{cases}$$

  Where $t_{restore}$ is the time when the reserve mode exit condition is met, i.e. the SoC returns in the interval [SoC_{inf} ; SoC_{sup}].

If the network leaves the Alert State or the Emergency State, the active charge management can be reactivated, according to the paragraph 5.2 and the set point Power (P_c) potentially modified. The return in the interval [SoC_{inf} ; SoC_{sup}] must occur in less than two hours. In the case where the set point power used for charge management does not allow a return in this interval in less than two hours the set point power can go up to 25% of the FCR.

In both Normal and reserve modes, the relevant performance for the frequency sensitivity mode must be respected (the full frequency range is used as the input signal, but the provision of FCR is limited to short-term frequency deviations in reserve mode).

When the Reserve Providing Group is in transition or reserve mode, the remote signalling PART.FSM must then be set to the "PART.FSM HS" out of service state.

5.3.2 Stock renewal after depletion or saturation

Applicable to LER without reserve mode

When the stock is depleted, the Reserve Providing Group must renew its stock no later than 2 hours after returning to Normal State. In an Emergency or Alert State, stock should not be renewed.

When the stock is renewed, the Reserve Providing Group must once again participate in primary frequency control and the PART.FSM remote signalling must then be set to the in-service state "PART.FSM ES".

The principle of stock renewal will be described in Information file 1.

5.4 Optional: Case of units with implementation of LFSM[3]-O and LFSM-U/UI modes

Applicable to units with LFSM

For units that make up the Reserve Providing Group having implemented LFSM-O and LFSM-U/UI mode, regardless of the mode of operation (active stock management, reserve mode, or stock renewal), LFSM must remain activated.

[3] LFSM: Limited Frequency Sensitive Mode or frequency control mode limited to overfrequency (LFSM-O mode) or underfrequency (LFSM-U)

6. NATURE OF THE EXCHANGED INFORMATION

Information on primary frequency control at the Reserve Providing Group level:

Short reference	**Info**	Description **Sub function**	**Use**	**Unit Physical**	**TM configuration range**
P	TM	Active power of the Reserve Providing Group	P value can be negative (consumption)	MW	[-110% Pmax_consumption; 110% Pmax_generation]
PART.FSM	TS	Reserve Providing Group that is dependent on primary frequency control (in or out of FSM)	Indicates the participation in primary frequency control (switch positioned by the customer indicating the state of participation of the unit to FSM)		
F.PROD	TM	F frequency of the network used by the device providing continuous regulation of the Reserve Providing Group	Accuracy required: 1/100th Hertz	Hz	[47; 52 Hz]
PC	TM	Setpoint power of the Reserve Providing Group	Setpoint power of the Reserve Providing Group at reference frequency fn. Pc value can be negative (consumption)	MW	[-110% Pmax_consumption; 110% Pmax_generation]

Applicable to LER

Short reference	Info	Description **Sub function**	Use	Unit Physical	Range
SoC.RPG	TM	Reserve Providing Group state of charge	Indicates the state of charge of the Reserve Providing Group	%	[0; 100%]

Applicable for all non-synchronous storage units

Storage unit information:

Short reference	Info	Description **Sub function**	Use	Unit Physical	Range
P	TM	Active power P of the storage unit	P value can be negative (consumption)	MW	[-110% Pmax_unit; 110% Pmax_unit]

Applicable for all HV-B connected units

As a reminder, all HV-B connected sites must be observable. The list of information to be exchanged is defined in Telecontrols Specifications depending on the connection.

RTE reserves the right to specify additional information at a later date.

The accuracy of the power measurement sensors, separate from the metering devices, is at least 0.5 % (class 0.5) under the conditions laid down by the NF EN 60688 standard and its 1999 and 2001 additions.

Reference:

- Reference Technical Documentation [3], art. 4.7 "Information exchange and telecontrol system".

7. ADDITIONAL REQUIREMENTS IN THE CASE OF CONNECTION TO THE PUBLIC DISTRIBUTION SYSTEM

For Reserve Providing Group sites connected to the Public Distribution System (PDS), the Reserve Provider needs to contact the Distribution System Operator to ensure that there is no technical constraint or protection system preventing the provision of primary frequency control as defined in the preceding paragraphs. In particular, the maximum active power variation ramps imposed per Distribution System Operator must not affect the power variations required for primary frequency control (e.g. a maximum ramp of 8 MW/min imposes a maximum frequency containment reserve of 4 MW).

8. CERTIFICATION CONTROL FILES

Pre-certification controls are carried out using the information files, Simulations and Tests contained in Annex 1 and 2.

List of certification control files

Step 1 (Annex 1): Information and Simulations to be performed before testing

Files	**Check**	**Type of control**	**Facility concerned:**
Information 1	List of data	Information	Yes
Information 2	Compliance of systems dedicated to information exchange	Information	Yes
Simulation 1	Dynamic behaviour of frequency control and reserve availability	Simulations	RPG LER

The RTE validation of step 1 with the terms defined in paragraph 5.3 of [1] is a prerequisite for the completion of step 2 tests.

Step 2 (Annex 2): Testing

Files	**Check**	**Type of control**	**Facility concerned**
Test 1	Tests of systems dedicated to information exchange	Real test	Yes
Test 2	Primary Frequency Control	Real test	Yes
Test 3	Frequency Control	Real test	Yes

9. REFERENCES

[1] Frequency Ancillary Services Terms and Conditions in force.

[2] Technical Reference Documentation in force.

[3] System Operation guideline (SOGL) : Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation.

[4] Demand Connection Code (DCC) : Commission Regulation (EU) 2016/1388 of 17 August 2016 establishing a Network Code on Demand Connection.

[5] All CE TSOs' proposal for additional properties of FCR in accordance with Article 154(2) of the Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation.

10. LIST OF ANNEXES

ANNEX 1: Information and Simulations to be provided by the Customer (Step 1)

ANNEX 2: Tests to be carried out by the Customer (Step 2)

ANNEX 3: Template for returning digital data

ANNEX 1: INFORMATION AND SIMULATIONS TO BE PROVIDED BY THE CUSTOMER (STEP 1)

INFORMATION FILE N°1: LIST OF DATA

Information
Intermediate folder

Objectives
The Customer must provide technical data to enable RTE to assess the impact of the Reserve Providing Group on the PTS.

Description

Special conditions
The Customer guarantees, with appropriate accuracy, the accuracy of the data supplied to RTE. If there is a change in one or more of the data, which may occur during the life cycle of the Reserve Providing Group, it is up to the Customer to transmit to RTE the new data values and to demonstrate to RTE that the characteristics of its Reserve Providing Group remain in compliance with the regulatory and contractual requirements.

Input data (RTE → Customer)
The list of data defined in this file

Results (RTE Client →)
The list of fully completed data (values and accuracy). If the Reserve Providing Group is not concerned, include the word "not applicable".
The Customer must provide:
- Before each element is first powered on: the data of these elements with a "revisable" status,
- Before the final Certification: the set of data with a "firm" status.

The "revisable" status of a data indicates that the data can be modified by the Customer.
The "firm" status of a data indicates that the data has the value of commitment of the Customer and cannot be changed, without affecting the corresponding connection request.

Criteria for compliance
- Completeness of data provided by the Customer
- The value of the data in accordance with the unit or format requested
- The accuracy entered for each numeric data

	Unit	***Value***	***Accuracy***
For each operating mode of the frequency regulation Reserve Providing Group			
Maximum frequency containment reserve of the RPG: FCR_{max}	MW		
FSM activation time: t1	ms		
Frequency control insensitivity	mHz		

Description of the control law and the conditions foreseen in operation (dynamic K gain, over-regulation, adaptation of response dynamics …)	Text		
K gain range to $FCR_{max.}$	MW/Hz		
Frequency containment reserve maintenance time based on FCR (justify if longer than 15 min)	Table / Text		
If relevant: If the maximum scheduled reserve depends on the external conditions: Conditions to reach the FCR_{max} according to external conditions and justification.	Text		
If relevant: If the maximum scheduled reserve depends on the external conditions: Theoretical table of the different frequency control parameters in operation according to the external conditions.	Table / Text		
Precise description of the strategy for managing frequency control and Stock of the Reserve Providing Group: the setpoint power alignment (frequency range, dynamic (ramp (MW/min), modification by step (with description of step change times) SoC range, etc.),of the behaviour of the Reserve Providing Group in the event of depletion/saturation of Stock, and the strategy to renew it, of the behaviour in Alert or Emergency State, reserve mode, ……	Diagram / Text		
Description of the location of the different control devices used to perform the frequency control, transmission channels, data exchanged between the different sites, transmission time….	Diagram / Text		
Description of the change in the charge management strategy in case of a scheduled frequency containment reserve of less than $FCR_{max.}$	Text		
Description of the frequency measurements used for frequency control (measuring location, processing, potential timeframe, type, performance (accuracy, resolution, acquisition time) etc.) and their processing to ensure the consolidation of the frequency used	Text		
Detailed diagram, in the form of block diagrams usually used, of the frequency control loop, of the associated limiting loops, comprising only the time constants of more than 10 ms and the values of the various parameters of this diagram.	Diagrams and numerical values		
Description of processing of frequencies to detect large-scale separate networks	Text		
Handling of the RPG in the event of detection or information of a large-scale split network.	Text		
Description of the method of estimating or measuring the state of charge of the RPG transmitted to RTE	Diagram / Text		
Studies carried out (simulation, tests, etc.) to ensure the state of charge management strategy	Text		
Description of the devices used to monitor the RPG's participation in frequency control, especially when incidents arise (including transmission channels) Description of the organisation in place to transmit the information to RTE (24/24h surveillance or working days/hours, on-call operators; the process of declaring a technical constraint to RTE in the event of the detection of insufficient participation or no participation in frequency control, of a large separate network)	Text		
Description of the site's exceptional frequency regime behaviour: behaviour of the process; description of possible protections / automated devices; duration of frequency control maintenance on the range 47.5 Hz – 51.5 Hz.	Table / Text		
If relevant: For each power-generating module: General data			
Maximum injection power (Pmax_unit)	MW		
Nominal apparent Power (Sn_unit)	MVA		
Type of primary energy or fuel	Text		
Active powers consumed (maximum, nominal and aggregate minimum values) by the auxiliaries of the power-generating module	kW/MW		

Description of the power-generating module auxiliaries (location, power, etc.)	Text		
Curve of the evolution of the maximum active power produced by the power-generating module as a function of external conditions.	Curve		
FCR constructive capacity	MW		
aFRR contructive capacity	MW		
Single line connection of the power-generating module	Diagram		
Common GPS coordinates and municipality of the entity	Text		
Description of frequency measurements (location, quality) on the site	Text		
Description and Location of the active power measurement used for the telemetry transmitted to RTE	Text		
If relevant: For each storage module: General data State in the column whether the value is rated AC or DC			
Maximum injection and extraction power (Pmax_unit)	MW		
Nominal apparent Power (Sn_unit)	MVA		
Type of technology, manufacturer, integrator of the storage component and DC/AC power electronics of the storage unit	Text		
FCR constructive capaciity	MW		
aFRR constructive capacity	MW		
Total stock capacity (E)	MWh		
Useful capacity of storage (E_{rated}):	MWh		
Justification (E_{rated}): the value will be justified by a test report (e.g.: Actual energy capacity test International Standard IEC 62933-2-1)	Diagram / Text		
Description of the degradation in storage unit performance over time and the management of this drop in performance (requalification, decrease in contractual performance, change of elements, etc.)	Text		
The evolution curve of the storage unit charge according to external conditions (temperature etc.).	Diagram/ Texte		

Description of the constraints that may affect the active power of the battery and which do not guarantee the maintenance of Pmax_generation and/or Pmax_consumption. For example those related to SoC, temperature, cell polarization etc. Where relevant, transmission of a Pmax generation / Pmax consumption table depending on the constraint: SoC, temperature etc.…	Diagram / Text		
Upper state of charge threshold in normal operation, guaranteeing the availability of maintaining 15 min at –FCR (SoC_{upper}) in power and energy	MWh		
Upper state of charge threshold in normal operation, guaranteeing the availability of maintaining 15 min at +FCR (SoC_{lower}) in power and energy	MWh		
Operating state of charge upper threshold, technical constraint (SoC_{max})	MWh		
Operating state of charge lower threshold, technical constraint (SoC_{min})	MWh		
The threshold above which Reserve Mode is activated to manage stock saturation ($SoC_{reserve\ upper}$)	MWh		
The threshold below which Reserve Mode is activated to manage stock depletion ($SoC_{reserve_lower}$)	MWh		
Charge/discharge output of the storage unit (charge/discharge)	%		
Single line connection of the Storage unit	DiagramText		
Description of the Storage unit auxiliaries (location, power, etc.)	TextText		
Description of the method of estimating or measuring the state of charge of the battery transmitted to RTE	Diagram / TextText		
If relevant: For each consumption site participating in the RPG			
Common GPS coordinates and municipality of the entity	Text		
Description of the controlled process.	Diagram / Text		
Description of frequency measurements (location, quality) on the site	Text		
Description and Location of the active power measurement used for the telemetry transmitted to RTE	Text		
Where relevant if using a sub-measure: Analyses, studies, and tests to demonstrate the absence of counter regulation throughout the site	Text		
If relevant: For each entity of the RPG connected to the Distribution System: General Connection Data			
Metering Code site and DSO concerned, (provide an Excel file with relevant metering code and DSO)	Table / texte		

If applicable: type of HV-A network protection installed by the local distribution company	Text		
Description of the behaviour of the unit after outage with or without a voltage shortage (cut-off or load shed): Manual or automatic restart, restart duration, setting restart time, transient to reach the setting, monitoring, etc.	Text		
If applicable: Constraints and potential exemptions imposed on the Storage unit by the local distribution company (dynamic restriction, maximum ramp MW/min, power limitation)	Text		
If applicable: the reactive range imposed by the local distribution company	MVAR		
If applicable: the voltage regulation law imposed by the local distribution company	Text		
Name of the HV-A network starting point and substation	Text		
If relevant: For each site of the RPG connected to the Transmission System: General Connection Data			
HV-B connection station	text		
Limitation imposed in active, presence of an automatic network control device….	Text		
If relevant: Decentralised RPG case			
Description of the controlled processes	Text		
Description and location of the active power measurement used for the telemetry transmitted to RTE	Table/text		
Where relevant if using a sub-measure: Analyses, studies, and tests to demonstrate the absence of counter regulation throughout the site	Text		
Total number of sites for each process led in France	Text		
Geographical breakdown by department (number of sites per process)	Table/text		
For each Metering Code site and DSO concerned, (provide an Excel file with relevant metering code and DSO)	Table/text		

Annex 15:
Template for certification
of qualification for primary frequency control

INFORMATION FILE N°2: COMPLIANCE OF SYSTEMS DEDICATED TO INFORMATION EXCHANGE
Information ***Intermediate folder***
Objectives Exchange of information is necessary for the proper integration of the Reserve Providing Group into the power system, at different time periods. The information exchanged, which is dependant on the size of the Reserve Providing Group and its participation in anciliary services, must be compatible and consistent with the telecontrol and communication systems RTE uses with the various players.
Description Verification of the compliance of the systems dedicated to information exchange with the performance specified by RTE in the information system specifications, if any, annexed to the connection agreement. These systems dedicated to information exchange concern specifically: ▫ the telecontrol system, (TS, TM, load-frequency control signals) Each piece of equipment will be tested in conjunction with RTE and in accordance with the exchange protocols. 1. Test of the RTE interface terminal block up to the RTE control centre from fake signals
Special conditions
Input data (RTE → Customer)
Results (Customer → RTE) The customer must provide RTE with the reports of the tests up to the control centre from the injection of fake signals. A complete test will be carried out by RTE in order to test the equipment put in place (see step 1 of the Test 1 file).
Criteria for compliance The provision of the documents described in the "Results" paragraph

Applicable to LER RPGs

SIMULATION FILE N°1 : DYNAMIC BEHAVIOUR OF FREQUENCY CONTROL AND RESERVE AVAILABILITY

- Case of Reserve Providing Groups LER–

Simulation

Objectives

The objective is to verify the behaviour of the primary frequency control facility and the ability to actively manage a stock equivalent to maintaining the maximum frequency containment reserve supply for t3 (15 minutes).

Description

Test 1: Simulation of the RPG's behaviour in primary frequency control and active charge management over the historical frequency of the period from 01/05/2015 to 30/04/2018

- **Test 1.a:** Numerical simulation over the test period
- **Test 1.b:** Analysis and inventory of out-of-range periods [SoC_{lower}; SoC_{upper}]
- **Test 1.c:** Detailed analysis of the days 09 and 10/01/2017 (low frequency profile)
- **Test 1.d:** Detailed analysis of the days 6 and 7/04/2018 (high frequency profile)

Test 2: Simulation of stock replenishment following use of the reservoir

- **Test 2.a:** In low frequency

Simulation from the following theoretical frequency profile:

Start	End	Frequency (Hz)
T0	T0 + 40 min	49.8
T0 + 40 min	T0 + 50 min	49.9
T0 + 50 min	T0 + 200 min	50.0

- **Test 2.b:** At high frequency

Simulation from the following theoretical frequency profile:

Start	End	Frequency (Hz)
T0	T0 + 40 min	50.2
T0 + 40 min	T0 + 50 min	50.1
T0 + 50 min	T0 + 200 min	50.0

Test 3: Simulation of the reserve mode

Applicable to RPGs with reserve mode.

Test 3a: Simulation of the behaviour of the RPG in reserve mode in case of low frequency:

3.a.1: Depletion: addition of an offset of -300 MHz from 8:40 to 9:40 on 10/01/2017
3.a.2: Saturation: addition of an offset of +300 MHz from 8:40 to 9:40 on 10/01/2017

Test 3b: Simulation of the behaviour of the RPG in reserve mode in case of high frequency:

3.a.1: Depletion: addition of an offset of -300 MHz from 3:15 to 4:15 on 07/04/2018
3.a.2: Saturation: addition of an offset of +300 MHz from 3:15 to 4:15 on 07/04/2018

Special conditions

- The Reserve Providing Group must be modelled in accordance with the information provided in the information file (useful energy, active charge management process, reserve mode, stock thresholds, performance of the different units, etc.).
- The initial conditions of the simulations are set at the mean values of the state of charge (SoC) and the setpoint power.

- The simulation must be representative of the primary frequency control behaviour of the Reserve Providing Group in operation.
- The dead band will be set to 0.
- The time interval for simulations is 10 seconds or less.
- If the Reserve Providing Group is concerned by the presence of an LFSM type device, test 3 will be adapted in consultation with RTE

Input data (RTE → Customer)

- Frequency time series at 10s intervals (available: https://www.services-rte.com/fr/telechargez-les-donnees-publiees-par-rte.html?category=public_transmission_system&type=network_frequencies)
- Annex 3: Template for returning digital data (CSV format file transmitted by RTE)

Results (Client → RTE)

The assumptions and the model adopted will be specified and justified.
The FCR_{max} value will be submitted for each simulation.

For each simulation, the following simulated time signals are returned:

- Setpoint power (50.00 Hz power)
- Active power
- SoC state of charge (%)
- K Gain (differentiated if upward and downward difference)
- TS PART.FSM
- Frequency
- Alert State
- Other external factors enter into the charge management strategy (Market Price etc.)

For Tests 3, in addition to the previous signals:

- Operating modes: normal mode, transition mode, reserve mode
- $\overline{\Delta f_{zero_{mean}}(t)}$
- $\Delta f_{reaction}(t)$
- Transition function

For tests 1,2 and 3, the results should be in the following format:
Digital data of the recordings (according to the template submitted by RTE in Annex 3).

For tests 1.c, 1.d, 2 and 3, the results should be presented as follows:

- Graphs with legend (simulated quantities and units, state of charge thresholds).
- Curve scales adapted to the measured amplitudes.

For the tests 3, a zoom will be carried out over the period with the offset of +/- 300 MHz.

For tests 1.b, c, and d, the input and output events in the range [SoC_{lower}; SoC_{upper}] will be shown (format dd/mm/yy hh:mm:ss).

Compliance criteria for all tests:

- The behaviour of the Reserve Providing Group must be consistent with the requirements described in paragraph "3 Primary frequency control (FSM mode)"
- The freezing of setpoint power must be consistent with the requirements described in paragraph "5.2 Active storage management"
- The state of charge in Normal State must remain in the range [SoClower; SoCupper]. Outputs in this range are allowed if the state of charge allows to provide upward or downward FCRmax for t3 (15 minutes)
- The results of the simulation should be consistent with the charge management strategy described in information file 1.
- The dates and times of input and output of the state of charge of the range [SoClower; SoCupper] must match the Alert State situations.

- In the absence of reserve mode, depletion or stock saturation must occur after release of an energy equivalent to 15 minutes of full activation of FCRmax. Otherwise, the transition to reserve mode must begin after the release of an energy equivalent to 10 minutes of full FCRmax activation.
- The behaviour in Reserve Mode corresponds to § 5.3.1
- Stock renewal complies with the requirements of § 5.3 (variation in set point power and return in the range [SoC_{inf}; SoC_{sup}]) .
- TS PART.FSM in accordance with the status of the RPG

ANNEX 2: TESTS TO BE CARRIED OUT BY THE CUSTOMER (STEP 2)

TEST FILE NO. 1: TESTS OF SYSTEMS DEDICATED TO INFORMATION EXCHANGE
Real tests ***Intermediate folder***
Objectives The test aims to verify the proper functioning of all equipment associated with information exchange systems.
Description Each piece of equipment will be tested in conjunction with RTE and in accordance with the exchange protocols. 1. Testing of all equipment dedicated to information exchange between the Reserve Providing Group and the RTE control centre when carrying out the first injection.
Special conditions All of the tests must be scheduled and performed in conjunction with RTE.
Input data (RTE → Customer)
Results (Customer → RTE) Equipment test reports.
Criteria for compliance Each equipment must operate correctly in accordance with the exchange protocols.

TEST FILE NO. 2: PRIMARY FREQUENCY CONTROL –FSM MODE

Real tests
Final folder

Objectives

If there is an imbalance between power generated and consumed on the network (uncertainties, load rise, etc.), all Reserve Providing Groups participating in load-frequency control must adapt the power generated in a sufficiently short period of time, in the appropriate proportions and a sufficient duration.

Description

The following tests will be performed:

Applicable to RPGs without reserve mode.

- **Test 1: Case of a drop in frequency: volume check and maintaining of maximum FCR (depending on external conditions) and temporal dynamics**

  Artificial injection of a frequency step Δf = - 200 mHz for 35 minutes at the frequency control device.

  The Reserve Providing Group is at the worst case P_{test1} power in terms of the compliance criteria, reflecting the operating conditions (e.g.: maximum Pc setpoint power and worst case state of charge in this normal state frequency configuration)

Figure 1

t_i: the time after which the power response is greater than the measurement uncertainty of the power response.

t_r time after which the power response reaches 95% of the frequency containment reserve FCR

Applicable to RPGs with reserve mode.

- **Test 1 bis: Case of a drop in frequency: volume check, maintaining maximum FCR (depending on external conditions), temporal dynamic and reserve mode**

  Artificial injection at the device level for frequency control of a frequency profile corresponding to the following:
  - Frequency step Δf =-200 MHz for 5 minutes
  - Then frequency times series based on history and indicated in the annex with an offset of -300 MHz
    This -300 MHz offset is maintained until the Reserve Providing Group has operated at a minimum for 5 minutes in established reserve mode
  - Removal of offset and continuation of frequency time series
  - Maintenance of the frequency time series without offset until switching back to normal mode for 5 min.

  The Reserve Providing Group is at the worst case P_{test2} power in terms of the compliance criteria (e.g.: Maximum Pc set point power and worst case state of charge in this normal state frequency configuration).

Figure 1

t_i: the time after which the power response is greater than the measurement uncertainty of the power response.

t_r time after which the power response reaches 95% of the frequency containment reserve FCR

Applicable to all RPGs.

- **Test 2: Case of a rise in frequency: volume check and maintaining maximum FCR (depending on external conditions) and temporal dynamics**

  Artificial injection of a frequency step Δf = + 200 mHz for 35 min at the primary frequency controller.
  The Reserve Providing Group is at the worst case P_{test2} power in terms of the compliance criteria (e.g.: minimum Pc setpoint power and worst case state of charge in this normal state frequency configuration).

Figure 2

t_i: the time after which the power response is greater than the measurement uncertainty of the power response.

t_r time after which the power response reaches 95 %- FCR.

- **Test 3: Case of a drop in frequency: temporal dynamic on a small step**

  Artificial injection of a frequency step Δf = - 50 mHz at the primary frequency regulator for 5 minutes.
  The Reserve Providing Group is at the worst case P_{test3} power in terms of the compliance criteria from which the FCR frequency containment reserve is subtracted.

Figure 3

t_i: the time after which the power response is greater than the measurement uncertainty of the power response.

t_r time after which the power response reaches 95% of min(FCR; -K.Δf).

- **Test 4: Case of an increase in frequency: temporal dynamic on small step**

  Artificial injection of a frequency step Δf = + 50 mHz at level of the primary frequency controller for 5 minutes
  The Reserve Providing Group is at the worst case P_{test4} power in terms of the compliance criteria.

Figure 4

t_i: the time after which the power response is greater than the measurement uncertainty of the power response.
t_r time after which the power response reaches 95% of min(FCR; K.Δf).

- **Test 5: Check there is no dead band or insensitivity**
  Artificial injection of a frequency profile according to the following profile:
  The Reserve Providing Group is at the worst case P_{test5} power from which the FCR frequency containment reserve is subtracted.

Special conditions

- Tests must be scheduled and performed in conjunction with RTE.
- The variation of the setpoint power must be in accordance with the charge management strategy described.
- If stock depletion management (Reserve Mode) is present, it must be activated on tests 1 and 2. There will be no replenishment of stock after depletion.
- If the Reserve Providing Group is concerned by the presence of an LFSM type device, test 1 will be adapted in consultation with RTE
- The tests must be performed in the worst case initial situation, in a normal state of frequency, as specified in the description of the charge management strategy. If applicable, a fake frequency profile will be introduced to bring the Reserve Providing Group into this unfavourable state (this profile will be described and explained).
- The Reserve Providing Group does not participate in primary frequency control in operation at the time of testing.
- If there is an intentional dead band in the frequency regulation, it must be inactive (set to 0) during the tests.
- If a variable gain is implemented in the charge management process of the Reserve Providing Group, the tests will be performed with the lowest expected gain. In addition, tests 1 to 4 will be performed a second time with the highest gain (test 1 and 2 reduced to a duration of 5 min).
- The frequency profile will be injected closest to the actual operating frequency measurement location. In case of processing between the actual frequency measurement and the site where the dummy frequency is injected during

the test, this will be specified. Specifically, if this processing introduces a significant additional period of time, it will be added to the different times requested for the compliance criterion.

- If the Local Distribution Company imposes a delay in the response time of the Reserve Providing Group when participating in primary frequency control, this delay shall not be implemented during these tests.
- If the frequency containment reserve that can be delivered during the tests depends on external conditions (temperatures, flow rate, level of water..) it will be scheduled at its maximum possible value (> 70% FCR_{max}) otherwise it will be equal to FCR_{max}.
- Where applicable, the frequency levels of test 5 may be extended beyond 30 sec to take into account the dynamics of the Reserve Providing Group and the fact that it is in steady state prior to the various ramps.

Input data (RTE → Customer)
t3: 15 minutes
Frequency time series at 10 sec intervals of test 1 bis in Annex 4.

Input data (Customer -> RTE)
A description of the load management strategy
Justification of the parameters chosen during the tests: worst case condition for the initial conditions, maximum FCR in relation to the external conditions,
Conditions to reach the FCR_{max} according to external conditions and justification.
Theoretical table of the different frequency control parameters in operation according to the external conditions: FCR
Description of the method characterising the measurement uncertainty to define t_i

Annex 15:
Template for certification
of qualification for primary frequency control

Results (Customer → RTE)

1. K (MW/Hz)
2. FCR maximum (MW)
3. Primary frequency control insensitivity (mHz)

For each of the tests, records of the time signals in figure 1:

4. Setpoint artificially injected into the primary frequency controller
5. Active power supplied by the Reserve Providing Group
6. Power setpoint (out of control power or power at 50.00 Hz)
7. Reserve Providing Group SoC (%)
8. TS PART.FSM compliant with the state of the RPG
9. If relevant:
    - Power of the various entities participating in the RPG
    - In the case of the use of a sub-measure, another measure (telemetering / counting) demonstrating the absence of counter regulation
    - Analysis of the behaviour of the different entities and information exchanged (orders, instructions, etc.)
    - If the Frequency Control Provider has a Storage unit, the active power, setpoint power, and SoC records will also be returned at the Storage unit level
    - If ΔP cannot be maintained for the duration of the test, an analysis of the origin of the power variations will be transmitted and should provide justification for the maintenance throughout the duration t_3 over the entire SoC range

For Tests 1bis, in addition to the previous signals:

10. Operating modes: normal mode, transition mode, reserve mode
11. K . $\overline{\Delta f_{zero_{mean}}(t)}$
12. K. $\Delta f_{reaction}(t)$
13. Transition function

the Frequency Control Entity's records include the following values:

- t_i,
- t_r
- ΔP
- t_{start}, $t_{restore}$
- P_{test}
- SoC_{upper} and SoC_{lower}
- SoC_{min} and SoC_{max}
- $SoC_{reserve\ upper}$ and $SoC_{reserve\ lower}$

These records must include the pre- and post-event steady-state phases (at least 10 seconds before and 60 seconds after). There is a need to zoom in on the transient phenomena with a minimum sampling of 10 Hz for the Reserve Providing Group. For the test 1bis, the sampling can change to 0.1 Hz after 5 min.
These records should be in the following format:

- PDF and digital format of records (e.g. Excel file).
- Graphs with legend (measured quantities and units).
- Curve scales adapted to the measured amplitudes.

In addition, the K gain of the controller will be calculated for each test from the value of ΔP measured in tests 1, 2, 3, 4 and the following formula:

$$K = \frac{P - P_{essai}}{f_n - f}$$

The choice of the worst initial state will be explained.

Annex 15:
Template for certification
of qualification for primary frequency control

Criteria for compliance

For all tests 1, 2, 3, 4, the records must visually prove that the following points are observed:

- The behaviour must be as described in Customer-supplied load management strategy
- TS PART.FSM compliant with the state
- K_{min} <K (MW/Hz) <K_{max}
- Non-oscillating waveform,
- Time t_i less than 0.5 sec (If t_i is greater than 0.5s, technical justification must be provided, in all cases t1 must be less than or equal to 2s).
- The active power response will be greater than the model below for 95% of the time, outside the activation delay period.
- Maximum FCR based on outdoor conditions greater than 70 % FCR_{max}

For test 1:

- Variation ΔP≥FCR maintained 15 min (t3) after t_r.
- Time t_r less than 30 s, visually proven by recordings

For test 1 bis:

- Variation ΔP≥FCR maintained 10 min after t_r.
- Time t_r less than 30 s, visually proven by recordings
- The behaviour in Reserve Mode corresponds to § 5.3.1 (transitions, maintenance of reserve mode for 5 minutes, etc.). Correspondence between P(t) and the theoretical curves K. $\overline{\Delta f_{zero_{mean}}(t)}$ and K. $\Delta f_{reaction}(t)$
- The renewal of the stock complies with the requirements of § 5.3 (variation in set point power and return in the range [SoC_{inf}; SoC_{sup}]) .

For test 2:

- Variation ΔP≤- FCR maintained 15 min (t3) after t_r.
- Time t_r less than 30 s, visually proven by recordings

For tests 1 and 2, if the power is not maintained after t3, the phenomena involved must be explained and linked to the selected initial state of charge.

For tests 3, 4:

- Variation ΔP≥min (FCR; -K.Δf) maintained 5 min after t_r.
- Time t_r less than 30 s, visually proven by recordings

For tests to calculate K gain, records must show that:

- K measured = K preset to within ±5%.

For test 5:

- The test must demonstrate that there is no dead band.
- The test must demonstrate that there is primary frequency regulation insensitivity < 10 mHz

TEST FILE NO. 3: FREQUENCY CONTROL – FSM MODE

Real tests
Final folder

Objectives

Observation of the frequency control when the Reserve Providing Group is in theprimary frequency control.
Depending on the conditions for participation in the desired frequency control in operation (for example, assymmetric gain), the tests carried out may be adapted in order to validate the functioning of the Reserve Providing Group.

Description

The Reserve Providing Group is coupled for eight hours.
The overall functioning of the Reserve Providing Group in terms of frequency control is monitored.

In addition, the following tests will be carried out during this time:
Test 1: Reserve Providing Group transition from non-FSM to FSM (and vice versa).
Test 2: Reliability test for 8 hours

Special conditions

- The test must be scheduled and performed in conjunction with RTE.
- The Reserve Providing Group participating in primary frequency control.
- The program of operation must be representative of the final operating of the Reserve Providing Group (e.g. the test must be carried out with the initial setpoint power and initial state of charge at their average value)
- The conditions for participation in primary frequency control must be consistent with those chosen in test file no. 2.
- Test 1 must include several transitions from non-FSM to FSM (and vice versa), allowing several minutes to pass between each change of state.
- If there is an intentional dead band in the primary frequency control, it must be inactive (set to 0) during the tests.
- If the frequency containment reserve that can be carried out during the tests depends on external conditions (temperatures, flow rate, level of water,..) it will be scheduled at its maximum possible value (> 70% FCRmax) otherwise it will be equal to FCRmax.

Input data (RTE → Customer)

- Justification of the parameters chosen during the tests: condition for the initial conditions, maximum FCR in relation to the external conditions,

Results (Customer → RTE)

- K (MW/) differentiated if upward and downward difference
- FCR (MW)
- Primary frequency control insensitivity (mHz)
- Active power supplied by the Reserve Providing Group at the connection point
- Power setpoint (out of control power or power at 50.00 Hz)
- Reserve Providing Group SoC (%)
- TS PART.FSM
- If relevant:
    - Power of the various entities participating in the RPG
    - In the case of the use of a sub-measure, another measure (telemetering / counting) demonstrating the absence of counter regulation
    - Analysis of the behaviour of the different entities and information exchanged (orders, instructions, etc.)
    - If the Reserve Providing Group has a Storage unit, the active power, setpoint power, and SoC records will also be sent at the Storage unit level

Using the information available at the RTE regional control centre, RTE examines the response of the Reserve Providing Group during the evolution of the frequency.

Criteria for compliance

The records at the RTE regional control centre should be consistent with expected data.

- The behaviour of the Reserve Providing Group must be consistent with the requirements described in paragraph "3 Primary frequency control (FSM mode)"
- The results of the test should be consistent with the charge management strategy described by the Customer (Pc evolution, respect of SoC thresholds…)

Annex 15:
Template for certification
of qualification for primary frequency control

- TS/TM in accordance with the state of the Reserve Providing Group and where relevant the storage unit
- K_{min} <K (MW/Hz) <K_{max}
- Dead band set to 0 mHz
- Primary frequency control insensitivity< 10 mHz
- Maximum FCR based on outdoor conditions greater than 70 % FCR_{max}

ANNEX 3: TEMPLATE FOR RETURNING DIGITAL DATA

File in ".csv" format:

- column separator: “;”
- Decimal separator: “. "

Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H	Column I	Column J	Column K	Column L	Column M	Column N
Date in dd/mm/yyyy format HH:MM:SS (sampling period of up to 10 seconds, to be specified when sending if less)	Frequency in Hz, at or near mHz (optional if RPG does not participate in Primary Load-Frequency Control)	Level of Secondary Load-Frequency Control between -1 and 1 (optional if RPG does not participate in Secondary Load-Frequency Control)	Power in MW	Power without MW regulation (optional)	Total installation power in MW (optional)	Alert state (to 1 when an alert state is declared, otherwise to 0)	upward FCR (in MW)	downward FCR (in MW)	upward K (MW/Hz) when f> fn	downward K (MW/Hz) when f < fn	SoC in %	upward aFRR (in MW)	downward aFRR (in MW)
01/07/2015 00:00	50.0245		25.32	25.121	24.32	0	1	1	25	5	50.05		
01/07/2015 00:00	50.023		25.17	25	24.17	0	1	1	25	5	50.06		
01/07/2015 00:00	50.022		24.8224	25	23.8224	0	1	1	25	5	50.07		
01/07/2015 00:00	50.022		24.755	25	23.755	0	1	1	25	5	50.08		
01/07/2015 00:00	50.023		24.91	25	23.91	0	1	1	25	5	50.09		
01/07/2015 00:00	50.025		25.6231599	25	24.62315987	0	1	1	25	5	50.1		
01/07/2015 00:01	50.031		25.80015	25.0145	24.80015	0	1	1	25	5	50.11		

Column Legend:

Column A: Date in dd/mm/yyyy format HH:MM:SS (sampling period of up to 10 seconds, to be specified when sending if less)

Column B: Frequency in Hz, to at least the nearest mHz

Column C: where relevant, RSFP Level (between -1 and 1), optional value, to be completed if the RPG participates in secondary frequency control

Column D: Active power in MW; Actual power supplied by the RPG in quasi-stationary mode, P= Pc + KdeltaF (positive value if injection),

Column E: Power without frequency control in MW (optional); RPG set point power at fn =50.00Hz (positive value if injection)

Column F: where relevant, Pt, total installation power in MW (positive value if injection), optional value. For a storage unit this is the sum at the connection point of the storage unit power and the other processes of the installation (auxiliaries, consumption of the consumer site if connection at a consumer site)

Column G: Alert state (to 1 when an alert state is declared, otherwise to 0)

Column H: Upward frequency containment reserve volume FCR scheduled in MW when f> fn;

Column I: Downward frequency containment reserve volume FCR scheduled in MW when f < fn;

Column J: Upward K gain in MW/Hz when f> fn;

Column K: Downward K gain in MW/Hz when f < fn;

The following columns are specific to LER RPGs (the fixed data SoC max in %, SoC upper reserve in %, upper SoC in %, SoC lower reserve in %, SoC min in %, …, E in MWh, are to be provided alongside the file)

Column L: SOC in %, state of charge at one moment;

Column M: Volume of automatic frequency restoration reserve aFRR scheduled in MW when N>0;

Column N: Volume of automatic frequency restoration reserve aFRR scheduled in MW wh

Annex 15: Template for frequency control Aggregate / Storage Qualification

ANNEXE 4 : FREQUENCY TIME SERIES AT 10 S INTERVALS 1 BIS

50.021; 50.017; 50.032; 50.02; 50.019; 50.019; 50.009; 50.003; 50.02; 50.023; 50.028; 50.023; 50.022; 50.007; 50.001; 50.001; 50.008; 50.014; 50.027; 50.017; 50.02; 50.022; 50.028; 50.027; 50.02; 50.001; 49.99; 49.998; 49.997; 50.007; 49.998; 49.992; 50.002; 50.011; 50.009; 49.994; 49.984; 49.985; 49.988; 49.989; 49.989; 49.998; 50.014; 49.995; 49.99; 49.986; 49.985; 49.988; 50; 49.998; 49.986; 49.991; 49.993; 50.003; 49.988; 49.992; 49.982; 49.981; 49.989; 49.988; 49.977; 49.972; 49.971; 49.955; 49.96; 49.957; 49.957; 49.951; 49.951; 49.948; 49.948; 49.961; 49.954; 49.95; 49.952; 49.944; 49.95; 49.954; 49.951; 49.946; 49.947; 49.946; 49.94; 49.944; 49.94; 49.924; 49.93; 49.938; 49.938; 49.929; 49.928; 49.933; 49.939; 49.945; 49.938; 49.934; 49.939; 49.936; 49.932; 49.942; 49.949; 49.95; 49.942; 49.945; 49.954; 49.943; 49.947; 49.962; 49.961; 49.96; 49.965; 49.968; 49.977; 49.981; 49.976; 49.98; 49.986; 49.974; 49.977; 49.98; 49.984; 49.968; 49.975; 49.988; 49.994; 49.997; 49.999; 49.996; 49.987; 49.992; 49.987; 49.978; 49.985; 50.002; 50.009; 50.003; 50.004; 50.017; 50.013; 50.006; 50.008; 50.003; 50.008; 50.021; 50.017; 50.022; 50.021; 50.016; 50.026; 50.028; 50.017; 50.007; 50.006; 49.998; 49.991; 50; 50; 49.989; 50.005; 50.015; 50.014; 50.008; 50.012; 50.011; 50.004; 50.015; 50.017; 50.018; 50.015; 50.014; 50.014; 50.026; 50.023; 50.033; 50.024; 50.022; 50.015; 50.021; 50.029; 50.028; 50.025; 50.019; 50.007; 50.016; 50.017; 50.023; 50.026; 50.027; 50.03; 50.022; 50.011; 50.014; 50.02; 50.015; 50.013; 50.011; 50.017; 50.008; 50.004; 50.004; 50.008; 50.001; 50.004; 50.01; 49.997; 49.99; 49.991; 50; 50.011; 50.016; 50.01; 50; 50.009; 50.005; 50; 50.003; 50.007; 49.996; 49.997; 50.001; 50.002; 50.001; 50.006; 49.996; 49.987; 49.985; 50; 50.001; 50.007; 50.013; 50.006; 50.005; 49.998; 49.992; 49.993; 49.987; 49.994; 50.008; 50.009; 50.006; 50.019; 50.005; 49.99; 49.984; 49.991; 50.001; 49.999; 49.994; 49.998; 50.007; 50.001; 50.011; 50.006; 50.005; 50.014; 50.011; 50.013; 50.015; 50.022; 50.015; 50.027; 50.024; 50.02; 50.02; 50.022; 50.014; 50.007; 50.019; 50.02; 50.016; 50.02; 50.012; 50.01; 50.008; 50.013; 50.012; 50.022; 50.025; 50.021; 50.021; 50.01; 50.012; 50.007; 50.003; 50.017; 50.013; 50.003; 50.014; 50.012; 49.992; 49.994; 50.005; 49.999; 49.991; 49.992; 50.005; 49.997; 49.995; 49.999; 49.987; 49.982; 49.979; 49.983; 49.994; 49.993; 49.991; 49.99; 49.997; 50.008; 50.004; 50.004; 50.001; 50; 50.003; 50.016; 50.012; 49.998; 49.995; 49.996; 49.996; 50; 50.005; 50.014; 50.013; 50.006; 49.996; 49.992; 50.003; 50.017; 50.005; 50; 50.008; 50.015; 50.017; 50.022; 50.003; 49.999; 50.011; 50.015; 50.008; 50.007; 50.001; 50.007; 50.019; 50.024; 50.024; 50.013; 50.016; 50.024; 50.024; 50.01; 50.004; 50.016; 50.02; 50.015; 50.02; 50.022; 50.015; 50.026; 50.016; 50.007; 50.004; 50.01; 50.004; 50.011; 50.016; 50.019; 50.023; 50.014; 50.022; 50.023; 50.017; 50.02; 50.022; 50.026; 50.021; 50.015; 50.005; 50.009; 50.014; 50.017; 50.019; 50.021; 50.025; 50.017; 50.002; 50.007; 50.003; 50.013; 50.009; 50.008; 50.022; 50.028; 50.028; 50.028; 50.028; 50.024; 50.015; 50.013; 50.022; 50.012; 50.004; 50.006; 50.009; 50.004; 50.009; 50.01; 50.017; 50.012; 50.012; 50.007; 49.998; 50.004; 50.009; 50.011; 49.999; 49.985; 49.991; 49.991; 49.982; 49.977; 49.964; 49.956; 49.952; 49.956; 49.952; 49.945; 49.944; 49.941; 49.94; 49.945; 49.957; 49.952; 49.954; 49.968; 49.955; 49.934; 49.946; 49.956; 49.957; 49.97; 49.962; 49.97; 49.967; 49.964; 49.967; 49.965; 49.973; 49.978; 49.97; 49.969; 49.971; 49.958; 49.961; 49.967; 49.963; 49.967; 49.964; 49.964; 49.976; 49.982; 49.983; 49.966; 49.972; 49.97; 49.954; 49.965; 49.969; 49.969; 49.967; 49.973; 49.97; 49.971; 49.983; 49.995; 49.994; 49.986; 49.989; 49.983; 49.982; 49.985; 49.976; 49.975; 49.972; 49.971; 49.979; 49.988; 49.982; 49.97; 49.97; 49.975; 49.974; 49.979; 49.976; 49.976; 49.974; 49.981; 49.985; 49.977; 49.983; 49.986; 49.976; 49.979; 49.983; 49.983; 49.989; 49.981; 49.976; 49.974; 49.98; 49.975; 49.963; 49.972; 49.966; 49.964; 49.978; 49.985; 49.978; 49.986; 49.988; 49.975; 49.981; 49.973; 49.965; 49.968; 49.983; 49.977; 49.983; 49.99; 49.988; 49.985; 49.98; 49.969; 49.979; 49.98; 49.989; 49.99; 49.98; 49.989; 50.007; 50.006; 50; 49.982; 49.991; 49.989; 49.994; 49.998; 50; 49.99; 49.987; 49.987; 50.001; 50.01; 50.002; 50.005; 50.001; 50.001; 50.006; 50.003; 50.006; 49.996; 49.995; 50.003; 50.011; 50.01; 50.013; 50.003; 49.998; 50.004; 50.009; 50.006; 50.009; 49.999; 49.995; 50.001; 50.016; 50.01; 50.01; 50.007; 50.006; 50.005; 49.999; 49.994; 49.993; 50.001; 50.012; 50.014; 50.02; 50.018; 50.009; 50.013; 50.008; 50.014; 50.016; 50.009; 49.999; 49.987; 49.994; 49.999; 49.997; 50.016; 49.999; 50.015; 50.006; 50.018; 50.017; 50.001; 49.999; 49.992; 49.998; 50.009; 50.015; 49.998; 49.992; 50.009; 50.015; 50.014; 50.016; 50.013; 50.02; 50.017; 50.01; 49.999; 49.998; 50.009; 50.013; 50.003; 50.013; 50.01; 50.005; 50.005; 50.013; 50.009; 50.014; 50.02; 50.021; 50.022; 50.019; 50.016; 50.012; 50.013; 50.019; 50.015; 50.016; 50.004; 49.995; 49.989; 49.999; 49.994; 49.989; 49.999; 50.025; 50.025; 50.008; 50.018; 50.011; 50.017; 50.018; 50.005; 50.017; 50.016; 50.01; 50.009; 50.014; 50.035; 50.028; 50.035; 50.027; 50.013; 50.012; 50.017; 50.016; 50.018; 50.028; 50.022; 50.03; 50.027; 50.028; 50.021; 50.024; 50.034; 50.015; 50.02; 50.025; 50.026; 50.025; 50.028; 50.012; 50.019; 50.022; 50.009; 50.011; 50.011; 50.011; 50.016; 50.023; 50.019; 50.007; 50.009; 50.008; 50.01; 50.012; 50.013; 50.021; 50.023; 50.031; 50.028; 50.034; 50.039; 50.033; 50.035; 50.045; 50.046; 50.045; 50.043; 50.041; 50.038; 50.038; 50.033; 50.031; 50.034; 50.029; 50.037; 50.033; 50.047; 50.046; 50.044; 50.044; 50.048; 50.054; 50.041; 50.032; 50.041; 50.037; 50.031; 50.031; 50.033; 50.045; 50.049; 50.046; 50.033; 50.033; 50.037; 50.046; 50.04; 50.042; 50.041; 50.037; 50.04; 50.044; 50.04; 50.045; 50.045; 50.047; 50.058; 50.062; 50.049; 50.047; 50.043; 50.047; 50.038; 50.039; 50.036; 50.049; 50.043; 50.042; 50.038; 50.048; 50.044; 50.029; 50.038; 50.044; 50.034; 50.03; 50.037; 50.029; 50.032; 50.025; 50.017; 50.019; 50.005; 49.994; 49.991; 49.98; 49.981; 49.978; 49.973; 49.974; 49.984; 49.973; 49.981; 49.98; 49.977; 49.97; 49.974; 49.971; 49.98; 49.977; 49.97; 49.954; 49.964; 49.96; 49.966; 49.965; 49.972; 49.97; 49.969; 49.978; 49.975; 49.967; 49.982; 49.975; 49.978; 49.974; 49.975; 49.978; 49.984; 49.985; 49.987; 49.978; 49.98; 49.984; 49.984; 49.992; 49.992; 49.99; 49.993; 50.004; 49.989; 49.99; 49.98; 49.99; 49.988; 49.992; 49.984; 49.977; 49.977; 49.984; 49.991; 49.991; 49.987; 49.98; 49.984; 49.982; 49.979; 49.995; 49.994; 49.989; 49.993; 49.988; 49.983; 49.975; 49.974; 49.982; 49.981; 49.981; 49.975; 49.988; 49.991; 50.002; 50.003; 49.994; 50.004; 50.007; 50.01; 50.004; 49.993; 50.001; 50.013; 50.02; 50.022; 50.015; 49.998; 49.996; 49.991; 49.998; 50.014; 50.009; 50.011; 50.003; 50.008; 49.995; 49.994; 49.994; 49.984; 49.991; 50.01; 50.007; 50.004; 50.016; 50.009; 50.013; 50.015; 50.013; 50.014; 50.011; 50.005; 50.011; 50.011; 50.005; 50.01; 50.013; 50.015; 50.014; 50.017; 50.012; 50.008; 50.003; 50.006; 50.003; 49.999; 49.999; 50.007; 50.007; 50.004; 50.004; 50.001; 49.993; 49.993; 49.986; 49.984; 49.989; 50.018; 50.015; 49.998; 50.006; 50.007; 50.011; 50.014; 49.997; 50; 50.005; 50.016; 50.02; 50.02; 50.017; 50.01; 50.011; 50.014; 50.003; 49.995; 49.989; 49.984; 49.994; 49.996; 49.99; 49.991; 49.995; 50.001; 49.992; 49.989; 49.993; 49.996; 49.994; 50.002; 49.997; 49.985; 49.99; 49.99; 49.982; 49.982; 49.987; 49.982; 49.978; 49.989; 49.983; 49.985; 49.983; 49.997; 49.998; 49.989; 49.998; 50.001; 50; 50.008; 49.998; 50.001; 50.012; 50.025; 50.014; 50.015; 50.01; 50.011; 50.01; 50.009; 50; 49.994; 49.999; 50; 50.011; 50.017; 50.016; 50.036; 50.026; 50.017; 50.011; 50.012; 50.009; 50.014; 50.009; 50.019; 50.01; 50.008; 50.01; 50.013; 50.016; 50.016; 50.012; 50.004; 50.009; 50.014; 50.003; 49.993; 49.998; 49.994; 49.988; 49.999; 49.998; 49.993; 50.005; 50.026; 50.011; 50.012; 50.006; 50.002; 50.006; 50.007; 50.017; 50.015; 50.017; 50.017; 50.014; 50.019; 50.024; 50.024; 50.028; 50.021; 50.016; 50.016; 50.019; 50.021; 50.026; 50.03; 50.019; 50.032; 50.029; 50.031; 50.041; 50.031; 50.025; 50.028; 50.026; 50.021; 50.032; 50.035; 50.029; 50.027; 50.026; 50.017; 50.02; 50.017; 50.014; 50.026; 50.024; 50.021; 50.017; 50.024; 50.016; 50.032; 50.026; 50.014; 50.019; 50.026; 50.02; 50.021; 50.026; 50.041; 50.021; 50.022; 50.012; 50.019; 50.018; 50.019; 50.02; 50.021; 50.025; 50.017; 50.021; 50.011; 50.01; 50.007;

50.005; 50.005; 49.997; 49.992; 50.006; 49.996; 49.998; 50; 50.002; 49.999; 50.006; 50.007; 50.006; 49.995; 50.002; 50.004; 50.005; 50.009; 50.01; 50.011; 50.008; 50.01; 50.005; 50.003; 50.004; 50.003; 50.008; 50.009; 50.003; 50.007; 50.003; 50.003; 49.99; 49.994; 49.997; 49.997; 50.006; 50.001; 50.004; 50.01; 50.003; 49.986; 49.989; 49.993; 49.992; 49.994; 49.986; 49.991; 49.991; 49.991; 49.993; 49.979; 49.974; 49.979; 49.965; 49.974; 49.971; 49.991; 49.983; 49.978; 49.969; 49.976; 49.974; 49.986; 49.988; 49.996; 49.997; 49.999; 50; 49.987; 49.989; 49.992; 49.989; 49.993; 49.996; 49.992; 49.999; 50.007; 50.005; 50.007; 49.999; 49.991; 49.995; 50.001; 50.008; 50.006; 50.001; 50.006; 50; 50.012; 50.01; 50.003; 50.008; 50.005; 49.993; 50.006; 50.007; 50.011; 50.004; 49.997; 50.002; 50.01; 50.005; 50.006; 50.008; 50.021; 50.022; 50.017; 50.026; 50.03; 50.017; 50.018; 50.006; 50.011; 50.002; 49.988; 49.985; 49.996; 49.998; 50.007; 50.008; 50.01; 50.003; 49.995; 49.989; 50.006; 50.005; 49.998; 50.004; 50.003; 49.999; 49.998; 49.989; 49.988; 49.985; 49.992; 49.995; 49.99; 50.001; 50; 49.996; 50.001; 50.012; 50.017; 50.005; 50.003; 49.996; 49.998; 49.989; 49.989; 49.995; 49.99; 49.986; 49.994; 50.003; 49.995; 49.992; 50.001; 49.993; 49.989; 49.993; 49.996; 50.003; 50.008; 50.001; 49.995; 49.987; 49.993; 50.012; 50.003; 50.006; 50.006; 50.001; 50.011; 50.015; 50.009; 50.009; 49.999; 50; 50.002; 50.002; 49.999; 50.002; 50.007; 50.004; 49.997; 49.991; 50.007; 50; 49.991; 50.005; 50.022; 50.01; 50.016; 50; 49.995; 49.993; 50.012; 50.006; 50.006; 50.008; 50.019; 50.014; 50.012; 50.007; 50.006; 50.004; 50.014; 50.008; 49.998; 50.001; 50.018; 50.003; 50.004; 50.011; 50.003; 49.998; 49.999; 49.995; 49.997; 49.998; 50.007; 50.006; 50.018; 50.007; 50; 49.991; 49.991; 49.997; 50.003; 50.008; 50.012; 50.002; 50.004; 50.012; 50.009; 50.01; 50.009; 50.005; 50.015; 50.015; 50.012; 50.011; 50.018; 50.01; 49.995; 50.006; 50.02; 50.008; 49.998; 50.014; 50.011; 50.009; 50.008; 50.012; 49.997; 50.001; 50.012; 50.001; 49.999; 49.996; 49.996; 50.009; 50.006; 49.996; 49.994; 49.991; 50.001; 50.001; 49.998; 49.992; 49.997; 50.016; 50.008; 50.006; 50.007; 50.007; 50.006; 50.015; 50.004; 49.981; 49.985; 49.992; 49.99; 50.004; 50.007; 50.001; 49.998; 49.988; 49.997; 49.995; 49.994; 50.003; 50.002; 50; 50.013; 50.013; 49.998; 49.991; 50.01; 50.015; 50.006; 50.007; 50.009; 50.014; 50.008; 50.007; 50.001; 50.006; 50.009; 50.002; 49.996; 49.993; 49.991; 50.003; 50.002; 49.995; 49.998; 50.005; 50.011; 50.004; 50.001; 50.004; 50.008; 50.015; 50.015; 50.017; 50.024; 50.02; 50.011; 50.01; 50.01; 50.013; 50.01; 50.004; 49.995; 50.003; 50.011; 50.014; 50.015; 50.001; 50.01; 50.01; 50.009; 50.003; 49.996; 49.995; 49.989; 50.011