Technical standard for monitoring the compliance of power generating modules according to P.O. 12.2 SENP

Review	Reason	Date	Comments
1.0	Publication	3/11/2020	English version contains Corrigendum to Spanish version 1 published on 13/4/2021.
1.1	Publication	9/7/2021	Relevant modifications to version 1

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1. INTRODUCTION

This procedure for assessing the requirements for grid connection[1] of generators, called **Compliance Monitoring Technical Standard** (hereinafter **Technical Standard**), explains the process for verifying compliance with the technical requirements of **P.O. 12.2 SENP** [1] by the power generating modules (**PGMs**) resulting from the application of RD 647/2020 [3].

This **Technical Standard** shall enter into force at the date of its publication and shall cease to be in force after a **transitional period of 12 months** following the publication of a new version of this **Technical Standard**. In the event of any substantial amendment to the previous regulation, network operators reserve the right to modify the duration of this transitional period.

PGM certificates for requirements, issued according to version 1.0 of this **Technical Standard**, shall be accepted for the purpose of obtaining the **final PGM certificate** according to this version of the **Technical Standard**, as specified in the equivalences in **Table 45**.

[1] The scope of this **Technical Standard** is different from the Access and Connection criteria used to determine the network connection point. Both documents regulate different aspects.

Important:

- This **Technical Standard** may always be modified and updated by the Monitoring Working Group (**GTSUP**), after its publication on the web of the system operator and the web of the Distribution System Operators.
- It is always recommended to consult the current version of this **Technical Standard** before starting the process of assessing the technical requirements of an **PGM**. Assessment by a non-current **Technical Standard** may be grounds for refusal of the **PGM** compliance assessment procedure by the Relevant System Operator (**RSO**).
- Any information received, exchanged or transmitted under this **Technical Standard** shall be subject to confidentiality by the subjects involved in monitoring compliance and shall be subject to professional secrecy and an obligation of confidentiality. Such persons shall ensure the confidentiality of such information and shall take all necessary measures to that end, being liable for the consequences of non-compliance.
- It is the responsibility of the **PGM owner** to keep all the information and documentation included in this **Technical Standard** during the entire lifetime of the PGM.
- **Disclaimer:**
    - In the event of any inconsistency or discrepancy between the Spanish version and the English version of this document, the Spanish version will prevail.
    - For the avoidance of the doubt, commas will be used for decimal separation in this **Technical Standard**.

2. DEFINITIONS

In addition to the definitions in Article 8.1 of [1] and of **Technical Standard NTS SEPE** [2], the following definitions shall be used in this **Technical Standard**:

1. **“NCP”:** For the purposes of this **Technical Standard**, the term NCP, Network Connection Point, shall be used to refer to PART, Technical Requirements Application Point, as defined in [1].

3. APPLICATION

This **Technical Standard** applies to all **PGMs** resulting from **P.O. 12.2 SENP** [1], i.e.:

- Power generating facilities connected to the Non-Peninsular Transmission system (**SENP**).
- Power generating facilities connected to the distribution system with significant involvement in the transmission system[2] as defined in [1].

Similarly, **PGMs** are divided into power park modules (**PPMs**) and synchronous power-generating modules (**SPGMs**).

Without prejudice to the provisions of this **Technical Standard**, system operators (**TSO**, **RSO** or **DSO**) may, in accordance with the regulation in force, perform or require additional tests and simulations of **PGMs** to verify compliance with any of the technical requirements established in the regulation in force ([1], [3] or regulation replacing or supplementing it) before they are commissioned or at any time during their entire lifetime. In particular, it will be necessary to carry out the tests stipulated by the system operator in accordance with the test protocols established in the regulations in force at the time of commissioning of the **PGM**.

[2] In **P.O 12.2 SENP,** generators or aggregations of generators whose recorded nominal power is greater than or equal to 1 MW per associated node of the transmission grid shall be considered, provided that such condition is caused by generation quotas equal to or greater than 100 kW that share a connection node to the distribution network, including existing generators within that quota.

4. COMPLIANCE ASSESSMENT PROCEDURE

The purpose of compliance assessment is to obtain a **final PGM certificate**.

4.1. General aspects

Compliance assessment of each requirement may be carried out by:

- **Compliance tests (T)**: **PGM compliance tests for each requirement** shall be carried out by an **accredited entity** which shall prepare a test report and send the results to an **authorised certifier** for assessment. For each requirement, compliance by the **PGM** or the **PGU**, as applicable, shall be assessed and the corresponding **certificate of compliance by test for each requirement** or written compliance from the **RSO**, as applicable, shall be issued.
- **Compliance simulations (S)**: the **PGM compliance simulations for each requirement** shall be carried out, as a general rule, by an **accredited entity**, from the model certified in accordance with section 6 of this **Technical Standard**. The **accredited entity** shall prepare a report on the simulations and send the results to an **authorised certifier** for assessment. For each requirement, compliance of the **PGM** or **PGU**, as applicable, shall be assessed and the corresponding **certificate of compliance by simulation for each requirement** shall be issued.
- **Equipment certificates (C)**: the **compliance assessment of the PGM for each requirement** may be carried out through **equipment certificates** – based on **PGU** and **ACPGM** tests – issued by an authorised **certifier, taking into account that**:
    - The availability of the **equipment certificates** of all **ACPGMs** and **PGUs** does not always imply automatic compliance of the **PGM** (as a whole), since:
        - The collection of **equipment certificates** (**PGU** and **ACPGM**) does not always guarantee compliance with the technical requirements at the **NCP**, therefore, depending on the technical requirement to be assessed, it shall be necessary, in general, to perform **supplementary simulations**[3].
        - The **DSO or TSO**, as appropriate, may require the assessment, by test or simulation, of certain technical requirements at **PGM** level. In such cases, if the result of the assessment is satisfactory, the **DSO or TSO** shall notify the **PGM owner** by a **letter of compliance from the DSO or TSO** that the **PGM** complies with the requirement in question. Such compliance shall be attached by the **authorised certifier** in the **final PGM certificate**, where applicable.
    - The validity of the **equipment certificates** of the **PGUs** and **ACPGMs** is conditional on the non-modification, after the certification, of the parameters used in the assessment process that have a relevant impact on the control

[3] **Supplementary simulations** specified in some of the technical requirements to be assessed in section 5 shall require the use of a certified model in accordance with section 6 but shall not be required to be carried out by an **accredited entity**; however, they must be referred to the **authorised certifier** for assessment. Supplementary simulations shall consider the active and reactive power capabilities of the inverter when the ambient temperature is the PGM maximum design temperature, which shall be defined by the **PGM owner**, so that the inverter power shall not exceed these values.

functionalities necessary to comply with the requirements of this **Technical Standard**.

The compliance assessment shall be carried out at a nominal frequency of 50 Hz.

Table 1 specifies the technical requirements to be assessed and the possible type of assessment(s) according to the type of **PGM** to obtain the **Final PGM Certificate**, as well as the sections of this **Technical Standard** and the corresponding articles of [1]:

REQUIREMENT			TYPE OF ASSESSMENT	
Article [1]	**Definition of Requirement**	**Subsection of the Technical Standard**	**PPM**	**PGMS**
8.2.3	Limited Frequency Sensitive Mode - Overfrequency (LFSM-O)	5.1	(S and T) or C**	(S and T) or C**
8.2.4	Limited Frequency Sensitive Mode -Underfrequency (LFSM-U)	5.2	(S and T) or C**	(S and T) or C**
8.2.5	Frequency Sensitive Mode (FSM)	5.3	(S and T) or C**	(S and T) or C**
8.2.2 (c)	Capability to limit production up and down ramps	5.4	T	T
8.2.2 (a)	Remote power control capability and range	5.5	T or C	T or C
8.4.1	Synthetic inertia during very fast frequency variations*	5.6	S	N/A
8.3.1 (b)	Reactive power capability at maximum capacity	5.7	N/A	(T) or C**
8.3.1 (c)	Reactive power capability below maximum capacity	5.7	N/A	(T) or C**
8.4.2 (a)	Reactive power capability at maximum capacity	5.7	(T) or C**	N/A
8.4.2 (b)	Reactive power capability below maximum capacity	5.7	(T) or C**	N/A
8.4.2 (c)	Reactive power control modes	5.8	T or C**	N/A
8.3.1 (f)	Power oscillation damping control	5.9	N/A	S or C
8.4.2 (d)	Oscillation damping control	5.10	S or C	N/A
8.4.3 (a) and (b)	Fast fault current injection at the connection point in case of balanced (3-phase) faults and in case of unbalanced (1-phase or 2-phase) faults	5.11	T (S***) or C**	N/A
8.4.3 (d), (e) and (f)	Fault Ride Through capability of PPMs	5.11	T (S***) or C**	N/A
8.4.3 (g) and (h)	Transient overvoltage withstand capability of PPMs	5.11	T (S***) or C**	N/A

Table 1. Assessment of technical requirements as defined in this Technical Standard.

Legend:

- In column "Form of Assessment": **S** means compliance simulation, **T** means compliance test, **C** means equipment certificate and **N/A** means does not apply.
- *: Requirement not mandatory according to [1].
- **: **Supplementary simulations** may be required for assessment purposes, as described in the relevant subsection of this **Technical Standard**.
- ***: In the cases specified as T (S***), the test shall be performed in PGU and, if it is unsuccessful, the simulation of the whole PGM shall be performed, incorporating the ACPGM that enables the pertinent requirement to be met.

For any requirements where there are several methods for assessing compliance ("Type of Assessment" column in **Table 1**), the **PGM owner**[4] **shall be entitled to choose the form in**

[4]**P.O. 12.2 SENP** defines the "**power generation facility owner**" as the natural or legal entity owning a power generation facility

which it is assessed. In any event, the **final PGM certificate** shall always incorporate the assessment methodology followed for each requirement assessed.

The **PGM owner** shall request authorisation from the **RSO** prior to performing the tests with the connected **PGM**.

At the time of the initial assessment of a **PGM** and throughout its lifetime, network operators may request the **PGM owner** to submit the entire technical certification dossier, i.e. documentation related to tests and simulations carried out by **accredited entities** and **authorised certifiers** in the **PGM** compliance assessment process.

The general compliance assessment scheme is shown in **Figure 1**, and can be divided into two stages, prior to the commercial operation of the **PGM**: 1) Obtaining **equipment certificates**, i.e. from **PGU** and **ACPGM**, constituting the **PGM**; 2) Obtaining the **final PGM certificate** and issuing the corresponding **final operational notification (FON)**, which, together with other information, technical and operational requirements, qualify for the third stage, which is the commercial operation of the **PGM**.

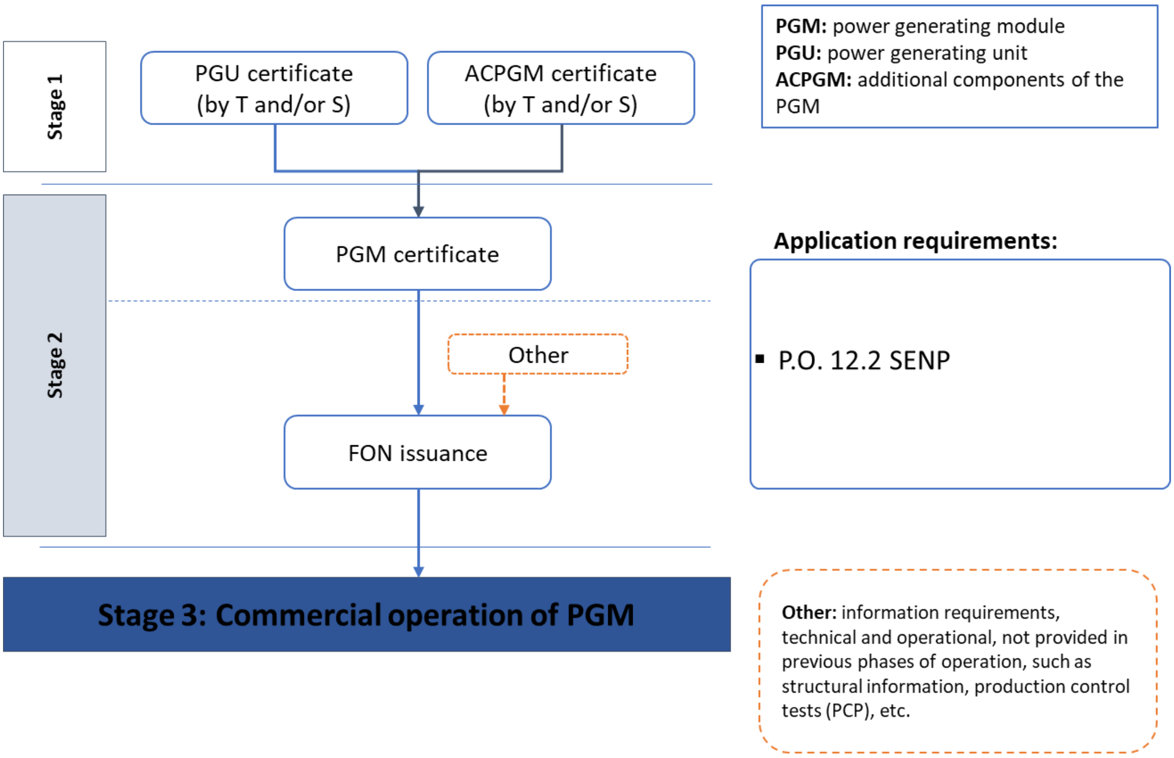


Figure 1. Stages in the general monitoring scheme.

The general scheme of stage 1 is shown in
Figure 2 and **Figure 3**:

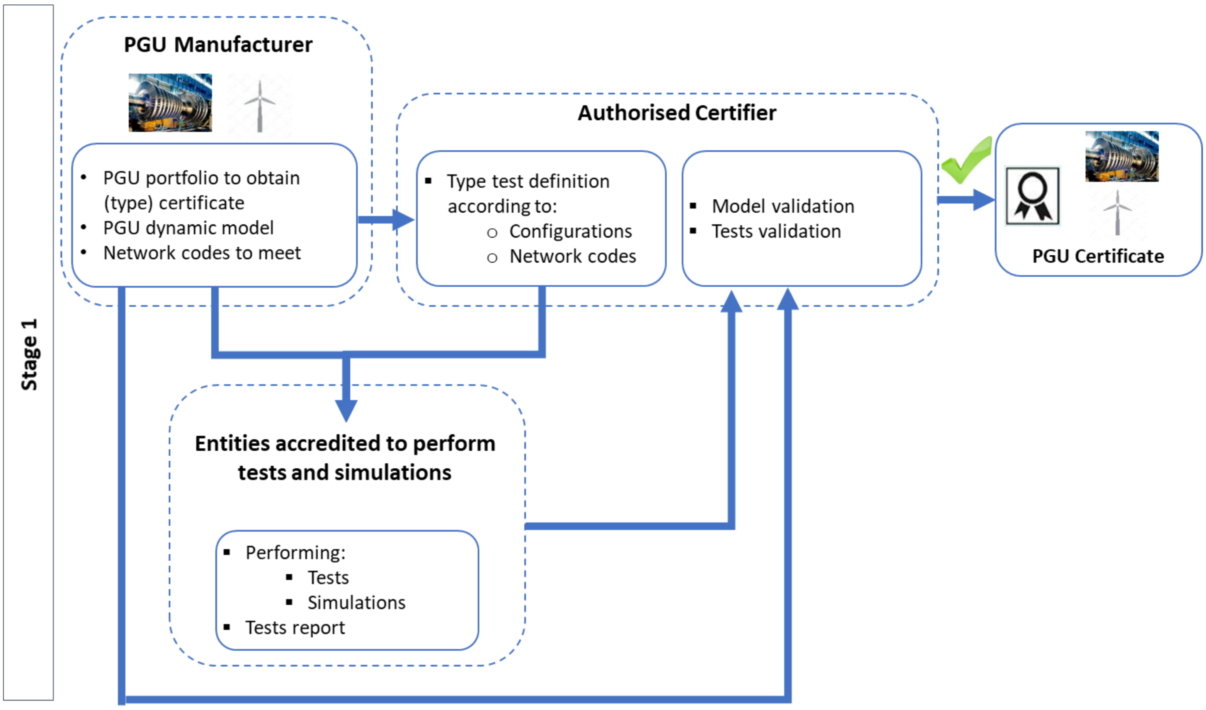


Figure 2. Scheme for obtaining the PGU certificate.

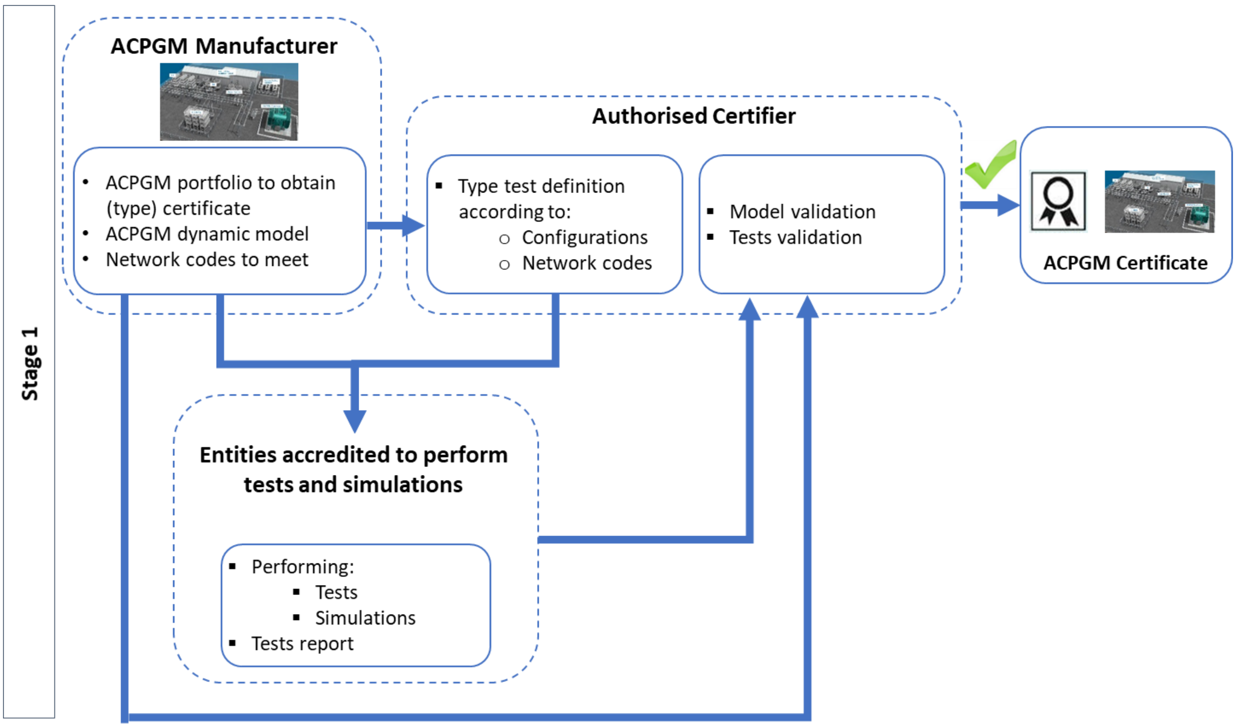


Figure 3. Scheme for obtaining the ACPGM certificate.

The general scheme of stage 2 is shown in **Figure 4**:

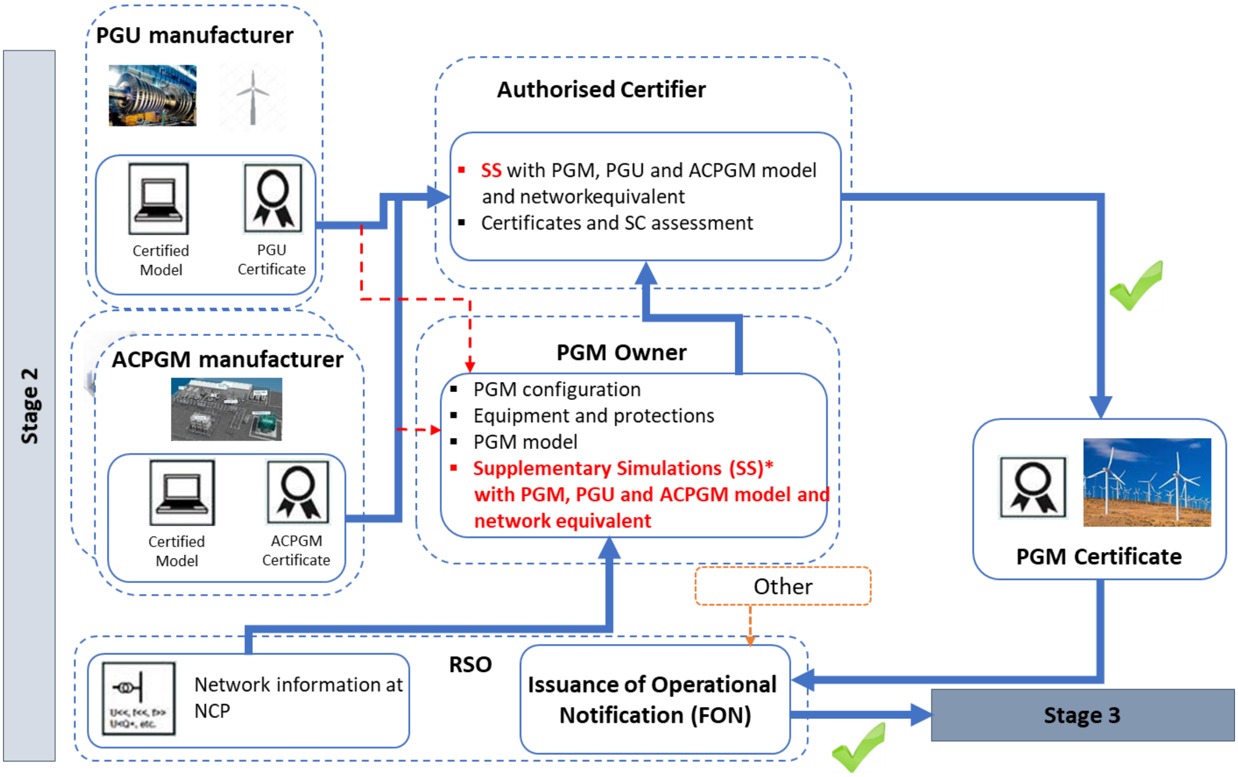


Figure 4. Scheme for obtaining the final PGM certificate from equipment certificates.

The following subsections elaborate on the schemes described in the figures in this subsection.

4.1.1. Final PGM Certificate

The **final PGM certificate** shall be issued by an **authorised certifier and shall specify that the PGM complies with all requirements to be assessed.** The **PGM owner** shall provide it to the **RSO**.

The **PGM owner** shall be entitled to obtain separately, through different **authorised certifiers**, the compliance certificate for each of the requirements applicable to it pursuant to **Table 1.** In such cases, the **final PGM certificate** must clearly indicate which **authorised certifier** has certified each of the requirements. Where the **RSO** grants the compliance to a requirement, the **PGM owner** shall provide the **authorised certifier** with such compliance and the **authorised certifier** shall attach the written compliance from the **RSO** to that requirement in the **final PGM certificate** (see subsection 4.1).

Figure 5 schematically represents the elements that make up the **final PGM certificate**:

1) For each technical requirement, the equipment manufacturer (**PGU and ACPGM**) shall provide the **certificates**, by simulation and/or test, which shall have been previously issued by an **authorised certifier**. The assessment of these technical requirements shall be carried out by the **authorised certifier** using **supplementary simulations**, in addition to **equipment certificates**, where applicable.

2) For any requirements assessed by the **DSO or TSO**, as appropriate, the latter shall send a written communication in accordance with the **PGM owner**, or the entity designated by the **PGM** (e.g. the manufacturer of **PGU** or **ACPGM**), if the assessment is favourable. It will be necessary for the owner to provide this written communication to the **authorised certifier** for inclusion in the **final PGM certificate**, for any requirements that need to be incorporated into the **final PGM certificate** and that are indicated in **Figure 5**. In particular, requirements related to oscillation damping (subsections 5.9 and 5.10) shall be assessed by the **TSO** but shall not form part of the **final PGM certificate**.

3) The **authorised certifier** responsible for issuing the **final PGM certificate** shall assess all **PGM** certificates for compliance. For any mandatory requirements, the **authorised certifier** may issue the **final PGM certificate** when it has all the relevant certificates and notifications of compliance from the **RSO**.

4) Derogations from the compliance with technical requirements which have been provided to the **PGM owner**.

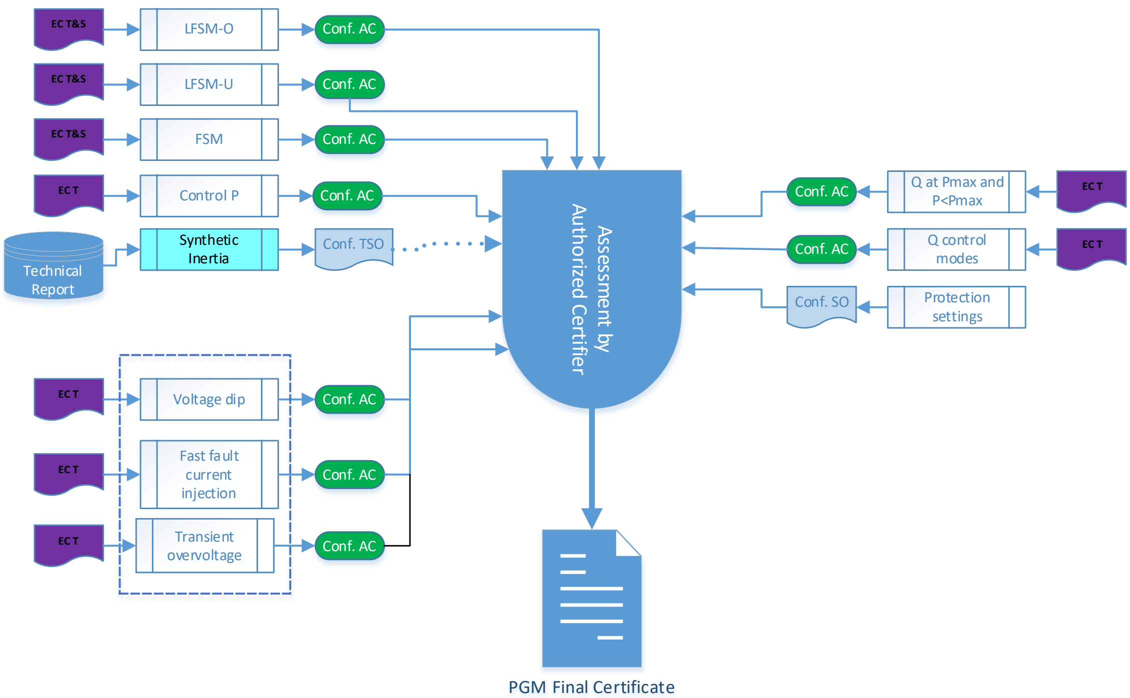


Figure 5. Scheme for obtaining the final PGM certificate from equipment certificates.

Figure 6 shows the general procedures that a **PGM** may follow for the compliance assessment of a given requirement, as described in section 5 of this **Technical Standard**. **Figure 7** details the complete process to be followed by a **PGM** for each requirement to be assessed.
The **PGM** owner may use **equipment certificates** provided by the **PGU** and/or **ACPGM manufacturer**, issued by an **authorised certifier** pursuant to this **Technical Standard**, to demonstrate compliance with a requirement (CAP by C). In these cases, the tests and simulations indicated in the assessment procedure by test (CAP by T) and simulation (CAP by S) shall be required.

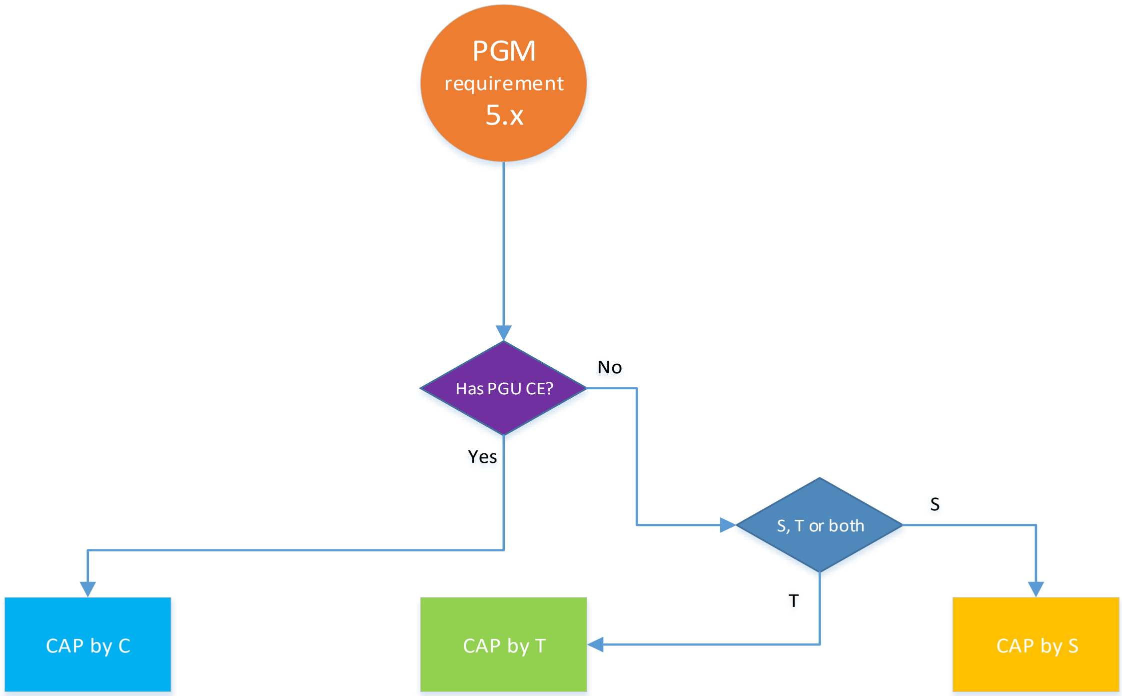


Figure 6. Compliance Assessment Procedures (CAP). General.

The details of the compliance assessment procedures (CAP) – certificate, test and simulation – are described in subsections 4.1, 4.2 and 4.3, respectively, and **Figure 7** illustrates the entire assessment process that an **PGM** shall follow for each technical requirement.

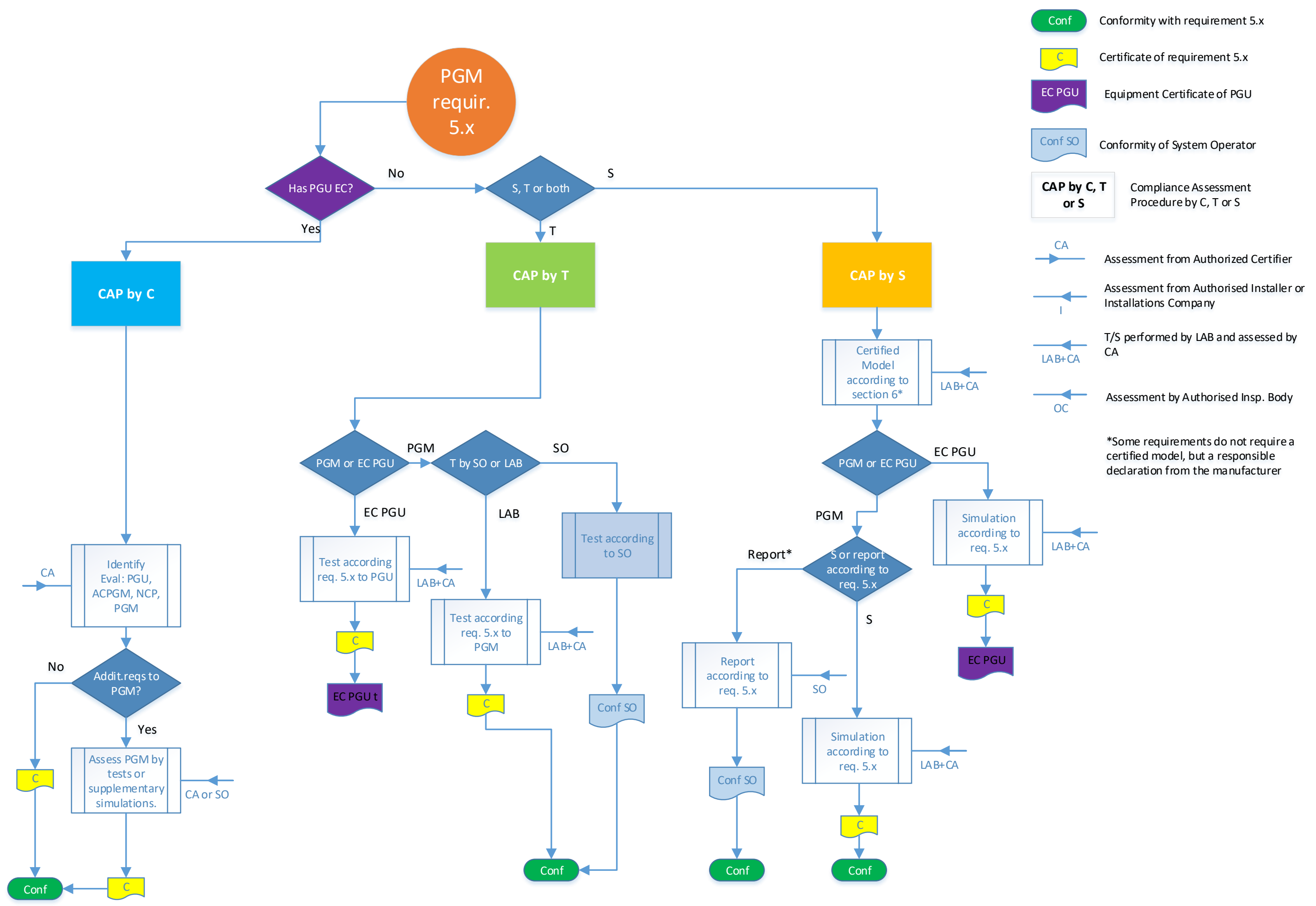


Figure 7. Compliance assessment procedures. Detailed.

4.2. Compliance assessment procedure by equipment certificate (CAP by C)

PGMs are composed of **PGUs** and **ACPGMs** (FACTS devices, **PGM** level controls, etc. that may affect compliance with the requirements of the **PGM**. If **ACPGMs** could affect compliance with a **PGM** requirement, they must be taken into account when assessing their compliance. In such cases, it will be necessary to have **equipment certificates of all these ACPGMs** in order to issue the **certificate of compliance with an PGM requirement**.

PGU manufacturers may obtain **equipment certificates** through the tests and simulations stipulated in section 5. Moreover, **ACPGM** manufacturers may obtain equipment certificates through the tests and simulations stipulated in subsection 4.6. Such **equipment certificates** shall subsequently be provided to the **owners** of the **PGMs. Figure 8** details the procedure to obtain **the PGM certificate for a requirement:**

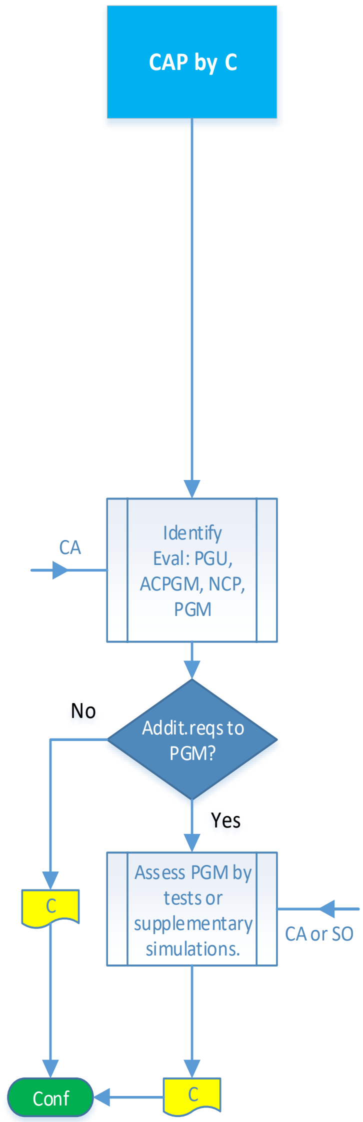


Figure 8. Compliance assessment procedure by equipment certificate (CAP by C)

The compliance assessment by **equipment certificate** according to the significance of the **PGM** is specified below, but the last paragraph of section 3, related to the capabilities of the **RSO** to carry out the checks that are necessary in accordance with the legislation in force, must be taken into account.

4.2.1. Assessment of PGMs

The **compliance assessment of each requirement for PGMs** may be performed using the following methods, taking always into account **Table 1.**

4.2.1.1. Compliance assessment by certificate.

Compliance assessment through equipment certificates shall be carried out as follows:

1) The **authorised certifier** shall identify the components of the **PGM** that may affect the requirement to be assessed: **PGU, ACPGM** and other elements (generation transformer, cables, lines, etc.).

2) Compliance assessment stages for each requirement of **Table 1**:

1. **Assessment of each PGU**: The **PGU** shall be checked to be the same as that stated in the **equipment certificate** or belong to the same type (see subsection 4.5), also checking the consistency with its **firmware** and **software** version.
2. **Assessment of ACPGMs**: The **ACPGMs** shall be checked to be the same as that stated in the **equipment certificate** or belong to the same type (see subsection 4.6), also checking the consistency with its **firmware** and **software** version.
3. Assessment of the remaining elements from **BC** of the **PGM** up to the **NCP**. It shall be assessed by the authorised certifier, on a documentary basis, whether it is equipped, as well as other power elements (transformers) up to the **NCP**, have an impact on the assessment of technical requirements and shall be appropriately modelled in the compliance simulations.
4. **Assessment of the PGM as a whole**: It shall encompass all of the above points.

3) For **PGM** connecting to the **distribution network**:

a. As a prerequisite for requesting the energisation of the **PGM** to the **DSO**, it should be reviewed that the implemented settings comply with the "*Acuerdo sobre ajustes de los sistemas de protección y control adecuados al punto de conexión entre el gestor de red pertinente y el propietario de la instalación de generación de electricidad*" [3] and a **Protection review report** made by an **Authorised inspection body**[5], shall be provided according to the minimum content specified in subsection 7.1.5 of [2].

b. For the **final certificate of PGM**, the **authorised certifier** shall check the compatibility of the settings as described in point 4) below. For this check, the **authorised certifier** may use the **Protection review report**, as referred to in paragraph 2) above, or other information.

[5] Protection systems are regulated by electrotechnical codes (Reglamentos electrotécnicos). Paragraph 3 of ITC-RAT-22 provides for its inspection by an authorised inspection body.

For **PGM** connecting to the **transmission grid**, the implementation of the settings of the protection systems requiring coordination with the transmission grid protections shall be provided by the **PGM owner** to the **TSO** and shall be reviewed by the **TSO**, in accordance with the provisions of procedimiento de operación 11.1 **"Criterios generales de protección en la red gestionada"**.

4) For **PGM** connected to either the **transmission grid** or the **distribution grid**, the **PGM owner** shall submit to the **authorized certifier** the settings or voltage and frequency functions or relays of the **PGM** that may exist. The **authorized certifier** shall verify their compatibility with the non-disconnection requirements set out in [1] below:

- Frequency and time settings compatible with the established in Table 1 of article 8.2.1 of [1].
- Voltage and time settings compatible with the established in Table 4 of article 8.2.6 of [1].
- Combined voltage and time settings compatible with the corresponding **PGM** fault ride through profile as specified in article 8.4.3 of [1].
- Combined voltage and time settings compatible with the corresponding **PGM** transient overvoltage settings, as specified in article 8.4.3 of [1].

This information shall be reflected in the **final PGM certificate**, in subsection 7.1.1.

5) In addition, for any technical requirements in section 5 of the **Technical Standard** in which the required collection of **equipment certificates** of the **PGUs** and **ACPGMs** is not sufficient, assessment at the **PGM** level shall be required by tests and/or **supplementary simulations** under the conditions established for each requirement.

In any case, for the **issuance of the final PGM certificate**, the requirements specified in subsection 4.1.1 shall be met.

4.2.1.2. Compliance assessment by test and/or simulation.

The **procedure for assessing the compliance of a technical requirement by test and/or simulation** shall have as its objective one of the following two points:

- Directly obtaining compliance with this requirement for the **PGM** by test and/or simulation; or
- obtaining the **equipment certificate** of the **PGU** for such requirement by test and/or simulation.

4.3. Compliance assessment procedure by test (CAP by T)

The **procedure for assessing the compliance of a technical requirement by test** shall aim to one of the following two points:

- To directly obtain compliance with this requirement for the **PGM** by test; or
- to obtain the **equipment certificate** of the **PGU** for such requirement by test.

Figure 9 details the test procedure to be followed to obtain the **final PGM certificate** for a requirement:

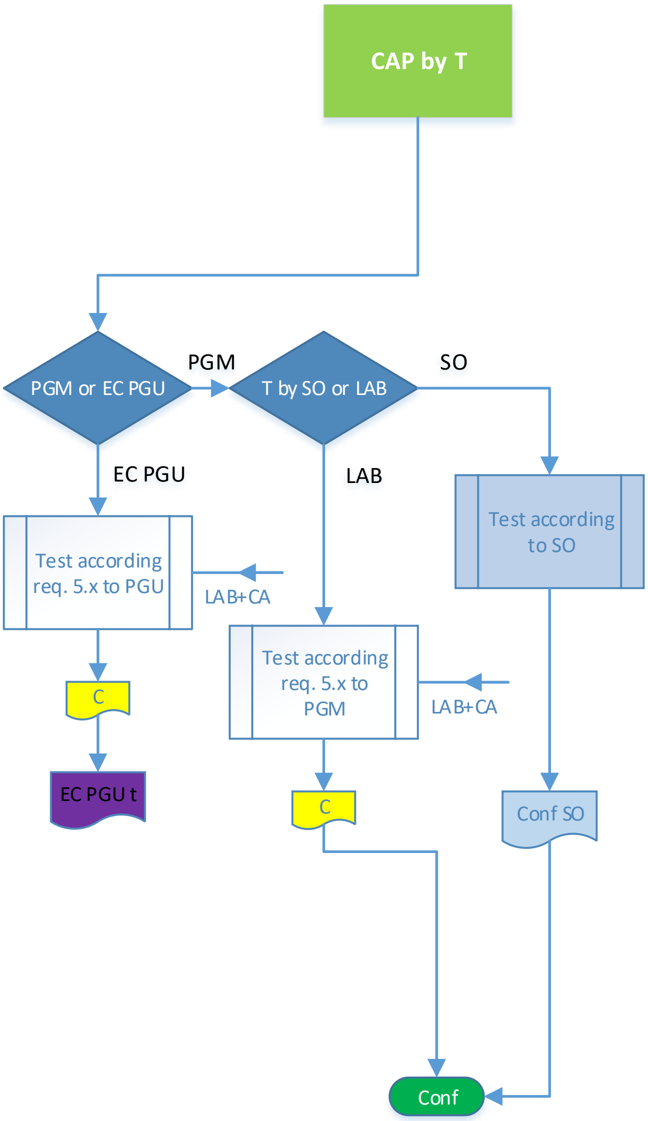


Figure 9. Compliance assessment procedure by test. (CAP by T).

Unlike the compliance assessment procedure by certificate, no differentiated procedures are established according to the significance of the **PGM**. In this case, the **compliance assessment through tests** shall be carried out as follows:

1) <u>The **authorised certifier** shall identify the components of the **PGM**</u>: They shall identify the **PGUs, ACPGMs** and other elements (generation transformer, cables, lines, etc.)

that may affect the technical requirement to be assessed. These elements shall be taken into account when conducting the tests.

2) The test of each requirement shall be carried out by the **accredited entity** or the **DSO or TSO**, as appropriate, and may refer to:

- **PGM** in the field: The tests described in section 6 of this **Technical Standard** shall be performed. It must be specified whether the tests are performed by the **accredited entity** or the **DSO or TSO**, as applicable**.** In the first case, the test results shall be incorporated into a test report for assessment by the **approved certifier**. In the latter case, the **DSO or TSO**, as appropriate**,** shall assess the results and notify the **PGM owner** in writing of the compliance of the **PGM** with the requirement in question, without the reference to that statement being required to be included in the final certificate.
- **PGU**: The tests shall be performed on the **PGU** in order to obtain a **PGU equipment certificate** by test for a specific requirement.
- **ACPGM**: The tests shall be performed on the **ACPGM** and associated **PGU** in order to obtain an **ACPGM equipment certificate (for a given PGU)** by test for a given requirement.

3) The **authorised certifier** shall assess the results of the tests carried out by the **accredited entity** and, if the assessment is positive, issue a **PGU equipment certificate** or a **PGM certificate** for the technical requirement by the **PGM**.

In any case, for the **issuance of the final PGM certificate**, the requirements specified in subsection 4.1.1 shall be met.

4.4. Compliance assessment procedure by simulation (CAP by S)

The **procedure for assessing the compliance of a technical requirement by simulation** shall aim to one of the following two points:

- To obtain compliance with this requirement for the **PGM** by simulation; or
- to obtain the **equipment certificate** of the **PGU or an ACPGM** for such requirement by simulation.

Figure 10 details the simulation procedure to obtain the **PGM certificate** for a requirement:

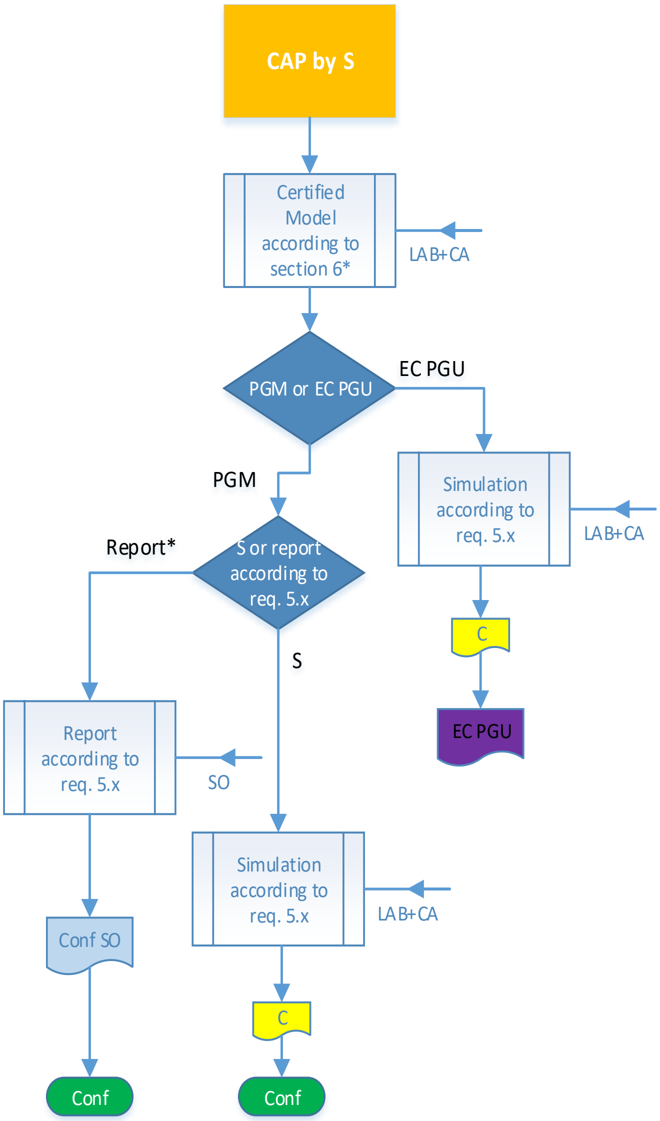


Figure 10. Compliance assessment procedure by simulation. (CAP by S).

Compliance assessment through simulations shall be carried out as follows:

1) Firstly, it will be necessary to have a **PGM**, **PGU** and **ACPGM** model certified by an **authorised certifier** as set out in section 6 of the **Technical Standard**. The

characteristics of the model for each requirement to be assessed are stated in section 6.

2) The **simulation of a requirement** shall be performed by the **accredited entity**, with the exception of **supplementary simulations**, and may relate to:

- **PGM**: The **simulations** described in section 6 of the **Technical Standard** shall be performed, and according to the specifications therein, the following shall be done:
  - If the **authorised certifier** requires simulations from an **accredited entity**, they shall be incorporated into a **simulation report** for further assessment.
  - If the **RSO** requires a report from the **accredited entity or the entity designated by the PGM (which could be the manufacturer), the RSO** shall be the one to assess and notify the **PGM owner** in writing of the compliance of the **PGM** for the requirement in question.

- **PGU**: The **accredited entity** shall perform the simulations on the **PGU** with the aim of obtaining a **simulation equipment certificate from the PGU** for a given requirement.
- **ACPGM:** Simulations shall be performed by an **accredited entity** on **ACPGM** and associated **PGU**, with the aim of obtaining an **ACPGM equipment certificate** (for one or more given **PGU(s)**) by simulation for a given requirement.

3) The **authorised certifier** shall assess the results of the simulations carried out by the **accredited entity**, as well as the **supplementary simulations**, which need not be carried out by an **accredited entity**, and shall issue, if the assessment is positive, either a **PGU equipment certificate** for the assessed requirement or a certificate of compliance with the technical requirement by the **PGM**.

In any case, for the **issuance of the final PGM certificate**, the requirements specified in subsection 4.1.1 shall be met.

4.5. PGU type with similar characteristics

Equipment certificates of a PGU may be used for other **PGUs with similar characteristics**, without the need to re-test. In such cases, the original **equipment certificates** shall be referred to as "**type PGU certificates per requirement**" for the purposes of this **Technical Standard**.

The **PGU certificate for a requirement** shall be considered as a **type PGU certificate per requirement** when the following conditions are met. In all cases, the **authorised certifier** shall carry out the assessment:

- **PPM**: The following criteria shall be followed with respect to the tested equipment:
  - Wind technology **PGU**:
    - Electrical generator with the same design specifications:
      - Nominal active power ±25% of the value corresponding to the electrical generator being tested.
      - Same typology (for example: asynchronous squirrel cage, doubly fed, etc.).
      - Same static connection voltage (asynchronous generators only), considering a tolerance in voltage of ±10%.
      - Transformation ratio ±20% (asynchronous generators only).
    - Electronic converter(s), if any, with the same hardware (which could be from different manufacturers) and specifications to withstand voltage dips.
    - Percentage short-circuit voltage of the transformer, referring to the base of the nominal active power of the wind turbine, within ±20 % of the value of the tested wind turbine. This point shall not apply to **PGUs** without a transformer connected to the medium voltage circuit.
    - Nominal active wind turbine power within ±25 % of the value of the tested wind turbine.

    The **PGU** manufacturer shall assess whether compliance with the technical requirements is affected by **software or firmware** updates and shall provide the **authorised certifier** with any additional information the **authorised certifier** deems appropriate to determine whether such updating has an impact on compliance with the technical requirements.

    Finally, the **authorised certifier** shall issue a favourable report, if appropriate, on the suitability of the proposed change to the wind turbine to further consider the validity of the **PGU type certificates per requirement**.

  - **PGU** of photovoltaic or other technologies:
    - Same topology of power stages. That is, the same arrangement of conversion stages, the same location of filters, the same location of relays, etc.
    - Same isolation class (low-frequency transformer, high-frequency transformer or no transformer).
    - Same AC connection state (1-phase or 3-phase).

- Nominal alternating current ±50% with respect to the type tested.
- Same control algorithm for all technical requirements.
- Groupings of several power stages (modular systems) shall be considered valid without the need for repeating tests.

The PGU manufacturer shall assess whether compliance with the technical requirements is affected by **software or firmware** updates and shall provide the **authorised certifier** with any additional information the **authorised certifier** deems appropriate to determine whether such updating has an impact on compliance with the technical requirements.

Finally, the **authorised certifier** shall issue a favourable report, if applicable, on the suitability of the proposed change to the **PGU** in order to further consider the validity of the **PGU type certificates per requirement**.

- **SPGM:** A variation of ±25% of the nominal active power of the **PGU** shall be permitted, where:
  - The **PGU** of **SPGM** as a whole, i.e. considering all the individual components (alternator and prime mover, speed and power control, voltage control including PSS, if applicable) has been previously certified in accordance with this **Technical Standard**.
  - The individual components share the same simulation model with the same parameters. However, variations in these parameters shall be permitted if the authorised certifier determines that they have no impact on the outcome of the simulations to be carried out to assess a special technical requirement.

  The **PGU** manufacturer shall assess whether compliance with the technical requirements is affected by **software or firmware** updates and shall provide the **authorised certifier** with any additional information the **authorised certifier** deems appropriate in order to determine whether such updating has an impact on compliance with the technical requirements.

  Finally, the **authorised certifier** shall issue a favourable report, if applicable, on the suitability of the proposed change to the **PGU of SPGM** in order to further consider the validity of the **PGU type certificates per requirement**.

The **PGU type certificate per requirement,** both for **PPM** and **SPGM**, **may** contain in its scope all the types of **PGU** for which it is applicable, considering the above criteria to define a **PGU type**. In this way, at the time of issuing the **final PGM certificate**, the **authorised certifier** will use this information to determine the applicability to the **PGU** of the **PGM** under assessment.

4.6. Assessment of the ACPGM

The methodology for obtaining **ACPGM** certificates shall be performed in accordance with the **Compliance Monitoring Technical Standard NTS SEPE** [2].

4.7. Tests and simulations of electricity generating units according to other regulations

The manufacturer of the **PGU or ACPGM** may submit to the **authorised certifier:**

- **PGU and ACPGM equipment certificates based on test and/or simulation requirements**, issued by an **authorised certifier** at all times, but in accordance with other technical standards of similar scope to this **Technical Standard**.
- **Test reports and/or simulations per requirement**, performed by an **accredited entity** in accordance with other technical standards similar to those established in this **Technical Standard**.

The **authorised certifier** may accept such reports and/or **equipment certificates** for the compliance assessment of the technical requirement concerned - without the need to repeat the test or simulation - provided that all of the following conditions are met:

1. The **stringency level of the requirement** in question is equal to or greater than that indicated in [1]**.**
2. The technical standard for certification of the requirement shall be preferably European or, failing that, internationally recognised (IEC, IEEE, etc.).
3. The **test or simulation methods** used in this **Technical Standard** shall be equal to or more demanding[6] than those specified in this **Technical Standard**.
4. The test and/or simulation has been carried out by an **accredited entity** and the **equipment certificate** issued by an **authorised certifier**.

In all cases, the **authorised certifier** shall always indicate in the **equipment certificate** which requirements are assessed in each **test report, simulation or equipment certificate** and under which technical standard they have been issued.

However, in order to clarify the equivalence that may exist between the certificates issued according to this **Technical Standard SENP** and those issued according to the **Technical Standard NTS SEPE** [2], an equivalency table has been developed, as described in subsection 7.1.2.1

[6] Increased number of tests and simulations and lower tolerance for accepted errors

5. METHOD OF TESTS AND SIMULATIONS FOR THE ASSESSMENT OF TECHNICAL REQUIREMENTS

The methodology to be followed in order to perform **tests and simulations** on **PGM** and **PGU** shall now be explained, from subsection 5.1 to subsection 5.11, in accordance with the procedures stated in section 4.

Measuring and instrumentation equipment (filter set, analogue/digital converter and data acquisition system (oscilloscopes and/or power analysers)), in order to conduct the tests, will be capable of measuring with a maximum error according to **Table 2** and be calibrated.

Magnitude	Value
Maximum error in voltage measurement	±0,5% of Un
Maximum error in current measurement	±0,5% of In
Maximum error in frequency measurement	±10 mHz

Table 2. Maximum errors allowed in measurements due to measurement equipment.

In addition, the **following aspects** shall be considered for measuring and instrumentation equipment:

- The accuracy of the equipment used as a voltage source and frequency of the tests that require it shall be assured and verified by the measuring equipment, requiring a THD < 1% (**IEC 61000-3-7**) and an asymmetry of less than µ< 0,5 % (**IEC 61000-3-13**) in stable operation (no switching transients).
- The minimum sampling frequency for voltage and current shall be at least 3 kHz; however, a sampling frequency greater or equal than 10 kHz shall be required for the assessment of robustness requirements.

The transducers (voltage transformers, current transformers, Rogowsky coils, electronically compensated resistive dividers, etc.) required for connection to the **NCP** must be at least Class 1 and may be those already installed in the **PGM**.

5.1. Limited Frequency Sensitive Mode-Overfrequency (LFSM-O)

5.1.1. Objective

The objective is to verify that the **PGM** is **capable to activate the power-frequency regulation reserve supply** as stated in:

- Article 8.2.3 of [1].

The **compliance of the PGM** with this requirement may be assessed by:

- **test and simulation**; or
- **equipment certificate**

Possible **assessment levels** for this requirement are:

- **PGM**
- **PGU when:**
  - the **PGM** does not have a hierarchical power-frequency control higher than the **PGU** itself; and
  - The **ACPGM** does not limit the response of the **PGU** to this requirement.

Where there is a **ACPGM** that may affect the control provided by the **LFSM-O** of the **PGU**, in addition to the **PGU** test or the **PGU test equipment certificates**, a **supplementary simulation** of the **PGM** shall be required, in accordance with subsection 5.1.3 to verify that the **LFSM-O** requirement is met at **BC**, and not only at the **PGU** level.

In the absence of such an **ACPGM**, the test and simulation of the **PGUs**, or their test and simulation **equipment certificates**, shall be required, and the **supplementary simulation** shall not be required.

The system operator shall specify to the **PGM owner** the value required for the final **PGU** adjustment. The **PGM owner** shall be responsible for communicating this adjustment to the **authorised certifier** so that it can assess the acceptance criteria.

It is important to take into account the following terms:

- **Δf**: deviation of frequency f from 50 Hz (Δf = f – 50).
- **ΔP**: expected active power response in the event of a frequency deviation (Δf) calculated according to the following formula:

$$|\Delta P| = \frac{|\Delta f| - |\Delta f_1|}{f_n} \times \frac{P_{max}}{s_2} \times 100$$

For the purposes of this **Technical Standard,** and in order to establish the response times, the following terms are introduced:

- **P_0**: active power of the **PGU** prior to performing a test (or frequency change).
- **P_{end}**: final active power of the **PGU** after performing a test (or frequency change).
- **ΔP_{test}:** deviation of the active power compared to the active power (P_0) prior to performing a test: $\Delta P_{test} = P_{end} - P_0$
- **Initial delay time (t_a)**: **LFSM-O** activation time. For the purposes of this **Technical Standard**, the reference to be used to measure this time shall be from the time when a frequency change is detected from which regulation is expected until a 1% change (of

ΔP_{test}). If the frequency is modified by means of a power supply connected to the controller, 20 ms must be subtracted from setpoint change to the **PGU**, so that a complete cycle can be detected with this new frequency.

- **Rise time (t_r)**: Concerning this **Technical Standard**, the value of t_r shall be the time to reach 90% of **ΔP_{test}** (not including the initial delay time t_a) taking into account the **measured** active power values prior to the disturbance (P_0) and final (P_{end}). That is, if, for example, P_0=7%P_{max} and the measured final power is P_{end}=14%P_{max}, **ΔP_{test}=7%P_{max},** where 90%ΔP_{test}= 6,3%P_{max}, and the value of t_r will be the corresponding value of P_0+6,3%P_{max} = 13,3% P_{max}.
- **Settling time (t_e):** For the purposes of this **Technical Standard,** the value of t_e shall be the time for the response to remain within a tolerance band less than ±5% of the **ΔP_{test}** (without including the initial delay time t_a) (**Figure 11**). If, for example, P_0=7%P_{max} and the measured final power is P_{end}=14%P_{max}, **ΔP_{test} =7%P_{max},** where 5% **ΔP_{test}** = 0,35%P_{max}, and the t_e value will be the value corresponding to the last P value that enters the band between P_{end}-5%**ΔP_{test}** = 13,65% P_{max} and P_{end}+5% **ΔP_{test}** = 14,35% P_{max}. However, and concerning this **Technical Standard**, in the **tests**, a permanent error between the final measured value and the expected value, less than ±5% of the P_{max} of the **PGU**, shall be considered as admissible. In addition, for the tests where the active power deviation is less than or equal to 20% of **P_{max}** of the **PGU** and in case of an oscillatory response that does not allow the assessment of the settling time, a trend line may be used to verify that the response is damped and consistent with the settling time required in the requirement.

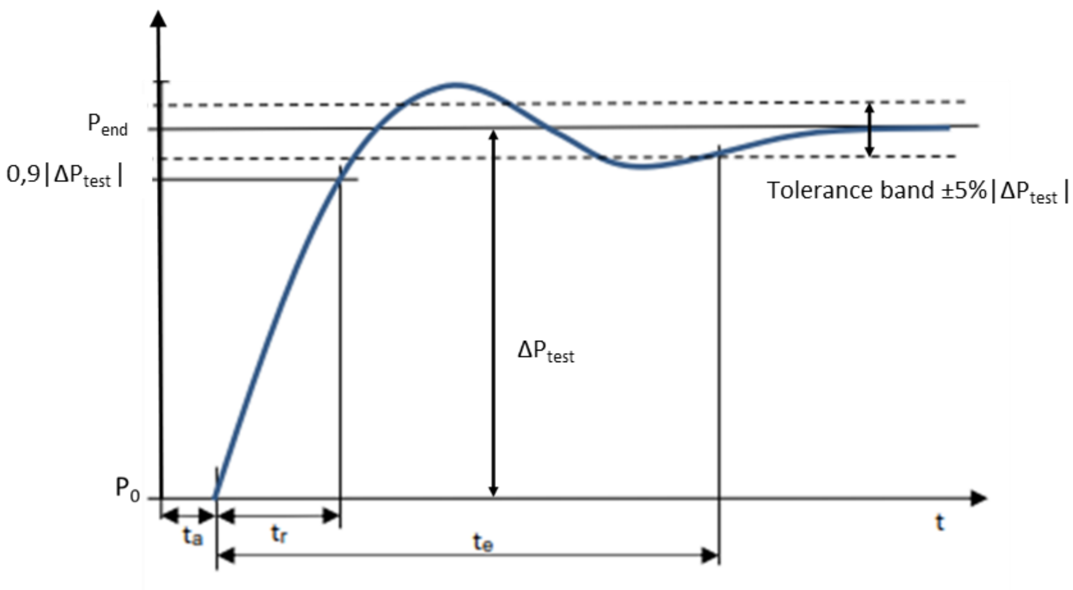


Figure 11. Example of a potential response that illustrates the times t_a, t_r, and t_e defined above.

5.1.2. Assessment at PGU level for obtaining PGU certificate

5.1.2.1. PGU test method

This subsection details how the **LFSM-O activation** will be **tested** at the set frequency thresholds and the **LFSM-O activation times**.

The **test conditions** shall be as follows:

- A power supply connected to the **PGU** terminals when the **PGU** is disconnected from the network.
- An **PGU** connected to the network.

Irrespective of whether the **PGU** is connected to the network or not, **the input frequency to the PGU will be modified** by using one of the following alternatives:

1. A device (internal or external) to introduce a digital or analogue input into the **PGU** control system.
2. A direct change of the frequency reference value in the **PGU** control system.
3. Direct modification of the frequency in the **PGU** terminals when the power supply has the capacity to modify the output frequency.

In order to **test this requirement**, the following **sequence of actions** shall be followed:

- The **FSM and LFSM-U** controls of the **PGU** shall be **disabled**.
- The **tests** described in the following tables **shall be performed**: **Table 3** to **Table 6.**
- For each previous test, **it shall be measured in PGU terminals**, depending on the connection point of the power supply. In any case, the measuring equipment shall always record voltage and current, the rest of the magnitudes being calculated from these.
- The **FSM and LFSM-U** controls of the **PGU** will be **enabled**.
- It shall be verified, and recorded in the test report, that the **LFSM-O** has implemented the following adjustments in the **PGU**:
    - The activation threshold Δf_1 shall be equal to 0,25 Hz (50,25 Hz).
    - The droop s_2 shall be equal to 4%.

For this purpose, tests shall be carried out for the extreme frequency ranges (50,2 Hz and 50,5 Hz) and at the extreme droop values (2% and 12%), so that the full capacity is covered.

The initial conditions to perform the test shall be at nominal frequency, f_n (50 Hz ± 10 mHz), nominal voltage (± 5%) and initial active power (P_{ini}), which shall ensure that the required power increases can be assessed within the time periods established in [1]:

- <u>For laboratory tests</u>**: The initial active power prior to the tests sequence shall correspond to the maximum capacity of the PGU.**

- <u>For field tests</u>**: The initial active power prior to the tests sequence shall correspond, at least, to:**
    - The minimum regulating level of the **PGU** (of a S**PGM**) shall be greater than or equal to 45% of the maximum capacity (P_{max}) of the **PGU**. If the minimum level of regulations declared by the manufacturer is greater than 55%of P_{max}, the test shall be carried out at a P_{ini}=P_{max}.

- The minimum regulating level of the **PGU** (of a **PPM**) shall be greater than or equal to 50% of the maximum capacity (P_{max}) of the **PGU**.

Under no circumstances shall the tests involve a reduction in active power below the minimum level of regulations declared by the manufacturer.

As regards the initial reactive power in the test, it shall be null, both for **PPM** and S**PGM**.

Below is a description of how the **LFSM-O activation capacity shall be tested** at 50,2 Hz and 50,5 Hz, for droops of 2% and 12%, in accordance with requirements specified in [1]. The frequency steps generated shall be large enough to activate an active power change equal to or greater than 10% of the P_{max} of the **PGU**. Therefore, for the tests where the expected active power deviation is less than or equal to 10% of the P_{max} of PGU, the response times t_r and t_e shall not be evaluated.

At least 1 minute shall be measured at each frequency step and in any case sufficient time to stabilise the frequency step response, and the average active power (P (%) recorded) and the corresponding times (t_r and t_e) shall be recorded.

Tests shall be performed for the entire permissible range of s_2 and of Δf_1, considering the following combinations to assess the **capacity of the PGU for this requirement**. The tests to be carried out shall be called:

- **OS2F2** test: s_2=2% and Δf_1=0,2 Hz (**Table 3**).
- **OS2F5** test: s_2=2% and Δf_1=0,5 Hz (**Table 4**).
- **OS12F2** test: s_2=12% and Δf_1=0,2 Hz (**Table 5**).
- **OS12F5** test: s_2=12% and Δf_1=0,5 Hz (**Table 6**).

The following tables describe these tests and the necessary frequency steps (Δf) and the expected active power variation in each test (ΔP_{test}) and the necessary response times.

The sequence of tests shown in the following tables shall be followed row by row, starting from the frequency final value of the previous test. Tests in which the first column specifies S**PGM** or **PPM** shall only be applicable to **PGUs of SPGM** or **PPM** respectively. For example, in the OS2F2 test, a **PGU** of a **PPM** shall perform the tests: 1, 2, 3, 4, 5 and 6b, in this order.

OS2F2									
No. of test point	**f_0 (Hz)**	**f_{end} (Hz)**	**ΔP_{test} expected (%P_{max})**	**ΔP_{test} recorded (%P_{max})**	**Deviation (%P_{max}) (<5%P_{max})**	**90% ΔP_{test} recorded (%P_{max})**	**t_r (s) (at 90% ΔP_{test} recorded)**	**t_a (s)**	**t_e (s) (Band +/- 5% ΔP_{test} recorded)**
1	50,00	50,10	0%			N/A	N/A	N/A	N/A
2	50,10	50,50	-30%						
3	50,50	50,70	-20%						
4	50,70	50,50	+20%						
5	50,50	50,10	+30%			N/A	N/A	N/A	N/A
6a SPGM	50,10	50,65	-45%						
6b PPM	50,10	50,70	-50%						

Table 3. LFSM-O Tests. 2% droop and 50,2 Hz frequency threshold.

OS2F5									
No. of test point	f_0 (Hz)	f_{end} (Hz)	ΔP_{test} expected ($\%P_{max}$)	ΔP_{test} recorded ($\%P_{max}$)	Deviation ($\%P_{max}$) ($<5\%P_{max}$)	90% ΔP_{test} recorded ($\%P_{max}$)	t_r (s) (at 90% ΔP_{test} recorded)	t_a (s)	t_e (s) (Band +/- 5% ΔP_{test} recorded)
1	50,00	50,40	0%			N/A	N/A	N/A	N/A
2	50,40	50,80	-30%						
3	50,80	51,00	-20%						
4	51,00	50,80	+20%						
5	50,80	50,10	+30%			N/A	N/A	N/A	N/A
6a MGES	50,10	50,95	-45%						
6b MPE	50,10	51,00	-50%						

Table 4. LFSM-O Tests. 2% droop and 50,5 Hz frequency threshold.

OS12F2									
No. of test point	f_0 (Hz)	f_{end} (Hz)	ΔP_{test} expected ($\%P_{max}$)	ΔP_{test} recorded ($\%P_{max}$)	Deviation ($\%P_{max}$) ($<5\%P_{max}$)	90% ΔP_{test} recorded ($\%P_{max}$)	t_r (s) (at 90% ΔP_{test} recorded)	t_a (s)	t_e (s) (Band +/- 5% ΔP_{test} recorded)
1	50,00	50,10	0%			N/A	N/A	N/A	N/A
2	50,10	51,40	-20%						
3	51,40	50,30	+18,33%						

Table 5. LFSM-O Tests. 12% droop and 50,2 Hz frequency threshold.

OS12F5									
No. of test point	f_0 (Hz)	f_{end} (Hz)	ΔP_{test} expected ($\%P_{max}$)	ΔP_{test} recorded ($\%P_{max}$)	Deviation ($\%P_{max}$) ($<5\%P_{max}$)	90% ΔP_{test} recorded ($\%P_{max}$)	t_r (s) (at 90% ΔP_{test} recorded)	t_a (s)	t_e (s) (Band +/- 5% ΔP_{test} recorded)
1	50,00	50,40	0%			N/A	N/A	N/A	N/A
2	50,40	51,40	-15%						
3	51,40	50,60	+13,33%						

Table 6. LFSM-O Tests. 12% droop and 50,5 Hz frequency threshold.

5.1.2.2. PGU test acceptance criteria

The **PGU** shall be deemed **capable of activating the power-frequency adjustment reserve supply** if the following conditions are met:

1) No undamped oscillations occur in the response in the transition between test points.
2) The results meet all the requirements established in [1].
3) When **active power reductions** occur during frequency rise and LFSM-O is active:
   - The **initial delay time (t_a)** shall be:
     - t_a will be less than or equal to the power response activation time set for the **FSM** mode because it defines the power response technical capability of the **PGM**.
     - If t_a exceeds the maximum permissible initial delay value t_1 defined in subsection 5.3.2.2 of this **Technical Standard:** the **PGM owner** must provide technical evidence to justify such value to the **TSO**, as established in [1]. If the

TSO accepts the justification, the **TSO** shall give its written consent to the **PGM owner**, who shall forward it to the **authorised certifier** for incorporation in the **final PGM certificate**.

Optionally, and in order to certify the PGU according to NTS SEPE, the following criteria must be met:

- The **rise time** (t_r) shall be:
  - For **PGU of SPGM** : less than or equal to 8 s for an active power variation of up to 45% of the maximum power.
  - For **PGU of PPM**: less than or equal to 2 s for an active power variation of up to 50% of the maximum power.
- The **settling time** (t_e) shall be:
  - For **PGU of SPGM** : less than or equal to 30 s.
  - For **PGU of PPM**: less than or equal to 20 s.

4) When **active power increases** during frequency down and **LFSM-O** being active:
   - The **initial delay time (t_a)** shall be:
     - t_a shall be less than or equal to the power response activation time set for the **FSM** mode because it defines the power response technical capability of the **PGM**.
     - If t_a exceeds the maximum permissible initial delay value t_1 defined in subsection 5.3.2.2 of this **Technical Standard**, the **PGM** owner must provide technical evidence to justify this value to the **TSO**, as established in [1]. If the **TSO** accepts the justification, the **TSO** shall give their written consent to the owner of the **PGM**, who shall forward it to the authorised certifier for incorporation in the final **PGM** certificate.

Optionally, and in order to certify the PGU according to NTS SEPE, the following criteria must be met:

- The **rise time** (t_r) shall be:
  - For **PGU of SPGM** : less than or equal to 5 minutes for an active power variation of up to 20% of the maximum power. This slow performance shall not be acceptable if the direction of frequency variation has reversed a few seconds earlier, in which case response times similar to the active power reduction case shall be expected.
  - For non-winding **PGU of PPM** : less than or equal to 10 s for an active power variation of up to 50% of the maximum power.
  - For **PGU** of wind **PPM**: less than or equal to 5 s for an active power variation of up to 20% of the maximum power if the power is above 50% of the maximum power. For powers less than 50% of the maximum power, the response time shall be as low as technically possible. The **owner** of the **PGM** shall provide the **TSO** with technical evidence to justify this value. If the **TSO** accepts the justification, the **TSO** shall give their written consent to the **owner** of the **PGME**, who shall forward it to the **authorised certifier** for incorporation in the **final PGM certificate**.

- The **settling time** (t_e) shall be:
  - For **PGU of SPGM** : less than or equal to 6 minutes. This slow performance shall not be acceptable if the direction of frequency variation has reversed a few seconds earlier, in which case response times similar to the active power reduction case will be expected.
  - For **PGU of PPM** : less than or equal to 30 s.

5) In the tests, a deviation of ±5 % of the P_{max} shall be permitted in the active power recorded from the expected active power according to the tables in subsection 5.1.2.1.

The **authorised certifier** shall issue an **PGU test equipment certificate for this requirement**, noting the test method followed, when it positively assesses that:

- The **LFSM-O** requirement is met for the droop and frequency ranges tested.
- The **PGU** adjustment corresponds to that required by the system operator.

5.1.2.3. PGU simulation method

In the event that the **PGM** does not have an **ACPGM** that can modify the **LFSM-O** response of the **PGU**, the simulation of the **PGU** or its **equipment certificates by simulation** shall be required, and the **supplementary simulation** shall not be required.

This subsection details how the **LFSM-O requirement will be assessed by simulation**.

The **model certified** in accordance with section 6 shall be used and the tests in subsection 5.1.2.1 shall be replicated. The following aspects shall be taken into account in carrying out the simulations:

- Network used in the simulation: an infinite network represented by a 5 s inertia constant (H) generator (in case the simulation tool requires this data) and apparent power at least one hundred times greater than the apparent power of the **PGU** to be analysed shall be used.
- Configuration of other **PGU** control systems: voltage control and power-frequency regulations systems shall remain active. Its parameters will be fixed during the simulation.

The simulation execution process shall be as follows:

The simulation shall be initialized correctly, i.e. the derivatives of the system status variables will be null.

- It shall be started in steady state, establishing:
    - Voltage 1 p.u. in **PGU terminals**.
    - **PGU of SPGM:** Reactive power less than or equal to zero.
    - **PGU of PPM:** Zero reactive power.
    - Three active power levels shall be simulated: minimum regulating level, 20%P_{max} and 90%P_{max}. If the minimum regulating level matches the 20%P_{max}, 30%P_{max} shall be chosen as the second active power level.

- The simulation shall be initiated without disturbance. After 100 ms, frequency increments of 0,1 Hz, at most, shall be applied, and if the simulation tool allows, by applying additional mechanical pairs to the generator representing the infinite network (equivalent to reducing system demand) until a new permanent state is reached.

5.1.2.4. PGU simulation acceptance criteria

The simulation report to be conducted by the **accredited entity** shall include the results of the simulations stated in subsection 5.1.2.3.

The acceptance criteria of the simulation results shall be the same as those indicated for the tests in subsection 5.1.2.2, except point 5) where only a deviation of ±5 % from the expected and recorded active power of **ΔP** (instead of P_{max}) shall be permitted. Additionally, a stable and well-damped active power evolution should be observed.

If the above requirements are met, the **authorised certifier** shall give approval to the report and issue a **simulated PGU certificate for this requirement.** This certificate shall contain all the information on the simulations in addition to their unequivocal identification.
The **certificate for this requirement** shall be issued by the **authorised certifier** at **PGU** level, depending on the scope of the simulation performed. Licences shall be issued after a positive assessment when:

- The **LFSM-O** requirement is met for the droop and frequency ranges tested.
- The **PGU** adjustment corresponds to that required by the system operator.

5.1.3. Supplementary simulation for obtaining PGM certificate

If there is a **ACPGM** that affects the control provided by the **LFSM-O** of the **PGU**, in addition to the **PGU test** or the **PGU equipment certificates**, a **supplementary simulation** of the **PGM** shall be required to verify that the **LFSM-O** requirement is met in **BC**, and not only at the **PGU** level.

With the full model of the **PGM** - equivalent models shall not be supported, with the exception specified in subsection 7.5- simulations shall be performed under the following initial conditions:

- $P=P_{max}$ at the **PGM** level.
- Voltage of 1 p.u. at the HV side of the **PGM** transformer.
- Q = 0 at the **PGM** level.
- infinite s_{cc} or network equivalent.
- Activation threshold Δf_1 equal to 0,25 Hz.
- Droop s_2 equal to 4%.

The simulations shall be performed with a frequency sweep according to **Table 7:**

No. of test point	f_0 (Hz)	f_{end} (Hz)	ΔP_{test} expected ($\%P_{max}$)	ΔP_{test} recorded ($\%P_{max}$)	Deviation ($\%P_{max}$) ($<5\%P_{max}$)	90% ΔP_{test} recorded ($\%P_{max}$)	t_r (s) (at 90% ΔP_{test} recorded)	t_a (s)	t_e (s) (Band +/- 5% ΔP_{test} recorded)
1	50,00	50,25	0%			N/A	N/A	N/A	N/A
2	50,25	50,65	-20%						
3	50,65	51,05	-20%						
4	51,05	51,45	-20%						
5	51,45	51,05	20%						
6	51,05	50,65	20%						
7	50,65	50,30	17,5%						
8	50,30	50,00	2,5%			N/A	N/A	N/A	N/A

Table 7. LFSM-O Supplementary Simulation.

The acceptance criteria shall be the same as those stated in subsection 5.1.2.4.

The **PGM certificate** for this requirement shall be issued under the version corresponding to the version of the **PGU** and/or **ACPGM certificates** used, even if the **supplementary** simulations have been performed according to this version of the **Technical Standard**.

The **supplementary simulation** report shall contain at least the following information:

- Description of the **PGM**, including **BC.**
- **PGM** model:
  - Simulation platform and version.
  - Equivalent network characteristics.
  - Data of the **PGU** model(s), including its validation certificate/report, simulation platform and version and parameters used in the simulations.
  - Data of the **ACPGM** model(s), including its validation certificate/report, simulation platform and version and parameters used in the simulations.
  - Description of the modelling of the other components of the **PGM**.

- Outcomes:
    - Table similar to **Table 7** completed, indicating the compliance of each simulation.
    - Simulation packets exportable. Upon request of the **RSO**, the model of the **PGM** used in the simulations shall be delivered.
- Conclusions.

5.1.4. Assessment at PGM level for obtaining PGM certificate

In the event that the **PGM owner** does not have or does not wish to use the **equipment certificates** for **PGU** and **ACPGM** for this technical requirement, the tests and simulations described in subsections 5.1.2.1 and 5.1.2.3, respectively, must be performed at **PGM** level. If the acceptance criteria for tests and simulations described in subsections 5.1.2.2 and 5.1.2.4 are met respectively, the **authorised certifier** shall issue an **PGM certificate** for this requirement without the need to perform the **supplementary simulations** stipulated in subsection 5.1.3.

5.2. Limited Frequency Sensitive Mode – Underfrequency (LFSM-U)

5.2.1. Objective.

The objective is to verify that the **PGM** is **capable to activate the power-frequency regulations reserve supply** as stated in:

- article 8.2.4 of [1]

The compliance of the PGM with this requirement may be assessed by:

- **test and simulation**; or
- **equipment certificate**.

Possible **assessment levels** for this requirement are:

- **PGM,** or
- **PGU when:**
    - the **PGM** does not have a hierarchical power-frequency control higher than the **PGU** itself; and
    - The **ACPGM** does not limit the response of the **PGU** to this requirement.

If there is a **ACPGM** that affects the control provided by the **PGU LFSM-U** in addition to the **PGU test** or the **PGU equipment certificates**, a **supplementary simulation** of the **PGM** shall be required, according to 5.2.3 to verify that the **LFSM-U** requirement is met in **BC**, and not only at the **PGU** level.

In the absence of such **ACPGM**, the test and simulation of the **PGUs** or their **equipment certificates** shall be required, and the **supplementary simulation** shall not be required.

The system operator shall specify to the **PGM owner** the value required for the final **PGU** adjustment. The **PGM owner** shall be responsible for communicating this adjustment to the **authorised certifier** so that they can assess the acceptance criteria.

The same terms as defined in subsection 5.1.1 shall be used.

5.2.2. Assessment at PGU level for obtaining PGU certificate

5.2.2.1. PGU test method

This subsection details how the **activation of the LFSM-U** will be **tested** at the set frequency thresholds as well as the **activation times** of the **LFSM-U**.

To **test this requirement**, the terms, test conditions, input frequency modification method and **sequence of actions** analogous to that carried out in subsection 5.1.2.1 (**LFSM-O**) shall be used.

It shall be verified, and reflected in the test report, that the **LFSM-U** has implemented the following adjustments in the **PGU**:

- The activation threshold Δf_1 shall be equal to -0,25 Hz (49,75 Hz).
- The droop s_2 shall be equal to 4%.

For this purpose, tests shall be carried out for the extreme frequency ranges (49.8 Hz and 49.5 Hz) and at the extreme droop values (2% and 12%), so that the full capacity is covered.

The initial conditions to perform the test shall be at nominal frequency, f_n (50 Hz ± 10 mHz), nominal voltage (± 5%) and next initial active power (P_{ini}), which shall ensure that the required power increases can be assessed within the time periods established in [1].

For both laboratory and field tests, the initial active power **prior to the tests sequence** (P_{ini}) must correspond to:

- For **PGU** in **SPGM** and **PGU** in non-wind technology **PPM**: the minimum regulating level of the **PGU**. If the minimum regulating level is so high that the maximum capacity of the **PGU** is reached at any of the frequency steps presented in the tests, the frequency steps shall be readjusted.
- For PGU in wind technology **PPM**: 50% maximum capacity (P_{max}) of the **PGU**.

Under no circumstances shall the tests involve an increase in active power greater than the **maximum capacity** declared by the manufacturer.

As regards the initial reactive power in the test, it shall be null, both for **PPM** and **PGMS**.

Below is a description of how the **LFSM-U activation will be tested** at 49.8 Hz and 49.5 Hz, for 2% and 12% droop, according to the requirements specified in [1]. The frequency steps generated must be large enough to activate an active power change of at least 10% of the P_{max} of the **PGU**. Therefore, for the tests where the expected active power deviation is less than 10% of the P_{max} of **PGU**, the response times t_r and t_e shall not be evaluated.

Each frequency step shall be measured for at least one minute, and in any case sufficient time shall be allowed to stabilise the response per frequency step and the average active power and corresponding times shall be recorded.

Tests shall be performed for the entire admissible range of s_2 and Δf_1, considering the following combinations in order to certify the capability of the **PGU**. The tests to be carried out shall be called:

- **US2F2** test: s_2=2% and Δf_1=-0,2 Hz (**Table 8**).
- **US2F5** test: s_2=2% and Δf_1=-0,5 Hz (**Table 9**).
- **US12F2** test: s_2=12% and Δf_1=-0,2 Hz (**Table 10**).
- **US12F5** test: s_2=12% and Δf_1=-0,5 Hz (**Table 11**).

The following tables describe these tests and the necessary frequency steps (Δf) and the expected active power variation. The sequence of tests shown in the following tables shall be followed row by row, starting from the final value of the previous test.

US2F2									
No. of test point	f_0 (Hz)	f_{end} (Hz)	ΔP_{test} expected ($\%P_{max}$)	ΔP_{test} recorded ($\%P_{max}$)	Deviation ($\%P_{max}$) ($<5\%P_{max}$)	90% ΔP_{test} recorded ($\%P_{max}$)	t_r (s) (at 90% ΔP_{test} recorded)	t_a (s)	t_e (s) (Band +/- 5% ΔP_{test} recorded)
1	50,00	49,90	0%			N/A	N/A	N/A	N/A
2	49,90	49,60	+20%						
3	49,60	49,40	+20%						
4	49,40	49,70	-30%						
5	49,70	50,00	-10%			N/A	N/A	N/A	N/A
6 PPM not wind	50,00	49,30	+50%						

Table 8. LFSM-U Tests. 2% droop and 49.8 Hz frequency threshold.

US2F5									
No. of test point	f_0 (Hz)	f_{end} (Hz)	ΔP_{test} expected ($\%P_{max}$)	ΔP_{test} recorded ($\%P_{max}$)	Deviation ($\%P_{max}$) ($<5\%P_{max}$)	90% ΔP_{test} recorded ($\%P_{max}$)	t_r (s) (at 90% ΔP_{test} recorded)	t_a (s)	t_e (s) (Band +/- 5% ΔP_{test} recorded)
1	50,00	49,60	0%			N/A	N/A	N/A	N/A
2	49,60	49,30	+20%						
3	49,30	49,10	+20%						
4	49,10	49,40	-30%						
5	49,40	50,00	-10%			N/A	N/A	N/A	N/A
6 PPM not wind	50,00	49,00	+50%						

Table 9. LFSM-U Tests. 2% droop and 49.5 Hz frequency threshold.

US12F2									
No. of test point	f_0 (Hz)	f_{end} (Hz)	ΔP_{test} expected ($\%P_{max}$)	ΔP_{test} recorded ($\%P_{max}$)	Deviation ($\%P_{max}$) ($<5\%P_{max}$)	90% ΔP_{test} recorded ($\%P_{max}$)	t_r (s) (at 90% ΔP_{test} recorded)	t_a (s)	t_e (s) (Band +/- 5% ΔP_{test} recorded)
1	50,00	49,90	0%			N/A	N/A	N/A	N/A
2	49,90	48,75	17.50%						
3	48,75	47,70	17.50%						
4	47,70	49,70	-33,33%						
5	49,70	50,00	-1,67%	N/A	N/A	N/A	N/A	N/A	N/A
6 PPM not wind	50,00	47,60	36,67%						

Table 10. LFSM-U Tests. 12% droop and 49.8 Hz frequency threshold.

US12F5									
No. of test point	**f_0 (Hz)**	**f_{end} (Hz)**	**ΔP_{test} expected ($\%P_{max}$)**	**ΔP_{test} recorded ($\%P_{max}$)**	**Deviation ($\%P_{max}$) ($<5\%P_{max}$)**	**90% ΔP_{test} recorded ($\%P_{max}$)**	**t_r (s) (at 90% ΔP_{test} recorded)**	**t_a (s)**	**t_e (s) (Band +/- 5% ΔP_{test} recorded)**
1	50,00	49,60	0%			N/A	N/A	N/A	N/A
2	49,60	48,60	15%						
3	48,60	47,70	15%						
4	47,70	49,40	-28,33%						
5	49,50	50,00	-1,67%	N/A	N/A	N/A	N/A	N/A	N/A
6 PPM not wind	50,00	47,70	30%						

Table 11. LFSM-U Tests. 12% droop and 49.5 Hz frequency threshold.

5.2.2.2. PGU test acceptance criteria

The **PGU** shall be deemed **capable of activating the power-frequency adjustment reserve supply** if the following conditions are met:

1) No undamped oscillations occur later in the response in the transition between test points.

2) The results meet the requirements established in [1].

3) For **SPGM** whose technology uses gas turbines or gas engines, the possible reduction of the active power from its maximum capacity with the frequency drop shall be considered, in the same way as is considered in **NTS SEPE** [2].

4) For active power increases during frequency down, with the **LFSM-U** activated:

- The **initial delay time (t_a)** shall be:
  - t_a will be less than or equal to the power response activation time set for the **FSM** mode because it defines the power response technical capability of the **PGM**.
  - If t_a exceeds the maximum admissible initial delay value t1 defined in subsection 5.3.2.2 of this **Technical Standard**: the **owner** of the **PGM** must provide technical evidence to justify such value to the **TSO**, as established in [1]. If the **TSO** accepts the justification, the **TSO** shall give their written consent to the **owner** of the **PGM**, who shall forward it to the **authorised certifier** for incorporation in the **final PGM certificate**.

Optionally, and in order to certify the PGU according to NTS SEPE, the following criteria must be met:

- The **rise time (t_r)** must be:
  - For **PGU of SPGM**: less than or equal to 5 minutes for an active power variation of up to 20% of the maximum power. This slow performance shall not be acceptable if the direction of the frequency variation has reversed a few seconds earlier, in which case response times similar to the active power reduction case shall be expected.
  - For **PGU** of non-wind **PPM**: less than or equal to 10 s for an active power variation of up to 50% of the maximum power. In the above tables, the first column indicates the "Non-wind" Test. Corresponding to the assessment of this response time.
  - For **PGU** of wind **PPM**: less than or equal to 5 s for an active power variation of up to 20% of the maximum power if the power is above 50% of the maximum power. For powers below 50% of the maximum power, the response time is as low as technically possible, however, it must be justified to the system operator if it exceeds 5 seconds.

- The **settling time (t_e)** must be:
  - For **PGU of SPGM**: less than or equal to 6 minutes. This slow performance shall not be acceptable if the direction of the frequency variation has reversed a few seconds earlier, in which case response times similar to the active power reduction case shall be expected.
  - For **PGU of PPM**: less than or equal to 30 s.

5) For active power reductions during frequency rise with **LFSM-U** activated:

- The **initial delay time (t_a)** shall be:
  - less than or equal to the activation time of the power response set for the **LFSM** mode because it defines the technical power response capability of the **PGM**.
  - If t_a exceeds the maximum admissible initial delay value t1 defined in subsection 5.3.2.2 of this **Technical Standard**: the **PGM owner** must provide technical evidence to justify such value to the **TSO**, as established in [1]. If the **TSO** accepts the justification, the **TSO** shall give their written consent to the **owner** of the **PGM**, who shall forward it to the **authorised certifier** for incorporation in the **final PGM certificate**.

Optionally, and in order to certify the PGU according to NTS SEPE, the following criteria must be met:

- The **rise time (t_r)** must be:
  - For **PGU of SPGM**: less than or equal to 8 s for an active power variation of up to 45% of the maximum capacity.
  - For **PGU of PPM**: less than or equal to 2 s for an active power variation of up to 50% of the maximum capacity.
- The **settling time (t_e)** shall be:
  - For **PGU of SPGM**: less than or equal to 30 s.
  - For **PGU of PPM**: less than or equal to 20 s.

6) In the tests, a deviation of ±5 % of the P_{max} in the active power recorded from the expected active power according to the tables in subsection 5.2.2.1.

The **authorised certifier** shall issue an **PGU test equipment certificate for this requirement**, noting the test method followed, when it positively assesses that:

- The **LFSM-U** requirement is met for the ranges of droop and frequencies tested.
- The **PGU** or **PGM** adjustment corresponds to that required by the system operator.

5.2.2.3. PGU simulation method

In the event that the **PGM** does not have an **ACPGM** that modifies the **LFSM-U** response of the **PGU**, the simulation of the **PGU** or its **equipment certificates by simulation** shall be required, and the **supplementary simulation** shall not be required.

The **model certified** in accordance with section 6 shall be used, i.e. the model whose characteristics enable the power-frequency adjustment capability to be simulated and the tests in subsection 5.2.2.1 shall be replicated. The simulation method shall be similar to that defined in subsection 5.1.2.3, whereas 0,1 Hz frequency decreases must be simulated by means of: at most, and if the simulation tool allows, the application of a negative mechanical torque to the generator representing the infinite network (equivalent to increasing the demand for the system) until a new permanent state is reached.

5.2.2.4. PGU simulation acceptance criteria

The acceptance criterion shall be similar to that described in subsection 5.1.2.4, considering the differences between the tolerances allowed for tests and simulations set out in that subsection.

5.2.3. Supplementary simulation for obtaining PGM certificate

If there is an **ACPGM** that affects the regulations provided by the **LFSM-U** of the **PGU**, in addition to the **PGU test** or the **PGU equipment certificates**, a **supplementary simulation** of the **PGM** shall be required in order to verify that the **LFSM-U** requirement is met in **BC**, and not only at the **PGU** level.

With the full model of the **PGM** – equivalent models will not be supported, with the exception specified in subsection 7.5 – simulations shall be performed under the following initial conditions:

- P= 50% P_{max} at the **PGM** level.
- A 1 p.u. tension. at the HV side of the **PGM** transformer.
- Q = 0 at the **PGM** level.
- infinite s_{cc} or network equivalent.
- Activation threshold Δf_1 equal to -0,25 Hz.
- Droop s_2 equal to 4%.

The simulation shall perform a frequency sweep according to **Table 12**:

No. of test point	f_0 (Hz)	f_{end} (Hz)	ΔP_{test} expected ($\%P_{max}$)	ΔP_{test} recorded ($\%P_{max}$)	Deviation ($\%P_{max}$) ($<5\%P_{max}$)	90% ΔP_{test} recorded ($\%P_{max}$)	t_r (s) (at 90% ΔP_{test} recorded)	t_a (s)	t_e (s) (Band +/- 5% ΔP_{test} recorded)
1	50,00	49,75	0%			N/A	N/A	N/A	N/A
2	49,75	49,35	20%						
3	49,35	48,95	20%						
4*	48,95	48,75	0%			N/A	N/A	N/A	N/A
5	48,75	49,35	-20%						
6	49,35	49,70	-17,5%						
7	49,70	50,00	-2,5%			N/A	N/A	N/A	N/A

Table 12. LFSM-U supplementary simulation example.

* The initial active power value of the PGM will be equal to 60% of P_{max}, so there will be a saturation of the response of LFSM-U mode after an increase of 40% of P_{max} when the maximum power of the plant is reached.

The acceptance criteria shall be the same as those stated in subsection 5.2.2.4.

The **PGM certificate** for this requirement shall be issued under the version corresponding to the version of the **PGU** and/or **ACPGM certificates** used, even if the **supplementary** simulations have been performed according to this version of the **Technical Standard**.

The information to be contained in the **supplementary simulation** report shall be analogous to that established in subsection 5.1.3

5.2.4. Assessment at PGM level for obtaining PGM certificate

In the event that the **PGM owner** does not have or does not wish to use the **equipment certificates** for **PGU** and **ACPGM** for this technical requirement, the tests and supplementary simulations described in subsections 5.2.2.1 and 5.2.2.3, respectively, must be performed at the **PGM** level. If the acceptance criteria for tests and simulations described in subsections 5.2.2.2 and 5.2.2.4 are met respectively, the **authorised certifier** shall issue an **PGM certificate** for this requirement without the need to perform the **supplementary simulations** stipulated in subsection 5.2.3.

5.3. Frequency Sensitive Mode (FSM)

5.3.1. Objective.

The objective is to verify that the **PGM** is capable to activate the power-frequency regulations reserve supply as stated in:

- article 8.2.5 of [1].

The compliance of the PGM with this requirement may be assessed by**:**

- **test and simulation**; or
- **equipment certificate**.

Possible **assessment levels** for this requirement are:

- **PGM,** or
- **PGU when:**
  - the **PGM** does not have a hierarchical power-frequency control higher than the **PGU** itself; and
  - The **ACPGM** does not limit the response of the **PGU** to this requirement.

For the **PPM** to be considered as "**PGM with inertia**", of the **PPM owner** shall submit to the **authorised certifier** the written compliance of the **TSO** with respect to compliance with the synthetic inertia requirement.

If there is a **ACPGM** that affects the control provided by the PGU **FSM**, in addition to the **PGU test** or the **PGU equipment certificates**, a **supplementary simulation** of the **PGM** shall be required, according to 5.3.3 to verify that the **FSM** requirement is met in **BC**, and not only at the **PGU** level.

In the absence of such **ACPGM**, the test and simulation of the **PGUs** or their **equipment certificates** shall be required, and the **supplementary simulation** shall not be required.

The system operator shall specify to the **PGM owner** the value required for the final **PGU** adjustment. The **PGM owner** shall be responsible for communicating this adjustment to the **authorised certifier** so that it can assess the acceptance criteria.

For clarification purposes, the requirement to be able to receive standby power setpoints to be lowered, as defined in article 8.2.5 (c) of [1], does not apply to generations that do not have a technical minimum of stable operation.

It is important to take into account the following terms:

- **Δf**: deviation of frequency f from 50 Hz (Δf = f – 50).
- **ΔP**: expected active power response in the event of a frequency deviation (Δf) calculated according to the following formula:

$$|\Delta P| = \frac{|\Delta f| - |Deadband|/2}{f_n} \times \frac{P_{max}}{s_1} \times 100$$

- **$|\Delta P_1|/P_{max}$**: Frequency response interval corresponding to the current value set by the **TSO**, which, according to [1], is equal to 10%.

For the purposes of this **Technical Standard** and in order to establish the response times, the following terms are introduced:

- **P_0**: active power of the **PGU** prior to performing a test (or frequency change).
- **P_{end}**: final active power of the **PGU after** performing a test (or frequency change).
- **ΔP_{test}:** deviation of the active power compared to the active power (P_0) prior to performing a test: $\Delta P_{test} = P_{end} - P_0$
- **Initial delay (t_1)**: **FSM** activation time. For the purposes of this **Technical Standard,** the reference to be used to measure this time shall be from the time when a frequency change is detected from which adjustment is expected until a 1% change in ΔP_{test}. If the frequency is modified by means of a power supply connected to the controller, 20 ms must be subtracted from setpoint change to the **PGU**, so that a complete cycle can be detected with this new frequency.
- **Full activation time (t_2)**: FSM activation time at a frequency change Δf_1 for which a response equal to $|\Delta P_1|/P_{max}$ (including initial delay t_1) is expected. For the purpose of determining t_2, the time corresponding to the value of P within the band ±1% of P_{max} for the tests or ±5% of ΔP_{test} around $|\Delta P_1|/P_{max}$ for simulations. However, and as far as this **Technical Standard** is concerned in the **tests**, a permanent error between the final measured value and the expected value, less than ±1% of the P_{max} of the PGU, shall be considered as admissible. If, for example, a frequency change Δf is applied, for which a P response of 10%P_{max} is expected, a test with a measured final P value between 9%P_{max} and 11%P_{max} is acceptable, which corresponds to a tolerance of ±10% of $|\Delta P_1|$

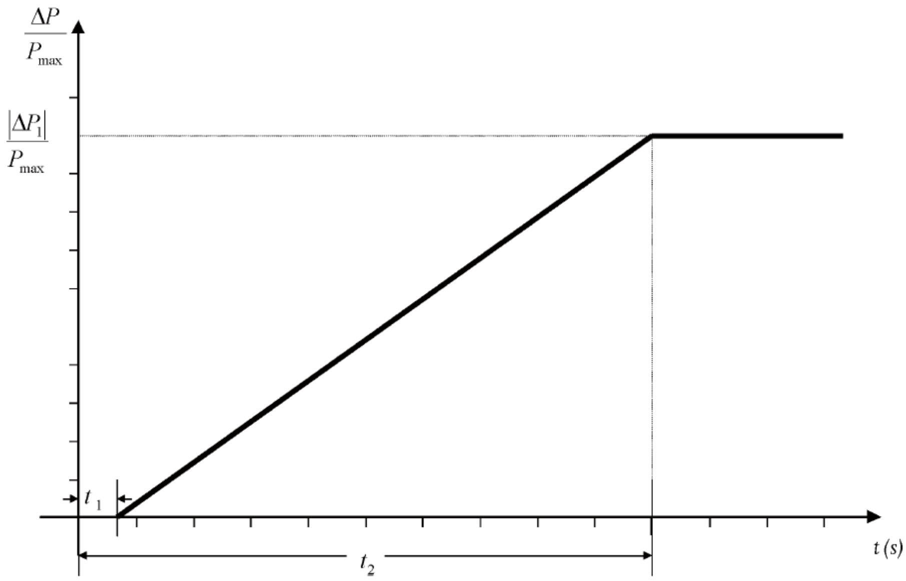


Figure 12. Response capacity of the FSM mode illustrating the times t_1, and t_2 defined above.

5.3.2. Assessment at PGU level for obtaining PGU certificate

5.3.2.1. PGU test method

This subsection describes how to **test the FSM activation time**.

To test this requirement, the **sequence of actions analogous to subsections 5.1.2.1 (LFSM-O) and 5.2.2.1 (LFSM-U)** shall be carried out.

It shall be verified, and reflected in the test report, that the **FSM** has implemented the following adjustments in the **PGU**:

- Response deadband with frequency variation equal to 50 mHz
- Response insensitivity with the frequency variation $|\Delta f_i|$ less than 30 mHz.
- The droop s_1 shall be equal to 4%.
- Active power interval in relation to the maximum capacity $|\Delta P_1|/P_{max}$= 10%.

The initial conditions to perform the test shall be at nominal frequency, f_n (50 Hz ± 10 mHz), nominal voltage (± 5%) and next initial active power (P_{ini}),, which shall ensure that the required power increases can be assessed within the time periods established in [1]:

- For both laboratory and field tests, the the initial active power **prior to the tests sequence** (P_{ini})must correspond to an intermediate value between the maximum capacity and the minimum level of regulations of the **PGU**, which allows variations in active power not exceeding the previous limits when performing the frequency steps displayed in **Table 13**.

The test shall be performed at zero reactive power. The tests to assess **FSM activation** and its **FSM activation time** are described below.

In **Table 13** the required tests and frequency steps (Δf) are described as well as the expected active power variation in each test (ΔP_{test}) and the required response times. The sequence of tests indicated in the following tables shall be followed, row by row starting from the final value of the previous test.

At least 1 minute shall be measured in each frequency step and in any case sufficient time shall be allowed to stabilize the response per frequency step and the average active power and corresponding times shall be recorded.

No. of test point	f_0 (Hz)	f_{end} (Hz)	ΔP_{test} expected ($\%P_{max}$)	ΔP_{test} recorded ($\%P_{max}$)	Deviation ($\%P_{max}$) ($<1\%P_{max}$)	t_1 (s)	t_2 (s)** (Band +/-1% P_{max})
FSM Over frequency							
1	50,00	50,10	-3,75%				N/A
2	50,10	50,20	-5,00%				N/A
3	50,20	50,00	8,75%				N/A
4*	50,00	50,30	-10,00%				
FSM Under frequency							
5	50,00	49,90	3,75%				N/A
6	49,90	49,80	5,00%				N/A
7	49,80	50,00	-8,75%				N/A
8*	50,00	49,70	10,00%				

Table 13. FSM Tests. 4% droop and active power range $|\Delta P_1|$= 10% with deadband equal to 50mHz.

* The active power interval in relation to the maximum capacity $|\Delta P_1|/P_{max}$ shall be equal to 10%, so there will be a saturation in this value.

** According to t_2 definition, it shall be measured over a frequency step for which an active power response equal to $|\Delta P_1|$/Pmax is expected. Therefore, the test points 4 and 8 must start from nominal frequency.

Optionally, and in the event that compliance of the FSM requirement is certified for both the **Technical Standard SENP** and the **Technical Standard NTS SEPE** [2], the following additional test shall be carried out without deadband and always with a response insensitivity with frequency variation $|\Delta f_i|$ less than 10 mHz.

No. of test point	f_0 (Hz)	f_{end} (Hz)	ΔP_{test} expected ($\%P_{max}$)	ΔP_{test} recorded ($\%P_{max}$)	Deviation ($\%P_{max}$) ($<1\%P_{max}$)	t_1 (s)	t_2 (s)** (Band +/-1% P_{max})
FSM Over frequency							
1	50,00	50,10	-4%				N/A
2	50,10	50,20	-4%				N/A
3	50,20	50,00	8%				N/A
4*	50,00	50,30	-10%				
FSM Under frequency							
5	50,00	49,90	4%				N/A
6	49,90	49,80	4%				N/A
7	49,80	50,00	-8%				N/A
8*	50,00	49,70	10%				

Table 14. FSM Tests. 5% droop and active power range $|\Delta P_1|$= 10% without deadband

* The active power interval in relation to the maximum capacity $|\Delta P_1|/P_{max}$ shall be equal to 10%, so there will be a saturation in this value.

** According to t_2 definition, it shall be measured over a frequency step for which an active power response equal to $|\Delta P_1|$/Pmax is expected. Therefore, t_2 shall be measured only in the test points 4 and 8.

5.3.2.2. PGU test acceptance criteria

The **PGM** shall be deemed **capable of activating the power-frequency adjustment reserve supply** if the following conditions are met:

1) No undamped oscillations occur in the response in the transition between test points.
2) The results meet the requirements established in [1].
3) Regarding response times:
    - Increase of active power in relation to the **maximum capacity** $|\Delta P_1|/P_{max}$ (frequency response interval) equal to 10%.
    - In the case of **PGMs** with inertia or synthetic inertia, the maximum admissible initial delay t_1 shall be equal to 300 ms.
    - In the case of **PGMs** without inertia or synthetic inertia, the maximum admissible initial delay t_1 shall be equal to 150 ms.
    - In the case of **PGMs** without inertia or synthetic inertia, the maximum admissible total activation time t_2 shall be 1s, unless the **TSO** allows longer activation times for system stability reasons.

4) In the tests, a deviation of ±1 % of the P_{max} at the active power recorded from the expected active power according to the tables in subsection 5.3.2.1 shall be permitted.

5.3.2.3. PGU simulation method

The methodology shall be similar to that described in subsections 5.1.2.3 and 5.2.2.3.

5.3.2.4. PGU simulation acceptance criteria

The criteria shall be similar to those described in subsections 5.1.2.4 and 5.2.2.4, considering the differences between the tolerances allowed for tests and simulations set out in that subsection.

5.3.3. Supplementary simulation for obtaining PGM certificate

If there is a **ACPGM** that affects the control provided by the **FSM** of the **PGU**, in addition to the **PGU test** or the **PGU equipment certificates**, a **supplementary simulation** of the **PGM** shall be required in order to verify that the **FSM** requirement is met in **BC**, and not only at the **PGU** level.

With the <u>full model of the **PGM**</u> - equivalent models will not be supported, with the exception specified in subsection 7.5 - simulations shall be performed with the following initial conditions:

- P= 80% P_{max} at the **PGM** level.
- Voltage of 1 p.u. at the HV side of the **PGM** transformer.
- Q = 0 at the **PGM** level.
- A frequency f = 50 Hz.
- Infinite s_{cc} or network equivalent.
- Active power interval in relation to the maximum capacity $|\Delta P_1|/P_{max}$ equal to 10%.
- Response insensitivity with the frequency variation $|\Delta f_1|$ less than 30 mHz.

- Response deadband with frequency variation equal to 50 mHz.
- Droop s_1 equal to 4%.

The simulation shall perform a frequency sweep according to the following tables:

No. of test point	f_0 (Hz)	f_{end} (Hz)	ΔP_{test} expected ($\%P_{max}$)	ΔP_{test} recorded ($\%P_{max}$)	Deviation ($\%P_{max}$) ($<5\%\Delta P_{ensayo}$)	t_1 (s)	t_2 (s)** (Band +/-5% ΔP_{test} recorded)
1	50,00	50,02	0%				N/A
2	50,02	50,10	-3,75%				N/A
3	50,10	50,20	-5%				N/A
4	50,20	50,00	8,75%				N/A
5*	50,00	50,30	-10%				

Table 15. Supplementary FSM simulation (overfrequency).

No. of test point	f_0 (Hz)	f_{end} (Hz)	ΔP_{test} expected ($\%P_{max}$)	ΔP_{test} recorded ($\%P_{max}$)	Deviation ($\%P_{max}$) ($<5\%\Delta P_{ensayo}$)	t_1 (s)	t_2 (s)** (Band +/-5% ΔP_{test} recorded)
1	50,00	49,98	0%				N/A
2	49,98	49,90	+3,75%				N/A
3	49,90	49,80	+5%				N/A
4	49,80	50,00	-8,75%				N/A
5*	50,00	49,70	+10%				

Table 16. Supplementary FSM simulation (underfrequency).

* The active power interval in relation to the maximum capacity $|\Delta P_1|/P_{max}$ shall be equal to 10%, so there will be a saturation in this value.
** According to t_2 definition, it shall be measured over a frequency step for which an active power response equal to $|\Delta P_1|$/Pmax is expected. Therefore, t_2 shall be measured only in test 5.

The acceptance criteria will be the same as those stated in subsection 5.3.2.4.

The **PGM certificate** for this requirement shall be issued under the version corresponding to the version of the **PGU** and/or **ACPGM certificates** used, even if the **supplementary** simulations have been performed according to this version of the **Technical Standard**.

The information to be contained in the **supplementary simulation** report shall be analogous to that established in subsection 5.1.3.

5.3.4. Assessment at PGM level for obtaining PGM certificate

In the event that the **PGM owner** does not have or does not wish to use the **equipment certificates** for **PGU** and **ACPGM** for this technical requirement, the tests and supplementary simulations described in subsections 5.3.2.1 and 5.3.2.3, respectively, must be performed at the **PGM** level. If the acceptance criteria for tests and simulations described in subsections 5.3.2.2 and 5.3.2.4 are met respectively, the **authorised certifier** shall issue an **PGM certificate** for this requirement without the need to perform the **supplementary simulations** stipulated in subsection 5.3.3.

5.4. Capability to limit the production up and down ramps

5.4.1. Objective.

The objective is to verify that the **PGM** is capable to adjust the value of the production up or down ramps **according to the instructions provided to the PGM owner by the TSO or RSO**, as stated in:

- Article 8.2.2.c of [1].

The compliance of the PGM with this requirement may be assessed by tests.

Possible **assessment levels** for this requirement are:

- **PGM,** or
- **PGU when:**
    - The **PGM** does not have a hierarchical power-frequency control higher than the **PGU** itself; and
    - The **ACPGM** does not influence the response of the **PGU** to this requirement.

However, the **assessment of this requirement** shall be made by the **TSO** in accordance with the **test protocols established in the regulations in force at the time of commissioning of the PGM**, which shall be indicated by the **TSO** to the **PGM owner.**

5.5. Active power control capability and range

The purpose is to verify that the **PGM** is capable to **adjust an active power setpoint according to the instructions provided to the PGM owner by the TSO or RSO** as stated in:

- Article 8.2.2 a of [1].

The compliance of the PGM with this requirement may be achieved through:

- **Test,** or
- **equipment certificate**.

Possible **assessment levels** for this requirement are:

- **PGM,** or
- **PGU when:**
    - The **PGM** does not have a hierarchical power-frequency control higher than the **PGU** itself; and
    - The **ACPGM** does not influence the response of the **PGU** to this requirement.

The test shall be performed by the **accredited entity** in accordance with subsection 8.4.2 of [5], applying it also to **PPM** of photovoltaic technology or PGMS as far as possible, i.e. any particular aspects of wind technology that are not applicable to photovoltaic technology must not be considered.

The test report shall be assessed by the **authorised certifier.**

5.6. Synthetic inertia

5.6.1. Objective.

The objective is to verify that the **PPM** is capable to **emulate inertia during very fast frequency variations** as indicated in:

- article 8.4.1 of [1].

As long as this technical capability is not regulated in a system adjustment service, it shall be a **voluntary capability** on the part of the **PPM**.

Compliance with the synthetic inertia requirement shall be verified in the same way as is considered in NTS SEPE[2].

5.7. Reactive power capability at maximum capacity and below maximum capacity

5.7.1. Objective.

The objective is to verify that the **PGM** is **capable of supplying the required reactive power** to the maximum capacity of the **PGM** and below the maximum capacity of the **PGM** as stated in:

- Articles 8.3.1b and c for **SPGM** and 8.4.2a and b for **PPM,** of [1].

The compliance of the **PGM** with these requirements must be assessed by means of the **PGU test**, or by means of the **PGU equipment certificate**, in addition to **supplementary simulations** that verify that the capabilities of the **PGU, or, in the case of PGU with ACPGM and/or passive elements**, allow compliance of the capability of the **PGM** at the **NCP**, as required by [1].

Two alternative methods are proposed for carrying out the **supplementary simulations**:

- a complete modelling procedure described in subsection 5.7.3.1 through which the capabilities of the **PGM** at the **NCP** are assessed,
- an alternative modelling procedure described in subsection 5.7.3.2 specially indicated for the case where there are generation evacuation facilities between the **PGM** and the **NCP** shared by several **PGMs**. This procedure establishes an alternative modelling method of the **supplementary simulation** through which it is possible to assess this capability at **BC** (PGM terminals) of the **PGM** instead of at the **NCP**, making it possible to model the **PGM** only up to **BC**. In this way, the reactive power requirement can be monitored individually for each **PGM**.

5.7.2. Assessment at PGU level for obtaining PGU certificate

5.7.2.1. Test method for PGU of PPM

The following tests are applicable to **PGUs of PPM**.

The tests described in this subsection are intended to assess the **reactive power capability at the maximum capacity** of the **PGU** as well as the **reactive capacity below the maximum capacity** of the **PGU**.

The test conditions shall include some of the following:

- A power supply connected to the **PGU** terminals when the **PGU** is disconnected from the network.
- An element or method capable of modifying the voltage at the **PGU** connection point when the **PGU** is connected to the network.
- A fictitious signal that simulates voltage changes connected to the **PGU** controller. The **PGU** must perform as if this signal were the voltage reading on its terminals.
- Test bench, including all reactive power management elements.

The voltage values indicated for the tests are considered nominal values of the configuration under which each step of the test is performed, although configurations with a variation of ±2.5% of the nominal voltage over the proposed values shall be permitted. Since the **PGU** can change the voltage value during the test, this margin of variation over measured values shall not be considered.

The following **sequence of actions** shall be followed for **testing this requirement**:

- The **reactive power control mode** of the **PGU** shall be selected at **fixed reactive power** setpoint.
- The tests described in **Table 17** shall be performed:
- Without prejudice to the fact that the tests under this subsection must be carried out on **PGU** terminals, in addition, in order to ensure **compliance by the PGM with this requirement at the NCP**, it shall always be necessary to carry out **supplementary simulations** to assess the entire **PGM** as a whole as described in 5.7.3.

Through the **PGU** test, the **maximum reactive power capability** of the **PGU** for different operating points of active power and voltage at **PGU** terminals shall be verified, establishing the test parameters listed in **Table 17**. For each operation point specified in **Table 17**, the **maximum reactive power** value in production (leading or capacitive) state or consumption (lagging or inductive) state that the **PGU** can provide must be noted:

P/P_{max} range [%]	U	Qmax inductive measure [MVAr]	Qmax capacitive measure [MVAr]	Duration of test
>90%	95%Un			60 min
>90%	105%Un			60 min
>90%	100%Un			5 min
10-20%*	95%Un			5 min
10-20%*	105%Un			5 min
10-20%*	100%Un			5 min
0-10%*	95%Un			5 min
0-10%*	105%Un			5 min
0-10%*	100%Un			5 min

Table 17. Reactive power test parameters at the maximum capacity of the PGU of PPMs.

*In the case of field test where the primary resource cannot be regulated, the limitation by control is allowed to be in the required power range.

5.7.2.2. Test method for PGU of PGMS

The following tests are applicable to **PGU of SPGM**.

The tests described in this subsection are intended to assess the **reactive power capability at the maximum capacity** of the **PGU** as well as the **reactive power capability below the maximum capacity** of the **PGU**.

The test conditions shall include some of the following:

- A power supply connected to the terminals of the **PGU** when the **PGU** is disconnected from the network.
- An element or method capable of modifying the voltage at the **PGU** connection point when the **PGU** is connected to the network.
- A fictitious signal that simulates voltage changes connected to the **PGU** controller. The **PGU** must behave as if this signal were the voltage reading on its terminals.
- Test bench.

The voltage values indicated for the tests are considered nominal values of the configuration under which each step of the test is performed, although configurations with a variation of ±2.5% of the nominal voltage over the proposed values shall be permitted. Since the **PGU** can change the voltage value during the test, this margin of variation over measured values shall not be considered.

The following **sequence of actions** shall be followed for **testing this requirement**:

- The **reactive power control mode** of the **PGU** shall be selected at **fixed reactive power** setpoint.
- The tests described in **Table 18** shall be performed:
- Without prejudice to the fact that the tests under this subsection must be carried out on **PGU** terminals, in addition, in order to ensure **compliance by the PGM with this requirement at the NCP**, it shall always be necessary to carry out **supplementary simulations** in order to assess the entire **PGM** as a whole as described in 5.7.3.

Through the **PGU** test, the **maximum reactive power capability** of the **PGU** for different operating points of active power and voltage on terminals of the **PGU** shall be verified, establishing the test parameters listed in **Table 18**. For each operation point specified in **Table 18**, the **maximum reactive power** value in production (leading or capacitive) state or consumption (lagging or inductive) state that the **PGU** can provide must be noted:

P/P_{max} range [%]	U	Qmax inductive measure [MVAr]	Qmax capacitive measure [MVAr]	Duration of test
100%	95%Un			60 min
100%	105%Un			60 min
100%	100%Un			5 min
60-70 %	95%Un			5 min
60-70 %	105%Un			5 min
60-70 %	100%Un			5 min
Technical minimum of stable operation	95%Un			5 min
Technical minimum of stable operation	105%Un			5 min
Technical minimum of stable operation	100%Un			5 min

Table 18. Reactive power test parameters at the maximum capacity of the PGU of PGMS.

5.7.2.3. PGU test acceptance criteria

The **authorised certifier** must verify that the results of the maximum reactive power tests of the PGU as stated in **Table 17** or in **Table 18** are consistent with the P-Q diagram of the **PGUs** for the different voltages, i.e., the maximum reactive power values recorded in the tests are greater than or equal to those shown in the P-Q diagrams of the **PGUs**.

Once the above has been verified, in order to ensure **compliance by the PGM with the reactive power requirements** and thus obtain the **PGM certificate**, **supplementary simulations** shall always be required in order to assess the entire **PGM** as described in subsections 4.2 and 5.7.3.

5.7.3. Supplementary simulation for obtaining PGM certificate

The **supplementary simulation** report shall contain, at least, the following information:

- Description of the **PGM**, including **BC.**
- **PGM** model:
  - Simulation platform and version.
  - Description of the modelling of the **PGM** components necessary to perform loadflow simulations.
- Outcomes:
  - Tables completed indicating the compliance of each loadflow simulation.
  - Exportable simulation packages. Upon request of the **RSO**, the model of the **PGM** used in the loadflow simulations will be delivered.
- Conclusions.

5.7.3.1. Complete modelling procedure in NCP

In order to obtain the **PGM certificate** based on **PGU** level tests or **PGU** certificates, it shall be necessary to perform a **supplementary simulation** demonstrating that the **PGU** capabilities meet the reactive power requirement at the **NCP**, based on the capacities declared in the **PGU** level tests and simulations and, where applicable, the **ACPGM**.

The **PGM** maximum design temperature, as defined by the **PGM owner**, shall be considered. The capacities (active and reactive power) of the **PGU** at the **PGM** maximum design temperature, according to the information provided by the manufacturer of the **PGU**, shall be used to carry out the supplementary simulations.

Issues related to network modelling to be considered in the **supplementary simulation** and consideration of other **PGMs** that could share **NCP** with the **PGM** to be assessed, are detailed in subsection 7.4.2.1.

With this model, and taking into account the maximum reactive power of the **PGU** and/or **ACPGM**, load flows shall be performed under the active power conditions of the **PGU** and voltage at the **NCP** listed in **Table 19** and **Table 20**, and the reactive power consumed or generated in the **NCP** shall be recorded. The active power value P/P_{max} [%] indicated shall be referred to the active power of the **PGM** under assessment and may be considered at **BC** of the **PGM**.

P/P_{max} [%]	U at NCP	Q at NCP	Required value at NCP Q/P_{max}
100%	95%Un		0
100%	100%Un		-0,15
100%	105%Un		-0,3
100%	95%Un		0,2
100%	100%Un		0,15
100%	105%Un		0
40%	100%Un		-0,15
20%	100%Un		-0,15
10%	100%Un		-0,15
10%	100%Un		0,15
20%	100%Un		0,15
40%	100%Un		0,15
80%	100%Un		0,15

Table 19. Parameters for supplementary simulation of the reactive power capability of PPMs.

P/P_{max} [%]	U at NCP	Q at NCP	Required value at NCP Q/P_{max}
100%	95%Un		0
100%	100%Un		-0,15
100%	105%Un		-0,3
100%	95%Un		0,3
100%	100%Un		0,15
100%	105%Un		0

Table 20. Parameters for supplementary simulation of the reactive power capability of PGMSs.

5.7.3.2. Alternative modelling procedure in case of shared evacuation network

Where there is a shared evacuation network from the **BC** of the **PGM** on which the simulation is being conducted to the **NCP**, the compliance assessment of the reactive power capabilities of the **PGM** at the **NCP** is complex. The reactive power requirements listed in [1] apply at the **NCP**, however, taking into account this case law, and in order to simplify the compliance assessment process, this subsection proposes an alternative **PGM** verification procedure to the one described in subsection 5.7.3.1.

For the reasons mentioned above, the compliance assessment of the **PGM**'s reactive power capability requirements at **BC** rather than at the **NCP** shall be accepted. However, this simplification of the compliance assessment of the **PGM**'s **BC** requirement means that at some **PGM**'s operating points, the reactive power values required at **BC** of the **PGM** differ from those required at the **NCP**, i.e. the reactive power values listed in [1].

In order to obtain the **PGM certificate** based on **PGU** level tests or **PGU** certificates, it shall be necessary to perform **supplementary simulations** to demonstrate that the **PGU** capabilities are: as declared in the tests and simulations at **PGU** level and, if applicable, **ACPGM**, meet the reactive power capability values at **BC** listed in **Table 21**, **Table 22**, **Table 23** or **Table 24**, as applicable.

The **PGM** maximum design temperature, as defined by the **PGM owner**, shall be considered. The capacities (active and reactive power) of the **PGU** at the **PGM** maximum design temperature, according to the information provided by the manufacturer of the **PGU**, shall be used to carry out the supplementary simulations.

The network modelling issues to be considered in the **supplementary simulation** and consideration of other **PGMs**, if applicable, are detailed in subsection 7.4.2.2, in which two cases are distinguished, depending on the location of **BC**[7]:

Case A:

If the **BC** of the **PGM** is located at the HV side of the **PGM** step-up transformer (**LAT**)**,** the instructions in the Case A alternative modelling procedure described in subsection 7.4.2.2.1 shall be followed, and the reactive power checkpoints listed in **Table 21** and **Table 22** shall be considered for a **PPM** or **SPGM**, respectively.

P/P_{max} [%]	U at BC (LAT)	Q at BC (LAT)	Required value at BC (LAT) Q/P_{max}
100%	95%Un		-0,3
100%	100%Un		-0,3
100%	105%Un		-0,3
100%	95%Un		0,2
100%	100%Un		0,2
100%	105%Un		0,2
40%	100%Un		-0,3
20%	100%Un		-0,3
10%	100%Un		-0,15
10%	100%Un		0,15
20%	100%Un		0,3
40%	100%Un		0,3
80%	100%Un		0,3

Table 21. Parameters for supplementary simulation of the reactive power capability of PPMs, alternative in case of shared evacuation network. Case A.

P/P_{max} [%]	U at BC (LAT)	Q at BC (LAT)	Required value at BC (LAT) Q/P_{max}
100%	95%Un		-0,3
100%	100%Un		-0,3
100%	105%Un		-0,3
100%	95%Un		0,2
100%	100%Un		0,2
100%	105%Un		0,2

Table 22. Parameters for supplementary simulation of the reactive power capability of PGMSs, alternative in case of shared evacuation network. Case A.

[7] See definition of **BC**.

Case B:

If the **BC** of the **PGM** is located at the LV side of the **PGM** step-up transformer, the instructions in the Case B alternative modelling procedure described in subsection 7.4.2.2.2 shall be followed, and the reactive power checkpoints listed in **Table 23** and **Table 24** shall be considered for a **PPM** or S**PGM**, respectively.

P/P_{max} [%]	U at LAT	Q at BC	Required value at BC Q/P_{max}
100%	95%Un		-0,3
100%	100%Un		-0,3
100%	105%Un		-0,3
100%	95%Un		0,3
100%	100%Un		0,3
100%	105%Un		0,3
40%	100%Un		-0,3
20%	100%Un		-0,3
10%	100%Un		-0,15
10%	100%Un		0,15
20%	100%Un		0,4
40%	100%Un		0,4
80%	100%Un		0,4

Table 23. Parameters for supplementary simulation of the reactive power capability of PPMs, alternative in case of shared evacuation network. Case B

P/P_{max} [%]	U at LAT	Q at BC	Required value at BC Q/P_{max}
100%	95%Un		-0,3
100%	100%Un		-0,3
100%	105%Un		-0,3
100%	95%Un		0,3
100%	100%Un		0,3
100%	105%Un		0,3

Table 24. Parameters for supplementary simulation of the reactive power capability of PGMSs, alternative in case of shared evacuation network. Case B.

5.7.4. Supplementary simulation acceptance criteria

The **authorised certifier** shall assess:

- **Equipment certificates** of **PGUs of PGM**.
- Information about all **ACPGM** of **PGM** according to subsection 4.6.
- Curved P-Q diagrams at different voltages of the **PGUs**.
- Results of maximum reactive power tests of the **PGUs**.
- That the capacities (active and reactive power) of the **PGUs** have been used to take into account the **PGM** maximum design temperature in the supplementary simulations.
- The data and parameters of the cables, lines and internal transformers of the **PGM**.
- In the case of supplementary simulation by the complete modelling procedure, the data of the connection network from the PGM up to the **NCP**.
- In the case of supplementary simulation by the alternative modelling procedure, and the **PGM** is Case B, the data of the shared step-up transformer.

- The results of the **supplementary simulation**, taking into account that they may follow the complete or alternative modelling procedure described in subsections 5.7.3.1 and 5.7.3.2, as appropriate.

The **reactive power capability of the PGUs** shall be considered validated when the results of the **supplementary simulation** listed in the relevant table demonstrate that the reactive power capabilities of the **PGUs** and/or **ACPGMs** measured in the tests comply with the values required in the corresponding tables.

Once the **supplementary simulation** has been validated, together with the **PGU** level tests and/or **PGU** certificates and the rest of the documentation, the **authorised certifier** may issue the **PGM certificate** for the reactive power requirement.

5.7.5. Assessment at PGM level for obtaining PGM certificate

In the event that the **PGM owner** does not have or does not wish to use the **equipment certificates** for **PGU** and **ACPGM** for this technical requirement, the tests described in subsection 5.7.2 must be performed, as well as the **supplementary simulations** described in subsection 5.7.3. If the acceptance criteria for each of these subsections are met, the **authorised certifier** shall issue an **PGM certificate** for the reactive power requirement.

5.8. Reactive power control in PPM

5.8.1. Objective.

The purpose of this test is to verify that the **PPM** is capable of controlling the reactive power according to:

- Article 8.4.2.c of [1].

Compliance of the **PPM** with this requirement shall be either by means of an **PGU** level **test** or an **PGU equipment certificate**, for which it will be necessary to complete the test with a **supplementary simulation**, or through testing at the **PPM** level.

5.8.2. Assessment at PGU level for obtaining PGU certificate

It shall be necessary to assess the reactive power control modes of the **PGUs** as described in subsections 5.8.2.1, 5.8.2.2.

The tests shall always be carried out at active power between 20% and 100% of the maximum capacity of the **PGU**.

5.8.2.1. Voltage control mode

5.8.2.1.1. Voltage control mode test

To **test the voltage control mode**, one of the following options shall be used:

- A power supply capable of maintaining the specified voltage on **PGU** terminals.
- A signal generator capable of injecting a voltage signal into the voltage control of the **PGU**, simulating voltage changes and serving the **PGU** to regulate the reactive production.
- A fictitious signal that simulates voltage changes connected to the PGU controller.

For each test, the voltage values in **PGU** terminals or in the control system specified in **Table 25**, **Table 26** and **Table 27** shall be sequentially set, according to which the tests are repeated for control slope values of 2% and 7%.

For each test, the following values shall be noted in the table:

- **Reactive power measured** in terminals of the **PGU** after its stabilization, calculated from the voltage and current measurements.
- **Time t_1 and time t_2**, where t_1 is the time when the reactive power response reaches 90% of the reactive variation, and t_2 is the time when the final value is stabilized, as defined in [1]

U at PGU terminals [p.u.]	U setpoint [p.u.]	Q measured	Q required (%P_{max})	t_1 measured	t_1 max	t_2 measured	t_2 max
1,0	1,00		0,0% ±1,5% P_{max}	-	-	-	-
1,02	1,00		-8,6% ±1,5% P_{max}		5 s		60 s
1,05	1,00		-21,4%±1,5% P_{max}		5 s		60 s
0,98	1,00		8,6%±1,5% P_{max}		5 s		60 s
0,95	1,00		21,4%±1,5% P_{max}		5 s		60 s
1,00	1,00		0,0% ±1,5% P_{max}		5 s		60 s

Table 25. Voltage control mode test parameters for 7% slope.

*These values of column “Q measured” could be saturated in the maximum reactive power capability of the **PGU** and declared in subsection 5.7.2.1 and in the P-Q diagrams at different voltages of the **PGU**.

U at PGU terminals [p.u.]	U setpoint [p.u.]	Q measured	Q required (%P_{max})	t_1 measured	t_1 max	t_2 measured	t_2 max
1,0	1,00		0,0%±1,5% P_{max}	-	-	-	-
1,02	1,00		-30%±1,5% P_{max}		5 s		60 s
1,05	1,00		-75%*±1,5% P_{max}		5 s		60 s
0,98	1,00		30%±1,5% P_{max}		5 s		60 s
0,95	1,00		75%*±1,5% P_{max}		5 s		60 s
1,00	1,00		0,0% ±1,5% P_{max}		5 s		60 s

Table 26. Test parameters of the voltage control mode for 2% slope.

*These values of column “Q measured” could be saturated in the maximum reactive power capability value of the **PGU** declared in the test specified in subsection 5.7.2.1 and in P-Q diagrams at different voltages of the **PGU**.

U at PGU terminals [p.u.]	U setpoint [p.u.]	Q measure	Q required (%P_{max})	t_1 measured	t_1 max	t_2 measured	t_2 max
1,0	1,00		0,0%±1,5% P_{max}	-	-	-	-
1,02	1,00		0,0%±1,5% P_{max}		5 s		60 s
1,05	1,00		-38%*±1,5% P_{max}		5 s		60 s
0,98	1,00		0,0%±1,5% P_{max}		5 s		60 s
0,95	1,00		38%*±1,5% P_{max}		5 s		60 s
1,00	1,00		0,0% ±1,5% P_{max}		5 s		60 s

Table 27. Voltage control mode test parameters for 2% slope and with deadband of 5%.

*These values of column “Q measured” could be saturated in the maximum reactive power capability value of the **PGU** declared in the test specified in subsection 5.7.2.1 and in P-Q diagrams at different voltages of the **PGU**.

In order to ensure proper stabilization of the electrical parameters of the **PGU**, at least 1 minute shall be reserved before a test is carried out without sending new reactive power setpoints.

5.8.2.1.2. Acceptance criteria for PGU voltage control mode tests

The test shall be considered valid when the following conditions are met:

- The **PGU** is capable of modifying the reactive power output in the event of a voltage change.
- The measured values of reactive power once stabilized in the final value are in the range according to the limits established in **Table 25**, **Table 26** and **Table 27**.
- The response times t_1 and t_2 are equal to or less than the values specified in each case, according to the provisions of [1].

If any of the above conditions were not met, it would not mean that the test would be invalidated, but it would be necessary to verify, by means of supplementary simulations, that the abilities of the **PGUs** demonstrated in the tests, together with any other **ACPGM** are able to comply with the requirement at **PGM** level.

5.8.2.2. Power factor control mode

5.8.2.2.1. PGU power factor control Mode test

For **power factor control mode tests**, the terminal voltage of the **PGU** shall be the nominal voltage. If the **PPC** is to be used for the power factor control of the **PGU**, it must be in service for the **PGU** test.

During the test, the power factor logs shall be established as stated in **Table 28**. For each test, it shall be measured in **PGU** terminals, as applicable, and the measuring equipment shall always record voltage and current.

The following values shall be noted in the table:

- Reactive power measured at **PGU** terminals.
- Active power produced by the **PGU** at the time of Q measurement.
- The time it takes for the new power factor value to stabilize in the ±5% Q_{max} band after receiving a new setpoint or a variation in active power.

The values marked in **Table 28** shall be set as the power factor setpoint, and measures shall be taken to check whether the system reaches the determined value.

Setpoint power factor	Active power produced, P ($\%P_{max}$)	Q required (%P)	Tolerance [Q/P_{max}]	Q measured	t measured	t maximum
0,95 inductive		-32,9%	±1,5%P_{max}			60 s
0,96 inductive		-29,2%	±1,5% P_{max}			60 s
0,97 inductive		-25,1%	±1,5% P_{max}			60 s
0,98 inductive		-20,3%	±1,5% P_{max}			60 s
0,99 inductive		-14,3%	±1,5% P_{max}			60 s
1		0	±1,5% P_{max}			60 s
0,99 capacitive		14,3%	±1,5% P_{max}			60 s
0,98 capacitive		20,3%	±1,5% P_{max}			60 s
0,97 capacitive		25,1%	±1,5% P_{max}			60 s
0,96 capacitive		29,2%	±1,5% P_{max}			60 s
0,95 capacitive		32,9%	±1,5% P_{max}			60 s

Table 28. Acceptance criteria for the tests of the power factor control mode of the PGU.

Each measurement shall be at least 1 minute and at least 1 minute of stabilization shall be left before each recording.

5.8.2.2.2. Acceptance criteria for the tests of the power factor control mode of the PGU

The test shall be considered valid when the following conditions are met:

- The **PGU** is capable of modifying the reactive power output in the event of a power factor change.
- The measured values of the output reactive power of the power factor control are within the range defined in **Table 28**. For the sake of clarity, it is noted that, in such table, the expected Q value is a function of the active power produced by the **PGU** at the time of the test, whereas the tolerance is to be calculated on the basis of the maximum capacity of the **PGU**.
- The response time is less than the value indicated in **Table 28**.

If any of the above conditions were not met, it would not mean that the test would be invalidated, but it would be necessary to verify, by means of supplementary simulations, that the abilities of the **PGUs** demonstrated in the tests, together with any other **ACPGM** are able to comply with the requirement at **PGM** level.

5.8.3. Supplementary simulations for obtaining the PPM certificate

In order to obtain the **PPM certificate** based on **PGU** level tests or **PGU certificates**, **supplementary simulations** shall be required for each reactive power control mode, in such a way that it is demonstrated that the **PGUs** comply with the requirement of reactive power control modes within the required times.

The considerations regarding the necessary modelling, as well as the consideration of other **PGMs** that may share a connecting point with the PGM to be assessed, are listed in subsection 7.4.

The **supplementary simulation** report shall contain, at least, the following information:

- Description of the **PGM**, including **BC.**
- **PGM** model:
  - Simulation platform and version.
  - Equivalent network characteristics.
  - Data of the **PGU** model(s), including its validation certificate/report, simulation platform and version and parameters used in the simulations.
  - Data of the **ACPGM** model(s), including its validation certificate/report, simulation platform and version and parameters used in the simulations.
  - Description of the modelling of the other components of the **PGM**.
- Outcomes:
  - Tables completed indicating the compliance of each simulation.
  - Exportable simulation packages. Upon request of the **RSO**, the model of the **PGM** used in the simulations will be delivered.
- Conclusions.

In the event that any **ACPGM** is required to comply with any of the reactive power control modes, the authorised certifier must take into account the information provided by each of them pursuant to subsection 4.6 of this **Technical Standard**.

5.8.3.1. Supplementary simulation of voltage regulations mode.

For the simulation, the **PPM** shall produce an active power of at least 80% P_{max}. Voltage modifications shall be simulated as indicated in the relevant tables depending on the modelling procedure, with 2% and 7% voltage control slopes respectively and considering a deadband equal to 1,5%. The response of the control shall be checked by recording the reactive power output after the voltage modification, as well as the response time.

Regardless of this simulation, the **RSO** may request additional tests of the operation of the on-load voltage control. According to the topology of the **PPM** and the **PPM** evacuation network up to the **NCP**, if **BC** is not located at the **NCP**, if necessary, the **RSO** may request voltage setpoint values outside the range from 0,95 p.u. up to 1,05 p.u. to comply with the requirement at the **NCP**.

5.8.3.1.1. Full modelling procedure in NCP

The sequence of **supplementary simulations** indicated in **Table 29** and **Table 30** shall be carried out.

U at NCP [p.u.]	U setpoint at NCP [p.u.]	Q measured	Q required at NCPC (%P_{max})	t_1 measured	t_1 max	t_2 measured	t_2 max (s)
1,0	1,00		0,0% ±1,5%P_{max}	-	-	-	-
1,02	1,00		-5,4% ±1,5%P_{max}		5 s		60 s
1,05	1,00		-18,2%±1,5%P_{max}		5 s		60 s
1,02	1,00		-5,4% ±1,5%P_{max}		5 s		60 s
1,0	1,00		0,0% ±1,5%P_{max}		5 s		60 s
0,98	1,00		5,4% ±1,5%P_{max}		5 s		60 s
0,95	1,00		18,2%±1,5%P_{max}		5 s		60 s
0,98	1,00		5,4% ±1,5%P_{max}		5 s		60 s
1,0	1,00		0,0% ± 1,5%P_{max}		5 s		60 s

Table 29. Parameters of the supplementary simulation of the 7% voltage control mode in PPM according to the complete modelling procedure at NCP

U at NCP [p.u.]	U setpoint at NCP [p.u.]	Q measured	Q required at NCP (%P_{max})	t_1 measured	t_1 max	t_2 measured	t_2 max (s)
1,0	1,00		0,0% ±1,5%P_{max}	-	-	-	-
1,02	1,00		-18,7%±1,5%P_{max}		5 s		60 s
1,05	1,00		-63,8%*±1,5%P_{max}		5 s		60 s
1,02	1,00		-18,7%±1,5%P_{max}		5 s		60 s
1,0	1,00		0,0% ±1,5%P_{max}		5 s		60 s
0,98	1,00		18,7%±1,5%P_{max}		5 s		60 s
0,95	1,00		63,8%*±1,5%P_{max}		5 s		60 s
0,98	1,00		18,7%±1,5%P_{max}		5 s		60 s
1,0	1,00		0,0% ± 1,5%P_{max}		5 s		60 s

Table 30. Parameters of the supplementary simulation of the voltage control mode 2% slope in PPM according to the complete modelling procedure at NCP.

*These values of the "Q measured" column could be saturated depending on the maximum reactive power capability of the **PPM**.

** Although it does not apply (N/A) at that operation point because answers of up to 60 seconds are allowed, t_1 must be noted in the table.

5.8.3.1.2. Alternative modelling procedure in BC. Case A

The sequence of **supplementary simulations** indicated in **Table 31** and **Table 32** shall be carried out.

U at BC [p.u.]	U setpointat PPM [p.u.]	Q measured	Q required at BC (%P_{max})	t_1 measured	t_1 max	t_2 measured	t_2 max (s)
1,0	1,00		0,0% ±1,5%P_{max}	-	-	-	-
1,02	1,00		-5,4% ±1,5%P_{max}		5 s		60 s
1,05	1,00		- 18,2%±1,5%P_{max}		5 s		60 s
1,02	1,00		-5,4% ±1,5%P_{max}		5 s		60 s
1,0	1,00		0,0% ±1,5%P_{max}		5 s		60 s
0,98	1,00		5,4% ±1,5%P_{max}		5 s		60 s
0,95	1,00		18,2%±1,5%P_{max}		5 s		60 s
0,98	1,00		5,4% ±1,5%P_{max}		5 s		60 s
1,0	1,00		0,0% ± 1,5%P_{max}		5 s		60 s

Table 31. Parameters of the supplementary simulation of the voltage control mode for a 7% in PPM according to the alternative modelling procedure at BC Case A.

U at BC [p.u.]	U setpoint at PPM [p.u.]	Q measure d	Q required at BC (%P_{max})	t_1 measu red	t_1 max	t_2 measured	t_2 max (s)
1,0	1,00		0,0% ±1,5%P_{max}	-	-	-	-
1,02	1,00		-18,7%±1,5%P_{max}		5 s		60 s
1,05	1,00		-63,8%*±1,5%P_{max}		5 s		60 s
1,02	1,00		-18,7%±1,5%P_{max}		5 s		60 s
1,0	1,00		0,0% ±1,5%P_{max}		5 s		60 s
0,98	1,00		18,7%±1,5%P_{max}		5 s		60 s
0,95	1,00		63,8%*±1,5%P_{max}		5 s		60 s
0,98	1,00		18,7%±1,5%P_{max}		5 s		60 s
1,0	1,00		0,0% ± 1,5%P_{max}		5 s		60 s

Table 32. Parameters of the supplementary simulation of the voltage control mode for a 2% slope in PPM according to the alternative modelling procedure at BC Case A.

*These values of the “Q measured” column could be saturated depending on the maximum reactive power capability of the **PPM**.

** Although it does not apply (N/A) at that operation point because answers of up to 60 seconds are allowed, t_1 must be noted in the table.

5.8.3.1.3. Alternative modelling procedure in BC. Case B

A variation of these tests is noted in comparison with those of the previous subsection applicable to the general and special procedure in case A: the maximum reactive power capability of the **PPM** is greater, which has a direct impact on the slope value, which, as indicated in [1], refers to the maximum reactive power.

U at LAT [p.u.]	U setpoint at PPM [p.u.]	Q measured	Q required at BC (%P_{max})	t_1 measured	t_1 max	t_2 measured	t_2 max (s)
1,0	1,0		0,0% ±2%P_{max}	-	-	-	-
1,02	1,0		-7,1% ±2%P_{max}		5 s		60 s
1,05	1,0		-24,3% ±2%P_{max}		5 s		60 s
1,02	1,0		-7,1% ±2%P_{max}		5 s		60 s
1,0	1,0		0,0% ±2%P_{max}		5 s		60 s
0,98	1,0		7,1% ±2%P_{max}		5 s		60 s
0,95	1,0		24,3% ±2%P_{max}		5 s		60 s
0,98	1,0		7,1% ±2%P_{max}		5 s		60 s
1,0	1,0		0,0% ± 2%P_{max}		5 s		60 s

Table 33. Parameters of the supplementary simulation of the voltage control mode for a7% slope at PPM according to the alternative modelling procedure Case B.

U at LAT [p.u.]	U setpoint at PPM [p.u.]	Q measured	Q required at BC (%P_{max})	t_1 measured	t_1 max	t_2 measured	t_2 max (s)
1,0	1,0		0,0% ±2% P_{max}	-	-	-	-
1,02	1,0		-25%±2%P_{max}		5 s		60 s
1,05	1,0		-85%*±2%P_{max}		5 s		60 s
1,02	1,0		-25%±2%P_{max}		5 s		60 s
1,0	1,0		0,0% ±2%P_{max}		5 s		60 s
0,98	1,0		25%±2%P_{max}		5 s		60 s
0,95	1,0		85%*±2%P_{max}		5 s		60 s
0,98	1,0		25%±2%P_{max}		5 s		60 s
1,0	1,0		0,0% ± 2%P_{max}		5 s		60 s

Table 34. Parameters of the supplementary simulation of the voltage control mode for a 2% slope at PPM according to the alternative modelling procedure Case B.

*These values of the "Q measured" column could be saturated depending on the maximum reactive power capability of the **PPM**. In case of saturation of the reactive power response, it is sufficient to indicate in the table that the response times are lower than their limiting values without specifying the measured time.

** Although it does not apply (N/A) at that operation point because answers of up to 60 seconds are allowed, t_1 must be noted in the table.

5.8.3.2. Acceptance criterion of the supplementary simulation of the voltage regulations mode.

The **authorised certifier** shall assess:

- The results of the voltage control test of the **PGUs**.
- That the capacities (active and reactive power) of the **PGUs** have been used to take into account the **PGM** maximum design temperature in the supplementary simulations.
- Information about all **ACPGM of PPM** according to subsection 4.6.
- Results of maximum reactive power capability of the **PGU** and **PPM** tests.
- The data and parameters of the cables, lines and transformers of the **PPM**.
- In the case of supplementary simulation by the full modelling procedure at **NCP**, the data from the connection network up to the **NCP**.
- The results of the **supplementary simulation** of the voltage control of the **PPM**.

The **supplementary simulation** of the voltage control of the **PPM** shall be considered valid when the following conditions are met:

- The reactive power output, for each slope value and each voltage step at the **PPM** terminals specified in **Table 29 to Table 34**, as the case may be, is within the required value, taking into account the maximum deviation stated in the table.
- The **PPM** achieves 90 % of the change in the reactive power output in a time less than or equal to the rise time specified in the above tables and indicated as t_1.
- The reactive power output of the **PPM** is stabilized in a time less than or equal to the settling time specified in the above tables, and indicated as t_2.
- The simulation time of each voltage step is sufficient to check the settling time in such a way that complete stabilization of the response has been achieved before the simulation of the next step is performed.

5.8.3.3. Supplementary simulation of power factor control.

For the performance of the **supplementary simulation** of the power factor control mode, the **PPM** shall produce an active power of 80% P_{max}. The values established in **Table 35**, **Table 36** or **Table 37**, **as applicable**, shall be simulated as power factor setpoint, and the **PPM** output reactive power as well as the stabilization time shall be recorded.

As stated in subsection 5.7.3, the point at which the reactive power must be measured will, as a general rule, be the **NCP**. However, for any **PPMs** connected to a shared evacuation network with other **PGMs**, in order to facilitate the compliance monitoring process, the **PPM**'s **BC** assessment (special procedure, Case A and Case B).

5.8.3.3.1. Complete modelling procedure at NCP

U at NCP	Setpoint power factor	Q required at NCP (%P)	Tolerance [Q/P_{max}]	Q measured	t measured	t maximum
1,05	0,95 inductive	-26,29%	±1,5% P_{max}			60 s
1,05	0,96 inductive	-23,33%	±1,5% P_{max}			60 s
1,05	0,97 inductive	-20,05%	±1,5% P_{max}			60 s
1,00	0,98 inductive	-16,24%*	±1,5% P_{max}			60 s
1,00	0,99 inductive	-11,40%	±1,5% P_{max}			60 s
1,00	1	0,00%	±1,5% P_{max}			60 s
1,00	0,99 capacitive	11,40%	±1,5% P_{max}			60 s
1,00	0,98 capacitive	16,24%*	±1,5% P_{max}			60 s
0,95	0,97 capacitive	20,05%	±1,5% P_{max}			60 s
0,95	0,96 capacitive	23,33%	±1,5% P_{max}			60 s
0,95	0,95 capacitive	26,29%	±1,5% P_{max}			60 s

Table 35. Supplementary simulation parameters of the power factor control mode of the full modelling procedure at NCP.

*These values of the column "Q expected in NCP" could be saturated depending on the maximum reactive power capability of the **PPM** for these voltage levels at **NCP**.

5.8.3.3.2. Alternative modelling procedure at BC. Case A

U at BC	Setpoint power factor	Q required at BC (%P)	Tolerance [Q/P_{max}]	Q measured	t measured	t maximum
1,05	0,95 inductive	-26,29%	±1,5% P_{max}			60 s
1,05	0,96 inductive	-23,33%	±1,5% P_{max}			60 s
1,05	0,97 inductive	-20,05%	±1,5% P_{max}			60 s
1,00	0,98 inductive	-16,24%	±1,5% P_{max}			60 s
1,00	0,99 inductive	-11,40%	±1,5% P_{max}			60 s
1,00	1	0,00%	±1,5% P_{max}			60 s
1,00	0,99 capacitive	11,40%	±1,5% P_{max}			60 s
1,00	0,98 capacitive	16,24%	±1,5% P_{max}			60 s
0,95	0,97 capacitive	20,05%	±1,5% P_{max}			60 s
0,95	0,96 capacitive	23,33%	±1,5% P_{max}			60 s
0,95	0,95 capacitive	26,29%	±1,5% P_{max}			60 s

Table 36. Power factor control mode supplementary simulation parameters for the alternative modelling procedure at BC. Case A.

5.8.3.3.3. Alternative modelling procedure at BC. Case B

U at LAT	Setpoint power factor	Q required at BC (%P)	Tolerance [Q/P_{max}]	Q measured	t measured	t maximum
1,05	0,95 inductive	-26,29%	±2% P_{max}			60 s
1,05	0,96 inductive	-23,33%	±2% P_{max}			60 s
1,05	0,97 inductive	-20,05%	±2% P_{max}			60 s
1,00	0,98 inductive	-16,24%	±2% P_{max}			60 s
1,00	0,99 inductive	-11,40%	±2% P_{max}			60 s
1,00	1	0,00%	±2% P_{max}			60 s
1,00	0,99 capacitive	11,40%	±2% P_{max}			60 s
1,00	0,98 capacitive	16,24%	±2% P_{max}			60 s
0,95	0,97 capacitive	20,05%	±2% P_{max}			60 s
0,95	0,96 capacitive	23,33%	±2% P_{max}			60 s
0,95	0,95 capacitive	26,29%	±2% P_{max}			60 s

Table 37. Power factor control mode supplementary simulation parameters for the alternative modelling procedure at BC. Case B.

5.8.3.4. Acceptance criterion of the supplementary simulation of power factor control.

The **authorised certifier** shall assess:

- The results of the power factor control test of the **PGUs**.
- That the capacities (active and reactive power) of the **PGUs** have been used to take into account the **PGM** maximum design temperature
- Information about all **ACPGM** of **PPM** according to subsection 4.6.
- The data and parameters of the cables, lines and transformers of the **PPM**.
- In the case of supplementary simulation by the full modelling procedure at **NCP**, the data from the connection network up to the **NCP**.
- The results of the **supplementary simulation** of the power factor control of the **PPM**.

The **supplementary simulation** of the power factor control mode shall be considered valid when the following conditions are met:

- The reactive power output of the **PPM** for each power factor and voltage value at the **NCP** is equal to the value stated in **Table 35** is within the required value, taking into account that the maximum deviation indicated in the table.
- The reactive power output of the **PPM** must be stabilized in a time less than or equal to the time specified in **Table 35**.
- The reactive power output of the **PPM** for each power factor and voltage value at the **BC** is equal to the value stated in **Table 36** or **Table 37**, as the case may be, is within the required value, taking into account the maximum deviation stated in each table.
- The **PPM**'s reactive power output must be stabilized in a time less than or equal to the time specified in **Table 36** or **Table 37**, as applicable.
- The simulation time of each voltage step must be sufficient to check the settling time.

5.8.4. Assessment at PPM level for obtaining PPM certificate

In the event that the **PPM owner** does not have or does not wish to use the **equipment certificates** for **PGU** and **ACPGM** for this technical requirement, the tests described in subsection 5.8.2 as well as the **supplementary simulations** described in subsection 5.8.3 must be performed. If the acceptance criteria described in both subsections are met, the **authorised certifier** shall issue a **PPM certificate** for this requirement.

5.9. Power oscillations damping for SPGM

The objective is to verify that the **SPGM** is **capable to damp power oscillations**[8], through a power stabiliser (**PSS**), as indicated in:

- Article 8.3.1 f) of [1].

This requirement applies in the event that the **maximum capacity** of the **SPGM** is greater than 40 MW unless expressly indicated by the system operator.

Compliance shall be verified in the same way as is considered in NTS SEPE [2].

[8] As a clarification, the power oscillations to be damped by the PSS will be electromechanical, as there may be power oscillations of a non-electromechanical nature that cannot be damped by the PSS.

5.10. Power oscillations damping for PPM

The aim is to verify that the PPM complies with the following:

- Article 8.4.2. d) of [1].

Compliance shall be verified in the same way as is considered in NTS SEPE [2].

5.11. Robustness requirements: Fault ride through, transient overvoltage and fast fault current injection capabilities

5.11.1. Objective

The objective is to verify that the **PPM** is capable of meeting the following robustness requirements:

1. **Support voltage dips**, as specified in:
   - Article 8.4.3 of [1].

   The compliance of the **PPM** with this requirement must be assessed by **simulation** or through **equipment certificates**.

2. **Support transient overvoltage**, as specified in:
   - Articles 8.4.3 (g) and (h) of [1].

   The compliance of the **PPM** with this requirement must be assessed by **simulation** or through **equipment certificates**.

3. **Fast fault current injection** in case of faults, as stated in:
   - Article 8.4.3 of [1].

The compliance of the **PPM** with this requirement must be assessed by **simulation** or through **equipment certificates**.

The relevant simulations shall be performed by an **accredited entity** using a model certified in accordance with section 6, which describes the tests necessary for the validation of the model.

For the purpose of assessing the requirements related to robustness, in the event that it has not been possible to comply with them by test as stated in subsection 5.11.2, a certified model shall be required to accurately represent the behaviour of the **PPM** in order to perform the compliance simulations specified in those subsections. If the tests specified in subsection 5.11.2.2.1 have been successful and therefore the **PGU** meets the robustness requirements, simulations for the assessment of this requirement at **PPM** level shall not be considered necessary as detailed in subsection 5.11.3.

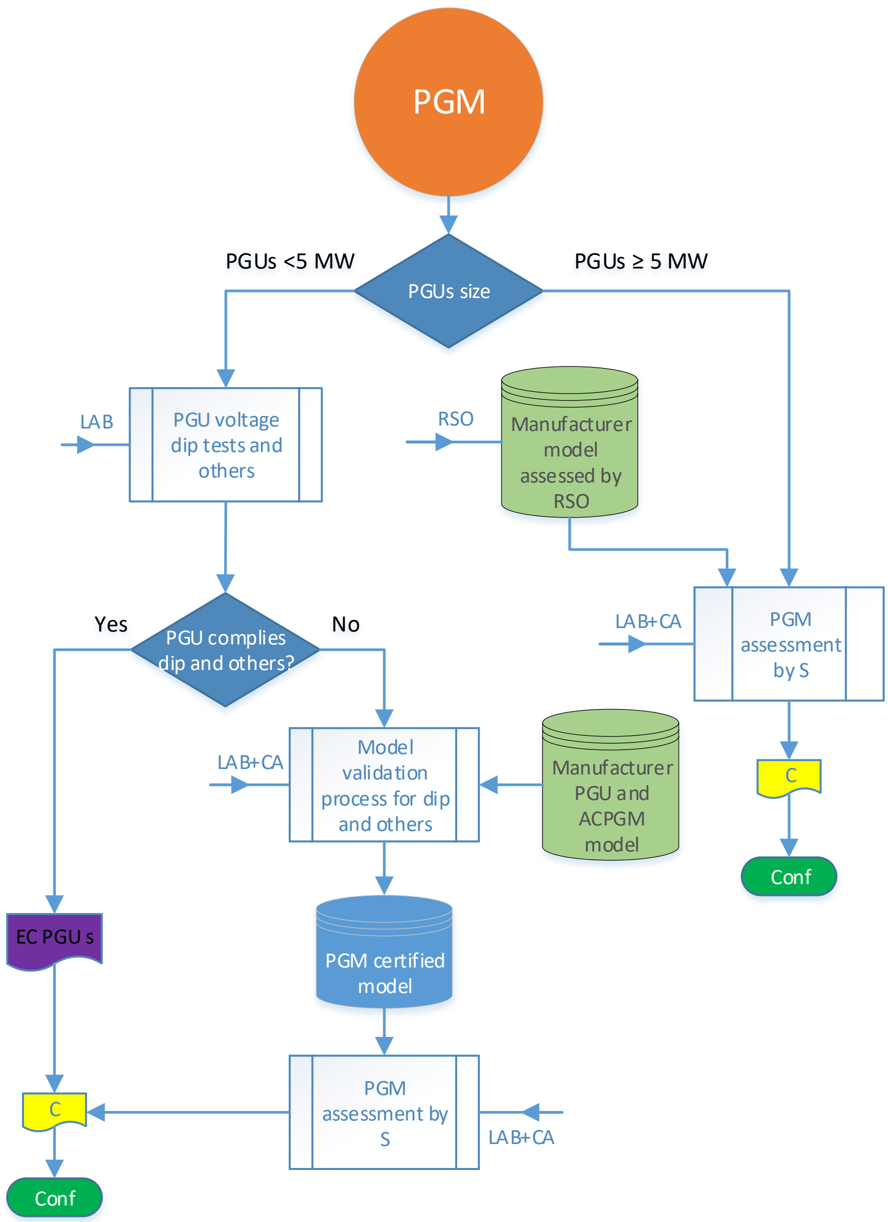


Figure 13. Detailed scheme of assessment of robustness requirements.

The structure presented in the scheme of **Figure 13** is developed below:

- In the case of **PPMs** consisting of **PGUs** of powers less than 5 MW, voltage dip (and related) tests shall be carried out on the **PGUs**:

    - If the **PGU** complies with the technical requirements specified in the tests of subsection 5.11.2, the **authorised certifier** shall issue an **PGU** equipment certificate for simulation of dip and related requirements. Therefore, in subsection 5.11, as explicitly stated, supplementary simulations shall not be required to assess compliance with these requirements. Compliance at the **PGU** level shall be equivalent to compliance at the **PPM** level.

- If the **PGU** does not comply with the technical requirements specified in the tests, it shall be necessary to have an **ACPGM** in order to comply with them at **PPM** level. In this case, certified models of **PGU** and **ACPGM** shall be required in order to construct the model of the **PPM** with which the simulations shall be performed in accordance with these requirements, as indicated in subsection 5.11. **PGU** and **ACPGM** models may have application limits beyond which they cease to be valid, e.g. an applicable minimum voltage. The **authorised certifier** shall verify that the terminal magnitudes of the **PGUs** and **ACPGMs** are within the above limits. **The model of the PPM shall be simulated over the network of subsection 7.2.**

- In the case of **PPMs** consisting of **PGUs** with a maximum capacity equal to or greater than 5 MW, they may opt to verify by means of a simulation model to carry out the compliance simulations in order to assess the technical requirements. Such simulation model shall be drawn up on the basis of the tests submitted by the **RSO** or **the PPM owner** (or the entity designated for this purpose, which may be the manufacturer) and which shall be approved by the **RSO**. Once the **RSO** accepts the simulation model, the owner of the **PPM** may use it for the assessment of the simulation requirements of this **Technical Standard**.

  Until such time as an assessment procedure for the simulation model is available, which is derived from the conclusions of the working group to be established for this purpose, the **RSO** shall assess the model and the methodology used to validate it on the basis of the tests indicated above, for which it shall have **2 months** from the time the information is complete.

5.11.2. Test method

The definition and conditions under which the test shall be carried out shall depend on the purpose of the test. Therefore, the tests may be used for:

- Simulation model validation according to 6, or
- for direct compliance with the technical requirement described in this subsection.

The tests described below, as indicated above, are intended to assess whether the **PGU** meets the robustness requirements.
This subsection specifies the conditions and validity criteria of the field or test bench test, as well as the definition of the equipment necessary to perform this test. It also specifies the measures to be taken to determine the parameters characteristic of the **PGU** dips response to be assessed.

The processes described in this subsection are valid for **PGU** of any power with a 3-phase connection to an electrical network.

The measurements shall be used to verify the characteristic parameters of the voltage dip response throughout the operating interval of the tested **PGU**.

The measured characteristics are only valid for the tested **PGU**. If the latter is considered to be a type **PGU**, variations in configuration or control that could affect its response to voltage dips would change the type consideration and require additional tests.

5.11.2.1. Test equipment

The use of the test equipment specified in any of the following references is recommended:

- Subsection 6.1 of [4].
- Subsection 8.5.2.2 of [5].
- Subsection 4.6.1.2 of [6].

5.11.2.2. Types of tests on PGU

The entire **PGU** must be tested in the field or on a test bench and must be performed by considering the operation points defined in **Table 38** for **PGU of PPM**.

The **PGU** to be tested shall be connected to the network through the test equipment, which will be able to produce the voltage dip by applying a short-circuit, as described in the test procedure. The voltage evolution during the tests must remain above the curve indicated in **Figure 14**, considering the tolerances indicated:

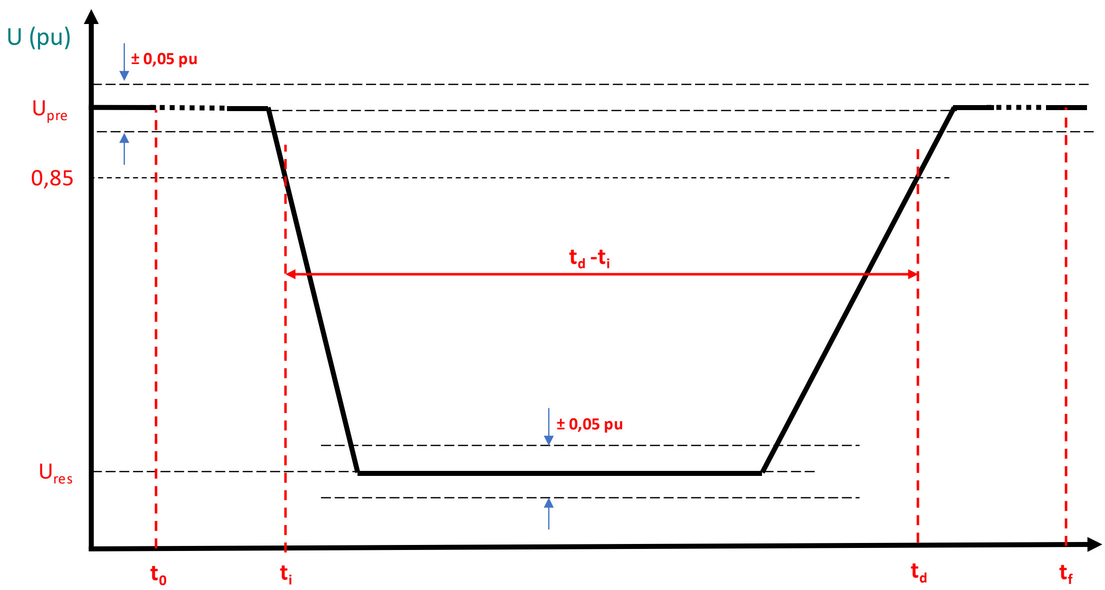


Figure 14. Dip test. Tensions and times. Tolerances.

The tolerances stated in **Figure 14** related to the voltage are expressed in p.u. of the pre-fault voltage (U_{pre}).

As a clarification, the start time of the fault, t_i, defined later in subsection 5.11.2.2.2, has been reflected in **Figure 14**, meeting only the criterion of that the positive voltage sequence drops by 0,85 p.u.

The internal electrical fault protection settings and schemes must not compromise the Fault ride Through Capability.

5.11.2.2.1. Tests to be performed at PGU of PPM

The **PGU of PPM** will be tested in the field, considering the operation points stated in **Table 38**:

Load	Recorded active power (field or test bench)	Recorded reactive power
Partial load (p_{med})	15%-50% P_{max}	**Table 39**
Full load	>90% P_{max}	**Table 39**
Minimum load (p_{min})	<15% Pmax*	**Table 39**

Table 38. Operation points prior to the PGU of PPM test.

* In the event of field tests where the primary resource cannot be regulated, the limitation by control is allowed to be in the required power range.

The **accredited entity** shall confirm that the tests have not sought a specific moment of occurrence and clearance of the short-circuit, nor a power factor of such a magnitude as to be particularly favourable to the permanence of the coupled **PGU** during the voltage dip. However, for each test, the value of the reactive power that the **PGU** must be generating or consuming is specified.

Several voltage dips corresponding to the requirement set out in **Figure 15** shall be generated and numbered according to the first column of **Table 39**, “Test Type”, and must be checked later if the records indicated in the tables in subsection 5.11.2.2.2 meet the acceptance criteria. **Two consecutive** tests shall be carried out for each type (or category) of test. It must be understood that no failed intermediate test has been performed between one test and another under the same conditions.

In order to assess the response time in the most unfavourable situation, the abrupt voltage change adjustment for tests must be parametrized at 0,15 p.u.

Type of Test	U_{res}(p.u.)	T_f(ms)	Type of fault	Load	Q/P_{max}	K[9]
$U5TP_{max.}$	0%Un (±5%)	≥500	3-phase	Full	0 ± 10%	K=3.5
$U5TP_{med}$				Partial	0 ± 10%	K=3.5
$U5BP_{max}$			2-phase	Full	0 ± 10%	K=3.5
$U5BP_{med}$				Partial	0 ± 10%	K=3.5
$U20TP_{max}$	20%Un (±5%)	≥620	3-phase	Full	0 ± 10%	K=3.5
$U20TP_{med}$				Partial	0 ± 10%	K=3.5
$U20BP_{max}$			2-phase	Full	0 ± 10%	K=3.5
$U20BP_{med}$				Partial	0 ± 10%	K=3.5
$U75TP_{max}$	75%Un (±5%)	≥945**	3-phase	Full	0 ± 10%	K=3.5
$U75TP_{med}$				Partial	0 ± 10%	K=3.5
$U75TP_{med}Q_{max}$[10]					Q_{max}/P_{max}	K=3.5
$U75TP_{med}Q_{min}$[11]					Q_{min}/P_{max}	K=3.5
$U75TP_{min}$				P_{min}*	0 ± 10%	K=6
$U75BP_{max}$			2-phase	Full	0 ± 10%	K=3.5
$U75BP_{med}$				Partial	0 ± 10%	K=3.5
$U75BP_{min}$				P_{min}*	0 ± 10%	K=6

Table 39. Tests of voltage dips to be performed for PPM

*In the case of field test where the primary resource cannot be regulated, the limitation by control is allowed to be in the required power range.

** If compliance with the robustness requirements of both **Technical Standard SENP** and **Technical Standard NTS SEPE** [2] is certified, it shall be necessary to make the dip at 75%Un with a time t_f greater than 1340ms.

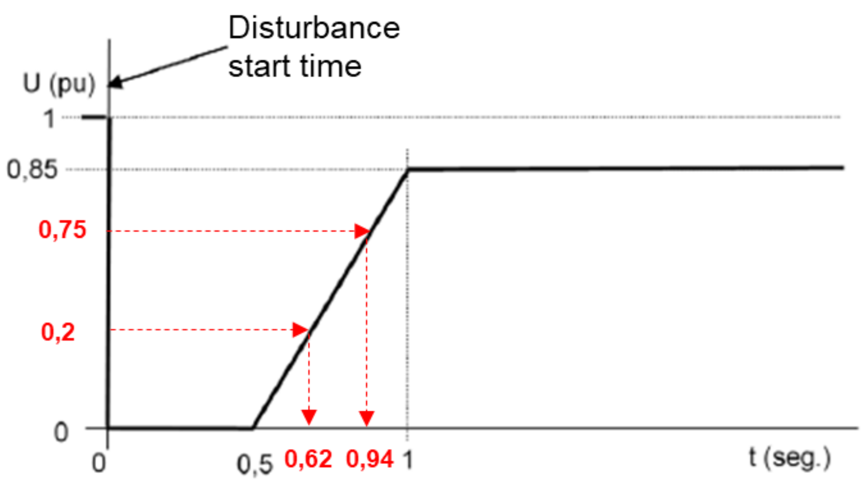


Figure 15 Profile of the capacity to support voltage dips of a PPM.

[9] According to [1]: K refers to K_1 or K_2, which are the gains from the fast current injection control, adjustable between 2 and 6 p.u. The default value of K_1 and K_2 shall be 3.5, unless expressly indicated by the system operator.
[10] Q_{max} is the maximum reactive injection capacity of the PGU.
[11] Q_{min} is the maximum reactive absorption capacity of the PGU.

5.11.2.2.2. Documentation of PPM tests

The active power, reactive power and voltage measurement methodology specified in [5] shall be used.

The following definitions, related to times, in the voltage dip shall be considered:

- t_0: Start of data recording.
- t_i: Time when the positive voltage sequence drops below 0,85 p.u. or current is detected in the short-circuit branch (value greater than 0,01 p.u.).
- t_a: Activation time. Time when the PGU is considered to have reacted to the dip. To measure it, the time from t_i until the fast current injection response has a greater variation of 5% of the nominal reactive current relative to its average t_i-60s value to t_i will be used.
- t_r: Rise time. Time counted after t_a until the fast current injection reaches 90% of its target value.
- t_d: Time when the positive voltage sequence exceeds 0,85 p.u.
- t_f: End of data recording.

These times shall meet the following requirements:

- The pre-fault recording time (t_i-t_0) must be at least 60 seconds.
- The fault time (t_d-t_i) shall be equal to or greater than those specified in **Table 40**, **Table 41** and **Table 42**.
- The post-fault recording time (t_f-t_d) must be at least 10 seconds or until a damped response is observed.

The following documentation shall be provided for each of the tests performed for the purpose of assessing whether the **PGU** test is valid for direct compliance with the technical requirements for robustness, as listed in the following tables: depending on the criteria established for each technical requirement of robustness, in particular as set out in the following subsections.

	Magnitude	Description
General Information	Type of test	
	Type of fault	
	Occurrence of the t_i fault	
	Clearing the t_d fault	
	Duration of the fault	
	t_f registration time	

Table 40. Information tests of voltage dips to PPM (I).

	Magnitude	Sequence	Time reference
PRE-FAULT: Information recorded prior to the operation of the fault to generate the dip (t_i)	Voltage (p.u.)	Pos.	1) t_i-60s to t_i 2) t_i-500ms to t_i -100ms 3) ti-1s to ti
		Neg.	1) t_i-60s to t_i 2) t_i-500ms to t_i -100ms 3) t_i-1s to t_i
	Apparent current (p.u.)	Pos.	t_i-500ms to ti -100ms
	Reactive current	Pos.	t_i-60s to t_i
		Pos.	t_i-1s to t_i
		Neg.	t_i-1s to t_i
	Active current	Pos.	t_i-1s to t_i
	Active power	Total	t_i-10s to t_i
		Total	t_i-2s to t_i
		Pos.	t_i-500ms to t_i -100ms
	Reactive power	Pos.	t_i-500ms to t_i -100ms
	Wind speed (if wind **PGU**)	-	t_i-2s to t_i

Table 41. Information tests of voltage dips to PPM (II).

	Magnitude	Sequence	Time reference
FAULT: Information recorded during the fault (t_i-t_d)	Factor K	Pos. (K_1)	
		Neg. (K_2)	
	Activation time (t_a)	Pos.	
	Rise time (t_r)	Pos.	
		Neg.	
	Settling time (t_e)	Pos.	
		Neg.	
	Voltage (p.u.)	Pos.	t_i+100ms to t_d-20ms
		Neg.	t_i+100ms to t_d-20ms
	Reactive current	Pos.	t_i+100ms to t_d-20ms
		Neg.	t_i+100ms to t_d-20ms
	Active current	Pos.	t_i+100ms to t_d-20ms
	Apparent current	Pos.	t_i+100ms to t_d-20ms
		Neg.	t_i+100ms to t_d-20ms
	Active power	Total	t_i+100ms to t_d-20ms
		Pos.	t_i+100ms to t_d-20ms
	Reactive power	Pos.	t_i+100ms to t_d-20ms
	Short-circuit current (for 3-phase fault only). Instant maximum current values	Phases 1, 2 and 3	t_i+20ms
	Short-circuit current (for 3-phase fault only).	Phases 1, 2 and 3	t_i+20ms
		Phases 1, 2 and 3	t_i+100ms
		Phases 1, 2 and 3	t_i+150ms
		Phases 1, 2 and 3	t_i+300ms
		Phases 1, 2 and 3	t_i+500ms
		Phases 1, 2 and 3	t_i+1000ms
	Fault ride Through Capability	Stays connected	Yes/No
POST-FAULT: Information recorded after the fault has been cleared (t_d) until the end of the recording time (t_f)	Reactive current	Pos.	t_d+1s to t_d+10s
		Neg.	t_d+1s to t_d+10s
	Active current	Pos.	t_d+1s to t_d+10s
	Active power	Total	t_d+1s to t_d+10s
	Reactive power	Pos.	t_d+1s to t_d+10s
	Voltage	Pos.	t_d+1s to t_d+10s
		Neg.	t_d+1s to t_d+10s
	Apparent current	Pos.	t_d+1s to t_d+10s
		Neg.	t_d+1s to t_d+10s
	Wind speed (if wind **PGU**)	-	t_d+1s to t_d+10s
	t_e of the active power	Pos.	
	Transient overvoltage capacity	Stays connected	Yes/No

Table 42. Information tests of voltage dips to PPM (III).

5.11.2.2.3. Criteria for assessing the voltage dip requirement

In addition to the information provided in **Table 40**, in **Table 41** and in **Table 42**, in order to assess whether the **PGU** has withstood each voltage dip without disconnection, the following shall be taken into account:

Operating point: For each test category, it is necessary that the active and reactive power recorded before the voltage dip performed is within the range defining partial and full load.

Supply continuity:

For wind **PGU**:

The field test shall be carried out on the entire **PGU**.

Two consecutive tests shall be carried out for each type (or category) of test identified in the first column of the above tables. It shall be verified that the **PGU** is not disconnected during the application of the voltage dip in two consecutive tests corresponding to the same category.

In the event of at least one disconnection in this test sequence (two consecutive first tests), the supply continuity condition shall be considered valid only when in the following three tests: corresponding to the same category, there is no disconnection of the **PGU**. If any disconnection occurs in this latter series of tests, the test shall be considered invalid. If the active power of the **PGU** is outside the limits set out in the above tables for its corresponding test, and there is no disconnection of the **PGU**, the test shall be considered invalid, but will not be counted for the purposes of considering it consecutive, i.e. it shall be rejected.

For photovoltaic **PGU**:

The use of a test bench is permitted to perform tests on the **PGU**, the presence of photovoltaic panels is not required and instead, the use of a DC source is permitted.

If the **PGU** is disconnected during the application of the voltage dip, in one of **two consecutive tests** for each test category, the test shall be deemed not to have been passed.

5.11.2.2.4. Criteria for assessing the fast injection requirement of reactive current

Pursuant to Article 8.4.3 (c) of [1], as regards the ability of **PPMs** to rapidly inject fault current, the requirement defined at the peninsular level in [7] applies.

The assessment of the fast injection requirement of reactive current shall be performed in the same way as in NTS SEPE [2], considering the following:

In the cases where:

- **PPM** power electronics blocks for faults where U_{res} < 10% as indicated in [1], this requirement will not be assessed.
- **PPM** is **doubly fed induction technology**, for faults where U_{res} < 10% this requirement will not be assessed, irrespective of the type of fault (three-phase or two-phase)

Without prejudice to what is indicated for the previous cases as far as the evaluation is concerned, the tests shall be carried out and the results shall be included in the test report. In this way, the **PGU certificate** shall establish the reactive current injection capacities for this type of events determined by the tests.

5.11.2.2.5. Criteria for the assessment of the transient overvoltage requirement

For the purpose of fulfilling this requirement, in the event that the active power response is oscillating, the trend line of the non-oscillating component of the active power after the fault is cleared shall be considered. Additionally, there will be no undamped oscillations.

Compliance with the requirement of subsection 8.4.3 (g) of [1] shall be assessed with the voltage records indicated in the tables of subsections 5.11.2.2.2 after the fault is cleared, i.e. between t_d and t_f. In this regard, the report will reflect the information stated in **Table 42**.

5.11.3. Simulation method and acceptance criteria for simulations

As indicated in subsection 5.11.1, simulations shall only be required to assess the performance of the **PGM** if the **PGU** constituting the **PGM** does not meet the robustness requirements of the tests to validate the model and requires an **ACPGM** to meet them.

The simulation models of the dynamic elements of the facility (**PGU** and/or **ACPGM**) shall be integrated into a simulation model of the **PGM** once their certificates have been obtained. Using this model, the **accredited entity** shall perform the simulation of the **PGM** by assessing its response at **BC**.

In order to conduct the simulation study of the **PGM**, a tool must be used to enable the phase modelling of the components of the electrical system, since dynamic studies will be conducted in the event of balanced and unbalanced failures. Such tool must be capable of using the validated **PGU** model without the need to perform any transformation thereof.

The topology of the electrical system to be used for the simulation and simulation methodology is specified in subsection 7.2 of this **Technical Standard**.

6. VALIDATION OF THE SIMULATION MODEL

It shall be performed in the same way as is considered in NTS SEPE [2].

7. ANNEXES

7.1. PGM model certificates

This annex has been intentionally translated into English at informative level, however it has to be considered that the **PGM certificate** must be provided in Spanish and using the template provided in subsection 7.1.1 in the Spanish version of this **Technical Standard**.

7.1.1. Model certificate of compliance with technical requirements through an authorised certifier

The model **final PGM certificate** issued by an **authorised certifier,** which the **RSO** shall receive from the owner of the **PGM,** shall contain at least the information detailed below (any additional information shall be provided in the Annexes) and according to the structure set out, with the aim of standardising the format for easier review.

The language in which the **final PGM certificate** will be issued shall be Spanish.

If the **RSO** requests any additional information, such as **PGU**, **ACPGM** or model certificates, this information must be delivered preferably in Spanish, or, in the absence thereof, in English or any other language agreed between the **RSO** and the **owner of the PGM**.

The content of the **PGM final certificate** issued by a **certifier** must include the following points:

1) **Header:**

Power Generating Module (**PGM**) Final Certificate Number

Date of issue

Accreditation Mark, including Accreditation no.

Certification Body Logo

2) **Title:**

Certificate of compliance [**No.**] of **PGM** in accordance with the technical requirements established in [**Rules**]

3) **Document body:**

The certification body [name] certifies that the following PGM:

File number of the Network Manager [**code**]

Name and identification of the **PGM**

Holding Company:
- Name
- Address

Characteristics of the PGM:
- **PPM** or **PGMS**
- Maximum capacity (MW)
- UTM coordinates
- Maximum design temperature

Characteristics of each type of **PGU** (electricity generation unit)
- Model
- Manufacturer
- Characteristics defining the **PGU** unambiguously
- Number of **PGUs** of each type and Maximum capacity (MW)

Characteristics of each type of **ACPGM** (**PGM** additional component)
- Model
- Manufacturer
- Characteristics that uniquely define the **ACPGM**
- **ACPGM** number of each type

Network Connection Point:
- Voltage (kV)
- Installation of the Network Manager to which it is connected
- UTM coordinates

Location of the **PGM**:
- Location description
- UTM coordinates

Registration at:

Administrative Register of Electric Power Production Facilities (RAIPEE):

- RAIPEE pre-registration code for **final PGM certificate**

Self-Consumption Facility Registry
- Registration code

CIL code (or CIL codes in case of different phases of the same RAIPEE)

, complies with:

Relevant regulations:
- PO12.2 SENP

- Real Decreto 647/2020
- Orden Ministerial TED 749/2020

Certification scheme:

- Compliance monitoring technical standard approved by the GTSUP
- Version/Date

, according to the documentation provided:

Equipment certificates: to be included in **Table 43** where applicable:

CERTIFICATION OF THE TECHNICAL REQUIREMENT				TYPE OF ASSESSMENT	
Requirement in the NTS	**Certificate reference**	**Issuing Entity Name**	**No obligation to comply (mark with X, if applicable)**	**PPM**	**PGMS**
5.1 Limited Frequency Sensitive Mode - Overfrequency (LFSM-O)				(S and T) or C**	(S and T) or C**
5.2 Limited Frequency Sensitive Mode - Underfrequency (LFSM-U)				(S and T) or C**	(S and T) or C**
5.3 Frequency Sensitive Mode (FSM)				(S and T) or C**	(S and T) or C**
5.4 Capability to limit production up and down ramps				T	T
5.5 Remote power control capability and range				T or C	T or C
5.6 Synthetic inertia during very fast frequency variations*				S	N/A
5.7 Reactive power capability at maximum capacity				N/A	(S and T) or C**
5.7 Reactive power capability below maximum capacity				N/A	(S and T) or C**
5.7 Reactive power capability at maximum capacity				(S and T) or C**	N/A
5.7 Reactive power capability below maximum capacity				(S and T) or C**	N/A
5.8 Reactive power control modes				T or C**	N/A
5.9 Power oscillation damping control				N/A	S or C
5.10 Oscillation damping control				S or C	N/A
5.11 Fast fault current injection at the connection point in case of balanced (3-phase) faults and in case of unbalanced (1-phase or 2-phase) faults				T (S***) or C**	N/A
5.11 Fault Ride Through capability of PPMs				T (S***) or C**	N/A
5.11 Transient overvoltage withstand capability of PPMs				T (S***) or C**	N/A

Table 43. Model of final PGM certificate (I).

Legend:

- In column "Form of Assessment": **S** means compliance simulation, **T** means compliance test, **C** means equipment certificate and **N/A** means does not apply.
- *: Requirement not mandatory according to [1].
- **: It may require the performance of **supplementary simulations** for assessment purposes, as described in the relevant section of this **Technical Standard**.
- ***: In the cases specified in T (S***), the test shall be performed in PGU and, if it is unsuccessful, the simulation of the complete PGM shall be performed, incorporating the ACPGM enabling the pertinent requirement to be met.

Dynamic models: the following shall be indicated for each of the dynamic models used in the certification of each requirement.

- Certified model:
  - Certification reference or number
  - Issuing entity
  - Format (Name of the simulation tool used)

- Model used for carrying out supplementary simulations:
  - Companies that have carried out the supplementary simulations
  - Model developer
  - Format (Name of the simulation tool used)

If the following documentation has been used, please provide references:

- Exceptions
- Technical justifications for non-compliance issued by the **RSO**
- Written in accordance with the **RSO**

Certification of maximum reactive power capability requirement at P_{max} and below P_{max}: option followed for certification.

- General procedure (subsection 5.7.3.1)
- Case A special procedure (subsection 5.7.3.2, Case A)
- Case B special procedure (subsection 5.7.3.2, Case B)

Certification of each of the following points regarding the compatibility of the settings of the voltage and frequency relays of the **PGM**:

- Frequency and time settings compatible with the established in Table 1 of article 8.2.1 of [1].
- Voltage and time settings compatible with the established in Table 4 of article 8.2.6 of [1].
- Combined voltage and time settings compatible with the corresponding **PGM** fault ride through profile as specified in article 8.4.3 of [1].
- Combined voltage and time settings compatible with the corresponding **PGM** transient overvoltage settings, as specified in article 8.4.3 of [1].

Requirements not met (specified in the table):
  - Exception justifying non-compliance (document reference)

4) <u>Certificate completion:</u>

Comments.

Signature

- City, [Day] of [Month] of [Year]
- [Name and surname of the **authorised certifier/authorised certifiers**]

5) **Annexes:**

For the **authorised certifier**.

The format of the model **PGU** and **ACPGM equipment certificates** shall be agreed between subjects exchanging test reports and simulations and **equipment certificates**: **accredited entity** for tests and/or simulations, laboratories, **authorised certifier**, manufacturer or **owner** of the **PGM**. By default, a structure similar to that specified for the **final PGM certificate** shall be used.

7.1.2. Certificate equivalence tables

7.1.2.1. Equivalence between NTS SENP and NTS certificates

Table 44 is a help table showing the certificate equivalences between the current versions of NTS SEPE and NTS SENP. The **authorised certifier** shall be responsible for verifying the validity of the certificate equivalence of each of the requirements of **Table 44** and for making it appear in the **final PGM certificate**.

NTS subsection	Definition of Requirement	NTS SEPE	NTS SENP
5.1	Limited Frequency Sensitive Mode - Overfrequency (LFSM-O)	Certificate according to NTS SENP accepted, provided that such certificate certifies compliance with the optional acceptance criteria (t_r y t_e) detailed in 5.1.2.2 of NTS SENP.	Certificate according to NTS SEPE accepted, provided that such certificate certifies compliance with the following requirements: • t_a > 0,3s for PGM with inertia • t_a > 0,15s for non-inertia PGM
5.2	Limited Frequency Sensitive Mode - Underfrequency (LFSM-U)	Certificate according to NTS SENPS accepted, provided that such certificate certifies compliance with the optional acceptance criteria (t_r y t_e) detailed in 5.2.2.2 of NTS SENP	Certificate according to NTS SEPE accepted, provided that such certificate certifies compliance with the following requirements: • t_a > 0,3s for PGM with inertia • t_a > 0,15s for non-inertia PGM
5.3	Frequency Sensitive Mode (FSM)	Certificate according to NTS SENP accepted, provided that such certificate certifies compliance with the optional test (no deadband and with insensitivity >10mHz) detailed in 5.3.2.1 of the NTS SENP	**Certificate according to NTS SEPE not sufficient**
5.5	Remote power control capability and range	Certificate equivalence according to both Technical Standards	
5.6	Synthetic inertia during very fast frequency variations	Certificate equivalence according to both Technical Standards	
5.7	Reactive power capability	**Certificate according to NTS SENP not sufficient**	Certificate according to NTS SENPaccepted
5.8	Reactive power control modes	**Certificate according to NTS SENP not sufficient**	Certificate according to NTS SEPE accepted, provided that such certificate certifies compliance with the voltage control test with deadband detailed in Table 27 of subsection 5.8.2.1.1 of the NTS SENP.
5.9	Power oscillation damping control	Certificate equivalence according to both Technical Standards	
5.10	Oscillation damping control	Certificate equivalence according to both Technical Standards	
5.11	Capacity to support voltage dips	Certificate according to NTS SENP accepted, provided that such certificate certifies compliance with the requirement with a 75% dip test of a duration greater than 1340ms	**Certificate according to NTS SEPE not sufficient**
5.11	Fast fault current injection	Certificate according to NTS SENP accepted	**Certificate according to NTS SEPE not sufficient**
5.11	Capacity to support transient overvoltage of PPMs	Certificate according to NTS SENP accepted	**Certificate according to NTS SEPE not sufficient**
5.11	Recovery of active power after a fault	**Certificate according to NTS SENP not sufficient**	NA

Table 44 Requirement certificate equivalences between NTS SEPE and NTS SENP.

7.1.2.2. Equivalence of PGM certificates by requirement between NTS versions

Table 45 shows the possibilities that the **PGM certificate** of a particular technical requirement, issued under the previous version (v1.0) of this **Technical Standard**, can be used for **PGM** certification under the present version (v1.1) of this **Technical Standard**. In the column "PGM certificates supported for NTS SENP v1.1" it is indicated, for each requirement, whether only the **PGM certificate** of version 1.1 is valid, or whether the **PGM certificate** of version 1.0 is also valid.

NTS Subsection	Definition of Requirement	PGM certificates supported for NTS v1.1
5.1	Limited Frequency Sensitive Mode - Overfrequency (LFSM-O)	≥ v1.0
5.2	Limited Frequency Sensitive Mode - Underfrequency (LFSM-U)	≥ v1.0
5.3	Frequency Sensitive Mode (FSM)	≥ v1.0
5.5	Remote power control capability and range	≥ v1.0
5.7	Reactive Power Capability at Pmax and under Pmax	**v1.1**
5.8	Reactive power control modes	**v1.1**
5.11	Fault-ride-through capability	≥ v1.0
5.11	Fast Fault Current Injection at NCP in case of faults	≥ v1.0
5.11	Capacity to support transient overvoltage after a fault	≥ v1.0

Table 45. Equivalence of PGM certificates by requirement between NTS SENP versions.

Similarly, the example provided in subsection 7.1.4.2 of [2], applies.

In the case where the **PGM** certificate of a requirement issued under the previous version of this Technical Standard is used, the authorised certifier is responsible for verifying the validity of this certificate and stating this in the final **PGM** certificate.

7.1.3. Scopes of accreditation

It shall be considered in the same way as defined in subsection 7.1.3 of [2].

7.2. Electric network equivalent to the Peninsular Electricity System and the Interconnected European System for simulation

It shall be performed in the same way as is considered in NTS SEPE [2].

7.3. Format for data exchange between entities accredited to conduct tests and simulations

It shall be performed in the same way as is considered in NTS SEPE [2].

7.4. Modelling procedure for complementary reactive power capability simulations and reactive power control modes

7.4.1. Purpose

The purpose of this subsection is to provide details of the modelling to be considered for the performance of **supplementary simulations** to verify the **reactive power capability** of **PGMs** according to subsection 5.7, and the **capability to control the reactive power** of **PPMs** according to subsection 5.8.

To this end, two modelling options are proposed for each capacity to be verified, which will be selected, and which are detailed in the following subsections:

- Complete modelling procedure at **NCP**.
- Alternative modelling procedure at **PGM terminals (BC)**

7.4.2. Modelling procedure for supplementary simulations of reactive power capability

7.4.2.1. Complete modelling procedure in NCP

The validation of reactive power capability by the full modelling procedure at **NCP** aims to verify that the **PGM** meets the reactive power capability requirements at the **NCP**, based on the declared capabilities of the PGUs, either by means of the tests listed in 5.7.2, or by means of certificates issued for **PGU** and, if applicable, for **ACPGM**.

An infinite network shall be used at the **NCP** to modify its voltage values. The simulation model must include the details of the **PGM** topology from the **PGU** up to the **NCP**, i.e. cables, lines, power transformers, tap changers, any **ACPGM** that alters the reactive capacity, or any electrical equipment that may involve the consumption or generation of reactive power of the **PGM** at the **NCP**, whether belonging to the connection network from the **PGM up** to the **NCP**, or the internal network of the **PGM** from the **PGU** up to the **PGM terminals (BC)**. Therefore, the use of an equivalent model of the **PGM** shall not be allowed, with the exception specified in subsection 7.5.

If the network modelled from the **NCP** to the **PGM** is shared or is planned to be shared with more **PGMs**, these must be taken into account in the supplementary simulation and must be modelled. In order to avoid the need and the transfer and verification of third-party information, and to deal with different cases in the temporal evolution of the **PGMs** connected at such **NCP**, these must be fictitiously modelled according to the structural parameters of the shared network, and more particularly according to the power of the power transformers.

In order to represent the modelling of the fictitious **PGMs** that share the connection at the **NCP**, the following must be considered:

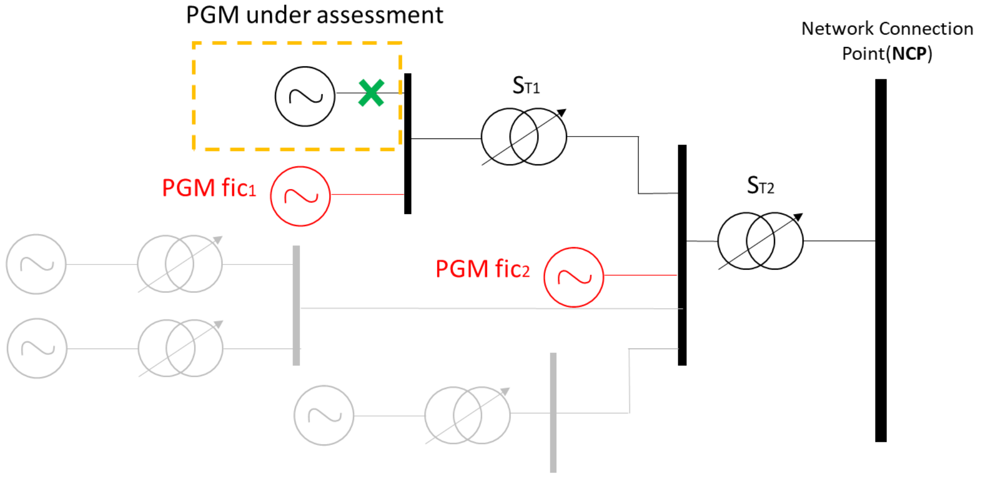
- The connection scheme must be available from the **PGM** being assessed up to the **NCP**.
- If **PGM terminals (BC)** is located on the low voltage side of the step-up transformer, a **fictitious PGM** must be modelled in parallel, whose maximum capacity is the

difference between the nominal power of the transformer and the maximum capacity of the **PGM** to be assessed.

- Following the connection scheme from the **BC** of the **PGM** under assessment up to the **NCP**, at each point where there is a transformer, a **fictitious PGM** must be modelled on the low voltage side, whose maximum capacity is equal to the difference between the nominal transformer power and the sum of the downstream modelled **fictitious PGMs**, i.e. the nominal power of the previous transformer.
- The above shall be repeated until the **NCP** is reached, which for the purpose of fictitious generator modelling is considered to occur when the nominal voltage on the high voltage side of the last transformer in which a **fictitious PGM** has already been modelled on the low voltage side coincides with the **NCP** voltage.

Below are five examples that illustrate the fictitious modelling of **PGMs** that share a connection network. Black shows the connection infrastructure from **BC** up to **NCP** that must be modelled to perform the supplementary simulations, grey shows the rest of the facilities and **PGMs** that share the connection at the same **NCP**, which shall not be modelled, and in red the fictitious **PGMs** are shown which need to be modelled according to the above mentioned considerations.

Example I



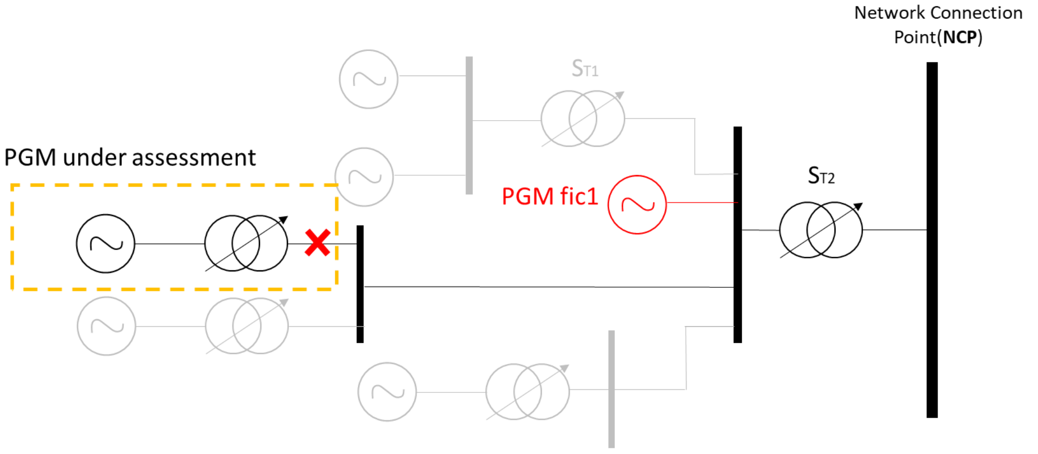
Pmax (PGM under assessment) =PmaxPGM

Pmax (PGM fic1)=0,9*ST1-PmaxPGM

Pmax (PGM fic2)=ST2 - ST1

Figure 16. Illustrative diagram Example I of modelling for the performance of supplementary simulations for verifying the reactive power capability of PGMs according to the full modelling procedure at NCP.

Example II

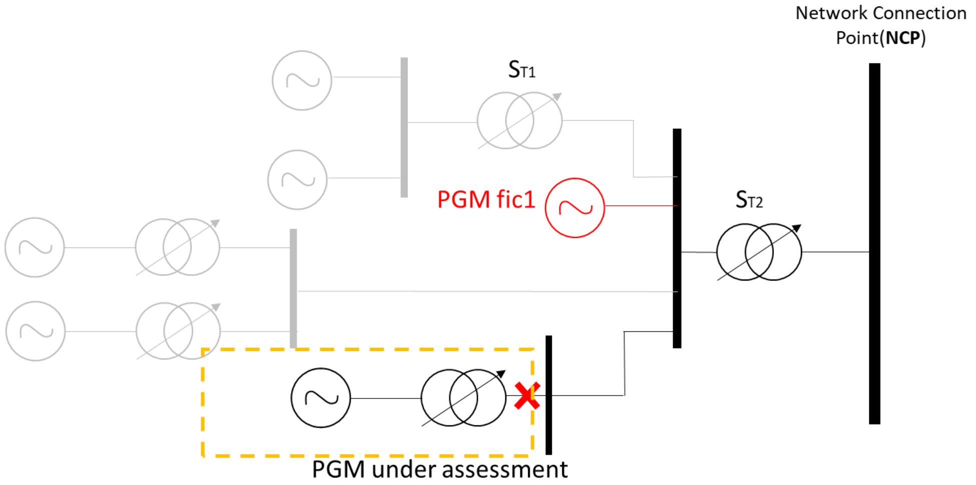


Pmax (PGM under assessment) =PmaxPGM

Pmax (PGM fic$_1$)=0,9*ST2- PmaxPGM

Figure 17. Illustrative diagram Example II of modelling for the performance of supplementary simulations to verify the reactive power capability of PGMs according to the complete modelling procedure at NCP.

Example III

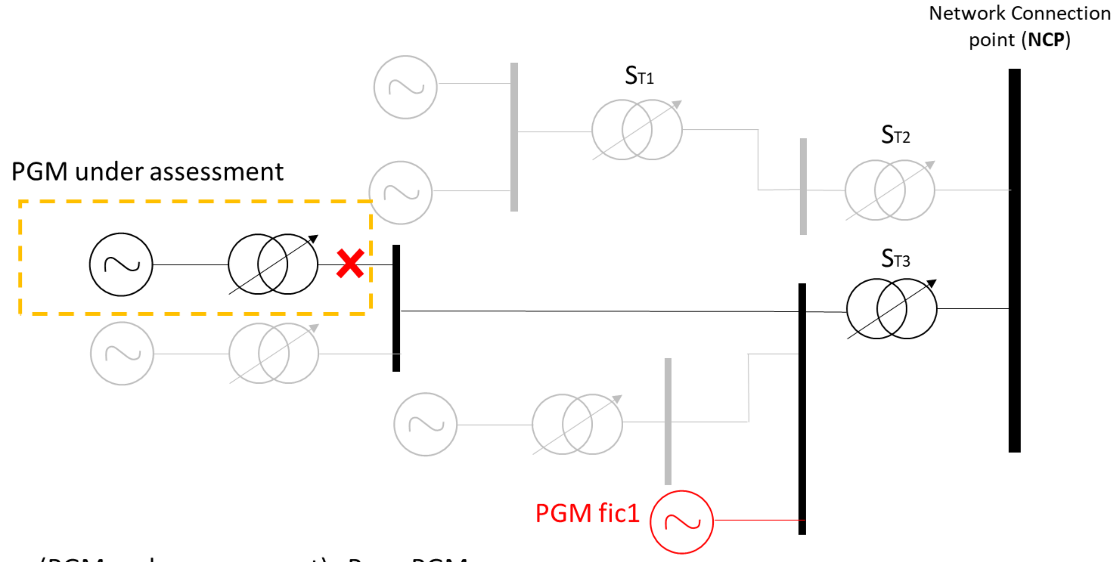


Pmax (PGM under assessment) =PmaxPGM

Pmax (PGM fic$_1$)=0,9*ST2- PmaxPGM

Figure 18. Illustrative diagram Example III of modelling for the performance of supplementary simulations to verify the reactive power capability of PGMs according to the complete modelling procedure at NCP.

Example IV



Pmax (PGM under assessment) =PmaxPGM

Pmax (PGM fic1)=0,9*ST3- PmaxPGM

Figure 19. Illustrative diagram Example IV of modelling for the performance of supplementary simulations to verify the reactive power capability of PGMs according to the complete modelling procedure at NCP.

Example V

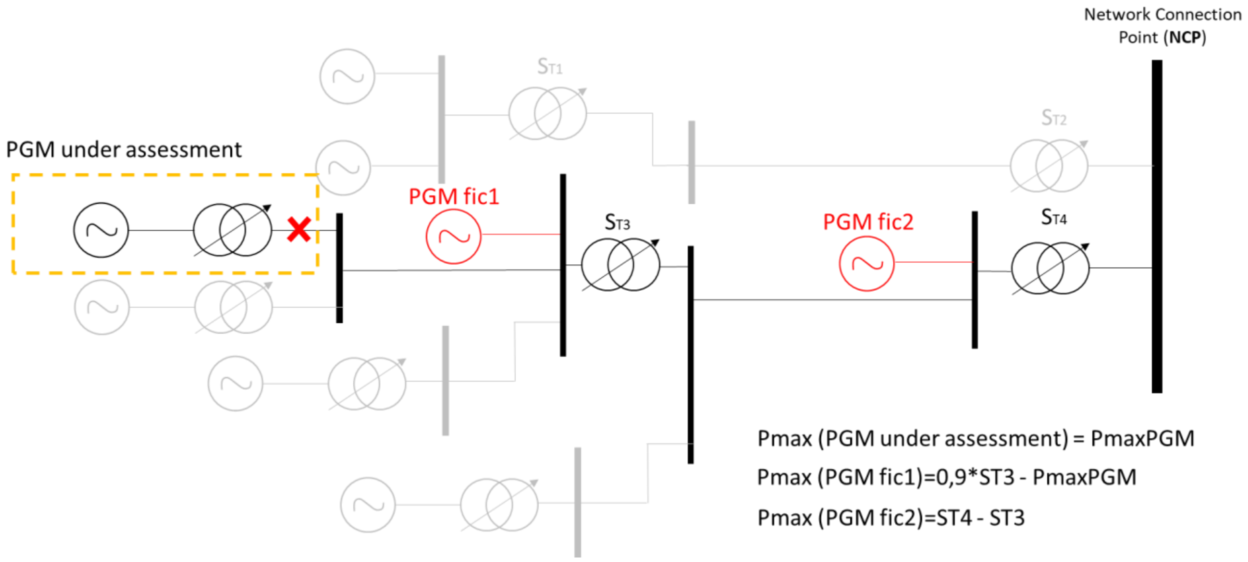


Figure 20. Illustrative diagram Example V of modelling for the performance of supplementary simulations to verify the reactive power capability of PGMs according to complete modelling procedure at NCP.

With the model described above, the **supplementary simulations** necessary to verify the maximum reactive power requirements shall be carried out, for which a static model is accepted for the realization of a load flow including the reactive power capabilities of the **PGUs**.

As regards the operation points of the **fictitious PGMs** to be considered for the performance of supplementary simulations:

- As regards the active power operation point of **fictitious PGMs**, the same active power (in p.u., P/P_{max}) as that requested for the **PGM** under assessment shall be considered for each supplementary simulation.
- As regards the reactive power operation point of **fictitious PGMs**, it shall be considered as unit power factor.

By means of the complete modelling procedure at **NCP**, using the modelling methodology described above, and by means of the simulations listed in the Tables of 5.7.3.1 the reactive power capabilities of the **PGM** must be checked at the check points illustrated in **Figure 21**.

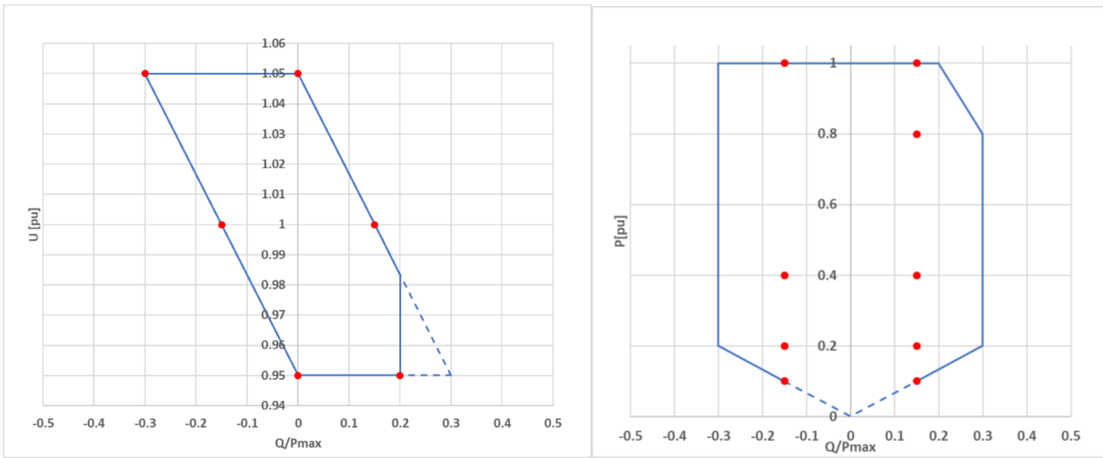


Figure 21. Graphical representation of the checkpoints of the reactive power capability at the maximum capacity of the PGMs (left) and of the checkpoints of the capacity of reactive power at active powers less than maximum capacity (right) according to the full modelling procedure at NCP

7.4.2.2. Alternative modelling procedure at BC.

In the event that there is a shared evacuation network from the **BC** of the **PGM** under verification up to the **NCP**, or in anticipation of being shared with other **PGMs**, the assessment of the compliance of the reactive power capabilities of **PGM** at the **NCP** becomes complicated. The reactive power requirements listed in [1] apply at the **NCP**; however, taking into account that assessment at the **NCP** will not always be possible, and in order to simplify the compliance assessment process, this subsection proposes an alternative procedure to that described in subsection 5.7.3.1.

The compliance assessment of the **PGM**'s reactive power capability requirements at **BC** instead of **NCP** will be accepted. However, it should be noted that this simplification of the compliance assessment at the **PGM** terminals means that for some of the **PGM**'s operating points, the reactive power values required at **BC** of the **PGM** differ from those required in [1], i.e. those required at the **NCP**.

In order to obtain the **PGM certificate** based on **PGU** level tests or **PGU** certificates, it shall be necessary to perform a **supplementary simulation** demonstrating that the capabilities of the **PGU**, as declared in the tests and simulations at **PGU** level and, if applicable, **ACPGM**, meet the reactive power capability values at **BC** listed in **Table 21**, **Table 22**, **Table 23** or **Table 24**, as applicable.

Two cases are distinguished, depending on the location of **BC**[12].

7.4.2.2.1. Case A.

In the event that **BC** of the **PGM** is located at the HV side of the step-up transformer (**LAT**) of the **PGM**, the **supplementary simulation** shall be carried out considering both the voltage and the reactive power at **BC** (i.e. **LAT** in this case) in such a way that it will be necessary to model the collector network from the **PGU** up to **BC**, but not the evacuation network up to the **NCP**. The simulation model must include the details of the **PGM** topology from **PGU** to **BC**, downstream of **BC** i.e. cables, lines, power transformers, tap changers, any **ACPGM** that changes the reactive power capability of the **PGM** at **BC**. Therefore, the use of an equivalent model of the **PGM** will not be allowed, with the exception specified in subsection 7.5.

The diagram shows an example in which the topology of the connection network that has not been modelled has been coloured in grey, and the PGM to be assessed has been coloured in black, as well as the network that has to be modelled up to BC, where an infinite network shall be used to vary the voltage values at that point.

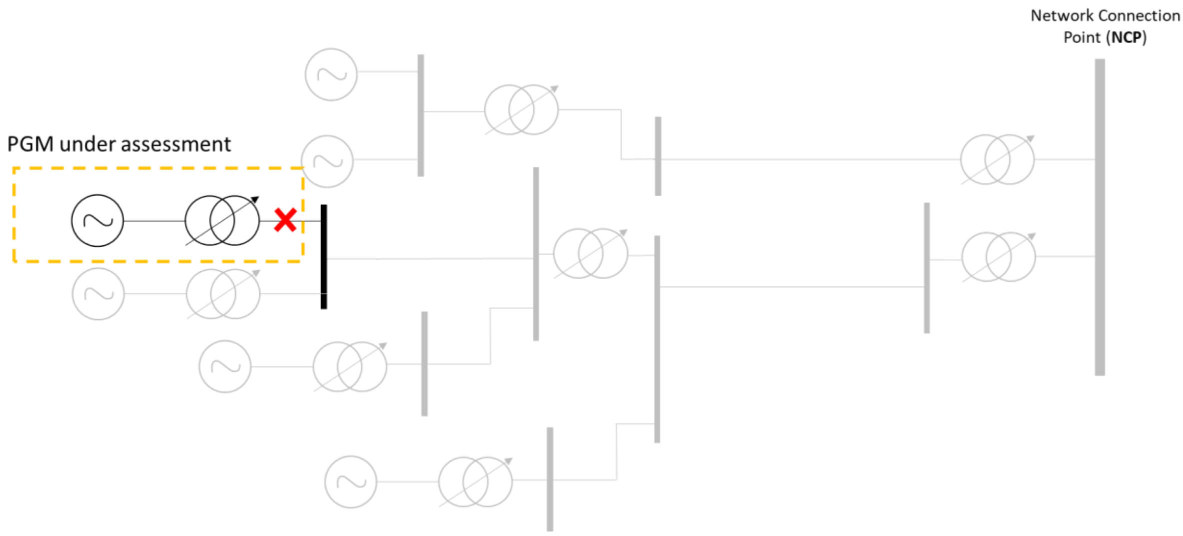


Figure 22. Illustrative diagram of modelling for the performance of supplementary simulations for verifying the reactive power capability of PGMs according to the alternative modelling procedure at BC Case A.

[12] See the definition of PGM terminals (BC) for the purposes of this Compliance Monitoring Technical Standard.

Through the alternative modelling procedure at **BC**, Case A, using the modelling methodology described above, and through the simulations listed in the tables of subsection 5.7.3.2 the **PGM**'s reactive power capabilities must be checked at the check points illustrated by **Figure 23**.

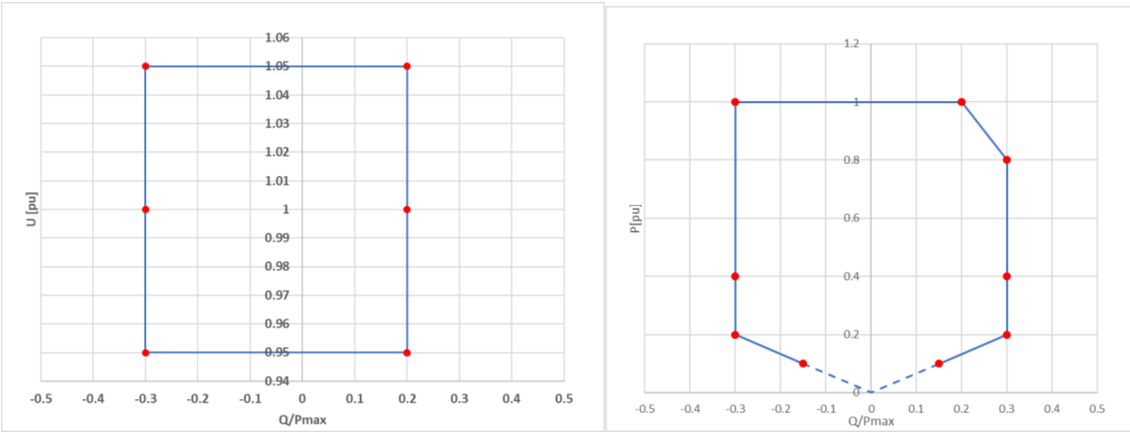


Figure 23. Graphical representation of the checkpoints of the reactive power capability at the maximum capacity of the PGMs (left) and of the checkpoints of the capacity of reactive power at active powers less than the maximum capacity of PPMs (right) according to the alternative modelling procedure at BC Case A

For clarification purposes, according to the values of the checkpoints stated in **Figure 23**, in this case A of the alternative modelling procedure, it is required that the PPM generating active power in the range from 10%P_{max} to 0%P_{max} (included) has the ability to move its reactive power between +5% capacitive and -10% inductive. This capacity can be provided through the following two alternatives:

- Through a dynamic control, in which it is understood that the **PGUs** and/or **ACPGMs** are capable of performing it.
- Through a passive element, usually a reactance. The passive element, in such a low production situation, must bring the **PGM** to the operation point in reactive power of -5% inductive (when the voltage at **BC** is nominal), to which the dynamic control capability (which it is understood must be provided by the **PGU** and/or **ACPGM**) of ±5% as provided in the P-Q/P_{max} diagram must be superimposed. In the event that the voltage at **BC** is outside the admissible range and such passive element is in operation, the **PGM** must first disconnect the passive element in order to attempt to recover the voltages and not trip the **PGM**.

7.4.2.2.2. Case B

If the **BC** of the **PGM** is located at the LV side of the **PGM** step-up transformer, the **supplementary simulation** shall be performed by measuring the reactive power at **BC** and considering the voltage at the HV side of the shared step-up transformer, so that it shall be necessary to model the collector network from the **PGU** to **BC** and the shared transformer, but not the rest of the evacuation network up to the **NCP**. The simulation model must include, downstream of **BC,** the details of the **PGM** topology from **PGU** up to **BC**, i.e. cables, lines, power transformers, tap changers, any **ACPGM** that changes the reactive power capability of the **PGM** at **BC**, in addition to the step-up transformer. Therefore, the use of an equivalent model of the **PGM** shall not be allowed, with the exception specified in subsection 7.5.

In order to model the remaining **PGMs** that share a step-up transformer with the **PGM** to be assessed, they shall be considered as a **fictitious PGM**, the maximum capacity of which will be the difference between the power of the transformer and the maximum capacity of the **PGM** to be assessed; that is, the fictitious generator will be of maximum capacity $Pf_{ic}=P_{trafo}$-PPGM, where P_{trafo} will be the 0,8*S_{trafo}, in order to prevent the transformer from becoming saturated.

The diagram shows an example of a topology for which the network should be modelled up to the LAT of the shared step-up transformer has been coloured black, and the fictitious PGM has been coloured red, and grey the rest of the network topology that does not need to be modelled.

At the LAT, an ideal source of voltage or an infinite network shall be considered to vary the voltage in each simulation.

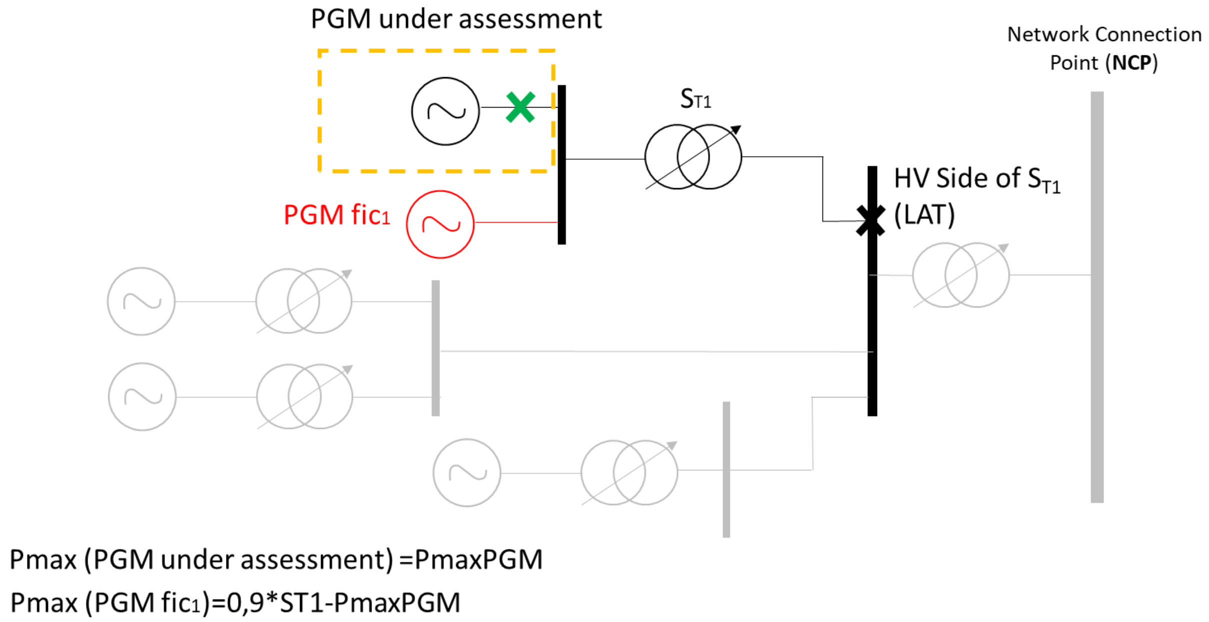


Figure 24. Illustrative diagram of modelling for the performance of supplementary simulations for verifying the reactive power capability of PGMs according to the alternative modelling procedure in BC Case B.

As regards the operation points of the **fictitious PGM** sharing a transformer to be considered for the performance of the supplementary simulations:

- The active power operation point of the **fictitious PGM** for each supplementary simulation shall be considered the same active power (in p.u., P/P_{max}) as that requested for the **PGM** under assessment.
- The operation point in reactive power of the **fictitious PGM** for each simulation shall be the same (in p.u., Q/P_{max}) as that ordered to the PGM under assessment.

Through the alternative modelling procedure at **BC**, Case B, using the modelling methodology described above, and through the simulations listed in the tables of subsection 5.7.3.2 PGM's reactive power capabilities must be checked at the check points illustrated by **Figure 25**.

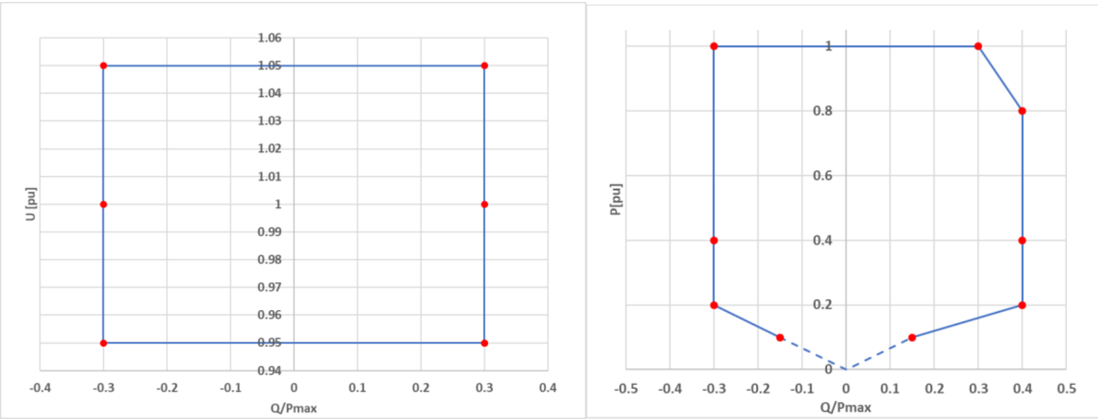


Figure 25. Graphical representation of the checkpoints of the reactive power capability at the maximum capacity of PGMs (left) and of the checkpoints of the capacity of reactive power at active powers less than the maximum capacity of PPMs (right) according to the alternative modelling procedure at BC Case B

For clarification purposes, according to the checkpoints stated in **Figure 25**, for this case B of the alternative modelling procedure at BC, it is required that the **PPM** generating active power in the range from 10%P_{max} to 0%P_{max} (included) has the ability to move its reactive power between +5% capacitive and -10% inductive. This capacity can be provided through the following two alternatives:

- Through a dynamic control, in which it is understood that the **PGUs** and/or **ACPGMs** are capable of performing it.
- Through a passive element, usually a reactance. The passive element, in such a low production situation, must bring the **PGM** to the operation point in reactive power of -5% inductive (when the voltage at **BC** is nominal), to which the dynamic control capability (which it is understood must be provided by the **PGU** and/or **ACPGM**) of ±5% as provided in the P-Q/P_{max} diagram must be superimposed. In the event that the voltage at **BC** is outside the admissible range and such passive element is in operation, the **PGM** must first disconnect the passive element in order to attempt to recover the voltages and not trip the **PGM**.

In addition, and unlike Case A, a different reactive power checkpoints at the maximum reactive power capability of the **PGM** is also set in order to compensate the losses of the **PGM**'s step-up transformer. This reactive power capability may also be supplied dynamically or statically.

7.4.3. Modelling procedure for supplementary simulations of reactive power control modes

It shall be performed in the same way as is considered in NTS SEPE [2].

7.5. Equivalent model for photovoltaic PPMs by low voltage aggregation

It shall be performed in the same way as is considered in **NTS SEPE** [2].

8. REFERENCES

[1] P.O. 12.2 (SENP) "*Instalaciones conectadas a la red de transporte y equipo generador: requisitos mínimos de diseño, equipamiento, funcionamiento, puesta en servicio y seguridad"* de los sistemas eléctricos no peninsulares (February 2018)

[2] Technical standard for monitoring compliance of power generating modules according to EU Regulations 2016/631 Version 2.1

[3] Real Decreto 647/2020, de 7 de julio, por el que se regulan aspectos necesarios para la implementación de los códigos de red de conexión de determinadas instalaciones eléctricas.

[4] Procedimiento de verificación, validación y certificación (PVVC) de los requisitos del P.O.12.3 sobre la respuesta de las instalaciones eólicas y fotovoltaicas ante huecos de tensión. Version 11 or higher.

[5] IEC 61400-21-1 Measurement and assessment of electrical characteristics - Wind turbines. Version May 2019.

[6] Technical Guidelines for Power Generating Units and Systems. Part 3 (**TG3**). Determination of the electrical characteristics of power generating units and systems, storage systems as well for their components in medium-, high- and extra-high voltage grids. Revision 25. FGW.

[7] Orden TED/749/2020, de 16 de julio, por la que se establecen los requisitos técnicos para la conexión a la red necesarios para la implementación de los códigos de red de conexión.

9. TABLES AND FIGURES

9.1. List of figures

9.2. List of tables