TC EC – Resolution on the
Technical Guideline
TG 8 Rev. 10

FGW e.V.

Fördergesellschaft Windenergie und andere Dezentrale Energien

Oranienburger Straße 45
10117 Berlin

Tel. : +49 (0)30 / 3010 1505 0

info@wind-fgw.de
www.wind-fgw.de

Berlin, 18 March 2026

Technical Committee on Electrical Characteristics (TC EC) – Resolution of 18 March 2026

The Technical Committee on Electrical Characteristics (TC EC) resolves to amend Revision 10 of Technical Guideline Part 8 (TG 8).

Supplement 1 to FGW TG 8 Rev. 10 serves to implement, at short notice, the FNN Guideline 'Technical Requirements for Grid-Forming Capabilities, including the Provision of Inertia' in Version 2.1 of January 2026.

On behalf of the Technical Committee on Electrical Characteristics

Simon Borsutzki

Executive Board: Prof. Dr.-Ing. Horst Schulte / Dipl.-Ing. Jan Liersch
Bank details: IBAN DE72 222 500 2000 5301 5301 • BIC NOLADE 21 WHO • Sparkasse Westholstein
VAT No.: DE203774047

Supplement 1 to FGW TG 8 Rev. 10

Certification of Electrical Characteristics of Power Generating Units and Systems, Storage Units as well as Related Components within the Electricity Grid

18 March 2026

Publisher

FGW e.V.
Fördergesellschaft Windenergie und andere Dezentrale Energien

Oranienburger Straße 45
10117 Berlin

Tel.	+49 (0)30 30101505-0
Email	info@wind-fgw.de
Website	www.wind-fgw.de

For the sake of readability, gender-neutral language has been used. Such terms apply to both genders in the spirit of equality.

Foreword

This supplement serves the short-term implementation of the FNN guideline “Technical requirements for grid-forming capabilities, including the provision of inertia” in version 2.1 dated January 2026 [1].

TG 8 Rev. 10 is optionally supplemented by this addendum and may still be applied independently. This addendum applies to the PGU and PGS requirements of the FNN Guideline [1] that must be met.

Table of Contents

1 Introduction

Representatives from the following groups contributed to the preparation of this Supplement 10.1 to the Technical Guideline for Power Generating Units (PGU) and Systems Part 8 Rev. 10 (TG 8) [2]:

- Grid operators.
- Manufacturers of power generating units and components.
- Accredited institutes and universities.
- Testing institutes.
- Certification bodies.

All parties involved have stated that this supplement is intended to complement TG 8 Rev. 10 [2].

The requirements, specifications and explanations described in TG 8 Rev. 10 [2] also apply to this supplement, unless they are replaced or supplemented as described in this supplement.

The abbreviations, symbols and units, as well as the terms and definitions listed in TG 8 Rev. 10 [2], also apply to this supplement.

2 Equipment certification

2.1 GENERAL

The provisions of FGW TG 8 Rev. 10 [2] apply. These are supplemented or replaced as follows: This supplement may be applied as follows to:

- Units with existing unit certificates that have been upgraded to grid-forming units by means of a corresponding amendment to the unit certificate
- Grid-forming units for which a new unit certificate is being issued.

Further details can be found in the FNN Guideline on grid-forming capabilities, Section 5.1 [1].

If existing unit certificates are amended, an evaluation report and a certificate must be issued in accordance with the requirements of the FNN Guideline on grid-forming capabilities, referencing the original evaluation report, model validation report and original certificate. Both the evaluation report and the certificate must provide a complete tabular overview of which requirements from TG 8 Rev. 10 are being replaced or supplemented.

For the purposes of metering, the temporary connection of a grid-forming unit without prototype approval is permitted in consultation with the grid operator. For wind turbines, a prototype procedure analogous to Section 12 of the applicable Technical Connection Regulation is to be submitted for the purposes of metering, as well as for submitting the grid connection application and commissioning, together with the electrical planning in accordance with TCR – not as authorisation to participate in the inertia market – in Version 2.2 of the FNN Guideline document [1].

Transferability of measurement results

The results of a measurement of a grid-forming unit may be transferred in part or in full to other grid-forming units, provided that the following conditions are met:

Technical equivalence

- The design, the relevant control technology and the software used in the unit under consideration must be technically equivalent to the metered unit.
- In particular, it must be ensured that there are no functional changes or further developments in the software that affect the control algorithms relevant to the electrical characteristics.
- Prior to a transfer, the manufacturer and the testing body must specifically verify and document whether such equivalence exists.

Power range

- Measurement results may be transferred if measurements are available for the smallest and largest power variants.
- Alternatively, transferability is given if the rated apparent power of the unit to be certified lies within the following limits:
    - Type 1 units: between $1/\sqrt{10}$ and $\sqrt{10}$ times the rated apparent power of the unit being tested.
    - Type 2 units: between $1/\sqrt{10}$ and 2 times the rated apparent power of the unit being tested.

Exception: Quasi-steady-state operation and static voltage maintenance (Type 2 only)

- There is an exception for verifications in quasi-steady-state operation and with regard to static voltage maintenance, which applies exclusively to Type 2 units.
- Under these conditions, the measurement results may be transferred to other units, provided that the technical design of the grid-forming unit and the components used are equivalent.
- In this exceptional case, transfers are permitted for Type 2 units in the range of 100 kVA to 10 MVA rated apparent power.

Inventory measurements

- Results from existing (inventory) measurements may be used, provided that technical equivalence within the meaning of point 1 (see above under Technical Equivalence) is clearly demonstrated.
- It must be checked on a case-by-case basis whether there have been any subsequent developments in the software used, the control technology or significant changes to the components that restrict or preclude transferability.
- A blanket adoption of existing inventory measurements is not permitted; the validity of the measurement results must be systematically verified as part of the certification process.

Note:
Measurements may only be transferred if all the above conditions are met and the evidence is clearly documented in the certification dossier.

2.2 EQUIPMENT PROTOTYPES

2.2.1 PROTOTYPE REGULATION

Add the following at the end of Chapter 2.12.1 '[2] ':

For grid-forming units, the provisions of Section 5.2 of the FNN Guideline on grid-forming capabilities apply in deviation from this chapter. The requirements for monitoring using fault recorders are described in Section 5.2.4 [1].

The regulations regarding equipment certification shall apply mutatis mutandis.

3 Verification procedure for power generating systems with grid-forming units with prototype status

For verification at system level, where prototypes are used (following retrofitting or for new units), a qualified opinion for prototypes (Prototype Qualified Opinion) of grid-forming units must be submitted.

Following the retrofitting or commissioning of an existing unit or new unit, an extended commissioning declaration for the power generating system must be submitted. The following documents must be provided for this purpose:

- For new units or units to be retrofitted, a prototype confirmation in accordance with the FNN Guideline on grid-forming capabilities,
- Confirmation of the implementation of necessary software updates for all retrofitted units by means of a relevant extract from the event log,
- A manufacturer's declaration confirming the replacement of necessary hardware components,
- A parameter extract for the retrofitted units,
- Measurement-based verification based on internally switchable signals on a unit in the field, freely selected by the certifier, through the following measurements: in accordance with sections 5.5.5.3, 5.5.5.8 and 5.5.5.9 (evaluation in accordance with section 5.5.5.9.3.3) [1],
- As an alternative to measurement-based verification, a verification document may be submitted for the retrofitted unit using fault recorder evaluations in accordance with the criteria of Section 5.2.4 [1]. In this context, the provisions of Section 5.2.4 [1] regarding monitoring in a system with several grid-forming units of the same type apply.
- The measurement-based verification or its alternative (monitoring using fault recorders) may be omitted provided that the retrofitting of the respective unit was carried out solely on the basis of a software update.

In addition, it must be verified that all retrofitted units in the system correspond to the status of the tested or monitored unit.

Verification at system level must be provided by a certification body accredited in accordance with DIN EN ISO/IEC 17065 [3] (for the applicable Technical Connection Regulation). The necessary measurements must be carried out by a testing institute accredited in accordance with DIN EN ISO/IEC 17025 [4] (for FGW TG 3 Rev. 26 [5]). The requirements set out in Section 12 of the applicable Technical Connection Rule apply to the subsequent submission of the system certificate and the declaration of conformity.

4 System certification

The provisions of FGW TG 8 Rev. 10 [2] apply. These are supplemented or replaced as follows: The supplementary sheet may be applied as follows to:

- Power generating systems with grid-forming units for which a unit certificate is available
- Power generating systems with grid-forming units for which no unit certificate is available

Further details can be found in the FNN Guideline on grid-forming capabilities [1], Sections 5.1 and 5.6.

4.1 SYSTEM CERTIFICATION FOR NEW UNITS

For the system certification of units with grid-forming capabilities, unit certificates in accordance with the FNN Guideline on grid-forming capabilities, version 2.1 (or later), must be used.

In addition, the following metrological evidence must be provided as part of the declaration of conformity:

- If, for the verification of static voltage maintenance (overall system behaviour), procedure (A) of section 5.6.2.6.1 [1] has been selected or specified in the system certificate, a measurement-based verification of the system behaviour with regard to voltage maintenance must be carried out as part of the declaration of conformity by a testing institute accredited for this purpose in accordance with DIN EN ISO/IEC 17025[4] .

4.2 SYSTEM CERTIFICATION FOR THE RETROFITTING OF EXISTING UNITS

If existing units are retrofitted to become grid-forming Type 2 units, a system certificate must be issued on the basis of the unit certificates for the retrofitted units in accordance with the FNN Guideline on grid-forming capabilities, Version 2.1 (or later).

In addition, the following evidence must be provided as part of the declaration of conformity:

- Confirmation that the necessary software updates have been carried out for all retrofitted units, supported by a relevant extract from the event log,
- Manufacturer's declaration confirming the replacement of necessary hardware components,
- Parameter extract for the retrofitted units,
- Metrological evidence based on internally switchable signals on a unit in the field freely selected by the certifier, using the following measurements: in accordance with Sections 5.5.5.3, 5.5.5.8 and 5.5.5.9 (evaluation in accordance with Section 5.5.5.9.3.3) [1],
- As an alternative to measurement-based verification, a verification document may be submitted for the retrofitted unit using fault recorder evaluations in accordance with the criteria of Section 5.2.4 of the FNN Guideline on grid-forming capabilities. In this context, the provisions of Section 5.2.4 of the FNN Guideline regarding monitoring in a system with several grid-forming units of the same type apply. This verification shall be carried out following the declaration of conformity. The grid-forming unit must be monitored for a period of at least one year. In this case, instead of a final operating licence, the system operator issues an operating licence limited to the monitoring period. Following successful verification of conformity accorded through the evaluation

of fault recorder data, the declaration of conformity can be revised and the final operating licence issued.

- The measurement-based verification or its alternative (monitoring by means of a fault recorder) may be omitted provided that the retrofitting of the respective unit was carried out solely on the basis of a software update.
- In addition, it must be verified that all retrofitted units of the system correspond to the status of the tested or monitored unit.

The necessary measurements must be carried out by a testing institute accredited in accordance with DIN EN ISO/IEC 17025[4] (for FGW TR 3 Rev. 26[5]).

As long as the required metrological evidence has been provided within the framework of a verification for grid-forming systems with prototypes in accordance with Chapter 3, this may also be used for the installation certificate.

If Type 1 units of an existing system are retrofitted to comply with the FNN Guideline on grid-forming capabilities [1] , a system certificate must be issued for these units based on the unit certificates of the retrofitted units in accordance with the FNN Guideline on grid-forming capabilities, Version 2.1 (or later). If no unit certificates are available for the units to be retrofitted, a system certificate C may be issued in accordance with the FNN Guideline on grid-forming capabilities, version 2.1 (or later).

4.3 SYSTEM CERTIFICATION WITH UNITS WITHOUT UNIT CERTIFICATES (INDIVIDUAL VERIFICATION PROCEDURE)

In the case of system certification of units with grid-forming capabilities using the individual verification procedure, the system certificate is based on manufacturer's declarations confirming compliance with the requirements of the FNN Guideline in version 2.1 (or later). As part of the extended declaration of conformity, measurement-based verification must be carried out in accordance with the FNN Guideline.

Table of Contents Appendices

Anhang G Specific requirements for grid-forming units and installations participating in market-based procurement of inertia

G.1 CERTIFICATION PROCEDURE

G.1.1 INTRODUCTION

Supplement G is to be applied, irrespective of the voltage level, for grid-forming units to demonstrate compliance with the requirements of the FNN Guideline "Requirements and Evidence for Grid-Forming Units and Installations Version 2.1, January 2026" by a certification body accredited in accordance with DIN EN ISO/IEC 17065 [3] and FGW TG 8.

Differences between voltage levels are addressed in the relevant assessment criterion where necessary.

This evidence is currently required for participation in market-based procurement of inertia. In future, evidence for battery storage systems in accordance with VDE-AR-N 4120 / VDE-AR-N 4130 will also be required.

The assessment of grid-forming Type 1 and Type 2 units or installations takes place in separate chapters (Chapter G.2 and Chapter G.3) due to the requirements and evidence, which are in some cases entirely different.

The assessment criteria of Supplement A described in TG 8 Rev. 10 [2] also apply to this supplement, unless they are replaced or supplemented as described in this supplement. Assessment criteria that have been amended compared to TG 8 Rev. 10 [2] are highlighted in the colour (blue).

Notes on the layout elements

References and prerequisites:

Requirement	References (source citations) for the requirements imposed on the assessment object and considered here in accordance with the Grid Code or FNN Guideline on grid-forming capabilities [1].
Evidence	References (source citations) for the requirements imposed on the verification process and considered here in accordance with the Grid Code or FNN Guideline on grid-forming capabilities [1].
Applicable documents	References (source citations) to further requirements for the subject of assessment or the verification process that are not immediately apparent from the Grid Code or the FNN Guideline on grid-forming capabilities [1]. (E.g. cross-references from the Grid Code or the FNN Guideline on grid-forming capabilities, or in the case of verification according to the 'state of the art' where the Grid Code lacks details on the verification procedure.)
Prerequisites	All relevant prerequisites that must be in place before the evaluation activity begins. The following terms are defined: **Manufacturer's declaration** = A manufacturer's declaration is available and permits conformity assessment against the requirement in question. **Test report** = A test report in accordance with TG 3 [5] or TG 3 Supplement 26.2 [6] is available and allows for conformity assessment against the relevant requirement.

	Equipment certificate(s) = Equipment certificates (= unit certificates) are available and allow for conformity assessment against the relevant requirement. *Note: The meaning of other keywords applies either mutatis mutandis or is explained in the relevant section.*
Remarks	Where the situation covered by the evaluation plan requires further explanation, additional clarifications and notes are provided here.

<u>Evaluation activity:</u>

General provisions (assessment criteria)	A bullet-point list of the assessment activities to be carried out **in accordance with the Grid Code or FNN Guideline on grid-forming capabilities** [1]. Where several assessment steps are required for a product attribute, this is indicated by the numbering. Assessment items are numbered sequentially. (Example: “2”). Investigation steps for a single investigation item are numbered as sub-items. (Example: “2.1”). If the assessment activity can be summarised, this summary is entered here. In doing so, the focus is limited to the essential points. If a summary is not feasible, a meaningful description of the assessment activity in the form of keywords is entered instead. In cases where an evaluation criterion in accordance with GCRS or FNN Guideline grid-forming capabilities [1] could be misunderstood, e.g. because an ambiguous interpretation is possible, the evaluation criterion is reproduced in such a way that only a single interpretation of the criterion is possible.
General rule (Further evidence)	A bullet-point list of the assessment activities to be carried out in accordance with applicable documents. Where several assessment steps are required for a product attribute, this is indicated by the list. Assessment items are numbered alphabetically. (Example: “A”). Assessment steps for an assessment item are numbered as sub-points. (Example: “A.1”). The same provisions apply as for “General provisions (evaluation criteria)”.
Acceptance criterion	Where the GCRS or the FNN Guideline on grid-forming capabilities [1] specifies a clear criterion (e.g. a tolerance limit), this is presented here in abbreviated form. If an abbreviated form is not feasible, a meaningful description of the criterion in the form of keywords is entered instead (Example: “Step response exhibits PT1 behaviour”). In the event that the GCRS or the FNN Guideline on grid-forming capabilities [1] specifies no acceptance criterion, or one that is not unambiguous or demonstrably unachievable, a criterion is defined here in an unambiguous manner that is fundamentally verifiable and achievable.

<u>Technology-specific modifications:</u>

A technology-specific modification is not required in this supplement due to the strict separation between Type 1 and Type 2 units/installations.

The scope of the evaluation activity is derived from the structure.

<u>Delimitation of the scope:</u>

PGU	Evaluation activities relating to power generating units within the framework of unit certification or an individual verification procedure.
Component / PGS controller	Evaluation activities relating to components of power generating units and systems or to PGS controllers within the framework of a type certification for components (in short: component certification).
PGS	Assessment activities relating to power generating systems within the framework of the issuance of system certificates.

G.1.2 UNIT CERTIFICATE

The evaluation criteria for Type 1 and Type 2 units to be replaced are set out below.

Table 1 provides an overview of the assessment criteria to be replaced in Supplement A according to FGW TG 8 Rev. 10 for grid-forming Type 1 units.

Table 1 Overview of evaluation criteria to be replaced in Supplement A for grid-forming Type 1 units

TG 8 Rev. 10 Chapter	Criterion	TG 8 Supplement 10.1 Chapter	Remarks
A.1.2.5.2.1 A.2.2.5.2.1 A.3.2.5.2.1	Active power output as a function of the grid frequency	G.2.1.4 G.2.1.2	A.1.2.5.2.1, A.2.2.5.2.1 and A.3.2.5.2.1 are replaced by G.2.1.4 for Type 1 units, and for rapid frequency changes (RoCoF) byG.2.1.2 .
A.1.2.9.1.1 A.2.2.9.1.1 A.3.2.9.1.1	Requirements for simulation models	G.2.1.5	A.1.2.9.1.1, A.2.2.9.1.1 and A.3.2.9.1.1 are each replaced by G.2.1.5 .

Table 2 provides an overview of the evaluation criteria in Supplement A to be replaced in accordance with FGW TG 8 Rev. 10[2] for grid-forming Type 2 units.

Table 2 Overview of evaluation criteria to be replaced in Supplement A for grid-forming Type 2 units (Type 2 PGU, PGSU, storage)

TG 8 Rev. 10 Chapter	Criterion	TG 8 Supplement 10.1 Chapter	Remarks
A.1.2.2.2.1 A.2.2.2.2.1 A.3.2.2.2.1	Polar-wheel and grid oscillations	G.3.1.4	A.1.2.2.2.1, A.2.2.2.2.1 and A.2.2.2.2.1 are replaced for Type 2 units by G.3.1.4 .
A.1.2.5.2.1 A.2.2.5.2.1 A.3.2.5.2.1	Active power output as a function of grid frequency	G.3.1.1.3 G.3.1.2.8 G.3.1.2.5	A.1.2.5.2.1, A.2.2.5.2.1 and A.3.2.5.2.1 are replaced for Type 2 units by G.3.1.1.3 and G.3.1.2.8 respectively, and for handling rapid frequency changes (RoCoF) by G.3.1.2.5 .
A.1.2.7.2.1 A.2.2.7.2.1 A.3.2.7.2.1	Island and sub-network operation capability	G.3.1.1.3 G.3.1.2.8	A.1.2.7.2.1, A.2.2.7.2.1 and A.3.2.7.2.1 are replaced by G.3.1.1.3 and G.3.1.2.8 respectively.
A.1.2.7.3.1 A.2.2.7.3.1 A.3.2.7.3.1	Dynamic network support	G.3.1.2.4.3 G.3.1.2.4.5 G.3.1.2.4.6	A.1.2.7.3.1, A.2.2.7.3.1 and A.3.2.7.3.1 are replaced by G.3.1.2.4.3, G.3.1.2.4.5 and G.3.1.2.4.6.
A.1.2.5.1.1.1 A.2.2.5.1.1.1 A.3.2.5.1.1.1	General and network security management	G.3.1.3	A.1.2.5.1.1.1, A.2.2.5.1.1.1 and A.3.2.5.1.1.1 are each replaced by G.3.1.3.1.1, G.3.1.3.1.2 and G.3.1.3.1.3
A.1.2.8.4.1 A.2.2.8.4.1 A.3.2.8.4.1	Setting ranges (decoupling protection)	G.3.1.5	A.1.2.8.4.1, A.2.2.8.4.1 and A.3.2.8.4.1 are replaced by G.3.1.5.1, G.3.1.5.2 and G.3.1.5.3
A.1.2.9.1.1 A.2.2.9.1.1 A.3.2.9.1.1	Requirements for simulation models	G.3.1.6	Replaced by G.3.1.6 .
Remarks			

G.1.3 SYSTEM CERTIFICATE

For grid-forming power generating systems, a complete system certificate A in accordance with FGW TG 8 Rev. 10 [2] must be submitted in conjunction with this addendum.

Deviations from the minimum scope of documents to be provided for the grid connection of grid-forming power generating systems are described in Section 5.6.2.2 [1].

Table 3 provides an overview of the evaluation criteria in Supplement A to be replaced in accordance with FGW TG 8 Rev. 10 [2] for power generating systems with grid-forming Type 1 units.

Table 3 Overview of assessment criteria to be replaced in Supplement A for power generating system with grid-forming Type 1 units

TG 8 Rev. 10 Chapter	Criterion	TG 8 Supplement 10.1 Chapter	Remarks
A.1.2.5.2.3 A.2.2.5.2.3 A.3.2.5.2.3	Active power output as a function of grid frequency Requirements for primary control based on network security	G.2.3.1	A.1.2.5.2.3, A.2.2.5.2.3 and A.3.2.5.2.3 are each replaced by G.2.3.1.
A.1.2.7.2.3 A.2.2.7.2.3 A.3.2.7.2.3	Island/sub-network operability	G.2.3.2	A.1.2.7.2.3, A.2.2.7.2.3 and A.3.2.7.2.3 are replaced, with regard to sub-network interoperability, by G.2.3.2.
A.1.2.4.2.3 A.2.2.4.2.3 A.3.2.4.2.3	Procedure for reactive power provision	G.2.3.3.1 G.2.3.3.2 G.2.3.3.3	A.1.4.2.3, A.2.4.2.3 and A.3.4.2.3 are replaced by G.2.3.3.1, G.2.3.3.2 and G.2.3.3.3.
A.1.2.5.1.3 A.2.2.5.1.3 A.3.2.5.1.3	General and grid security management	G.2.3.4.1 G.2.3.4.2 G.2.3.4.3	A.1.2.5.1.3, A.2.2.5.1.3 and A.3.2.5.1.3 are replaced by G.2.3.4.1, G.2.3.4.2 and G.2.3.4.3 respectively.
A.1.2.7.3.3 A.2.2.7.3.3 A.3.2.7.3.3	Dynamic network support	G.2.3.5.1 G.2.3.5.2 G.2.3.5.3	A.1.2.7.3.3, A.2.2.7.3.3 and A.3.2.7.3.3 are replaced by G.2.3.5.1, G.2.3.5.2 and G.2.3.5.3 respectively.

A.1.2.9.1.3 A.2.2.9.1.3 A.3.2.9.1.3	Requirements for simulation models	G.2.3.6.1 G.2.3.6.2 G.2.3.6.3	A.1.2.9.1.3, A.2.2.9.1.3 and A.3.2.9.1.3 are replaced by G.2.3.6.1, G.2.3.6.2 and G.2.3.6.3 respectively.
Remarks			

Table 4 provides an overview of the evaluation criteria in Supplement A to be replaced in accordance with FGW TG 8 Rev. 10 for power generating systems with grid-forming Type 2 units.

Table 4 Overview of evaluation criteria to be replaced in Supplement A for power generating systems with grid-forming Type 2 units (Type 2 PGU, PGSU, storage)

TG 8 Rev. 10 Chapter	Criterion	TG 8 Supplement 10.1 Chapter	Note
A.1.2.2.2.3 A.2.2.2.2.3 A.3.2.2.2.3	Phase swinging and grid oscillations	G.3.2.1	For Type 2 units, A.1.2.4.2.2, A.2.2.4.2.2 and A.3.2.4.2.2 are each replaced by G.3.2.1.
A.1.2.4.2.3 A.2.2.4.2.3 A.3.2.4.2.3	Procedure for reactive power provision	G.3.2.2	A.1.2.4.2.3, A.2.2.4.2.3 and A.3.2.4.2.3 are each replaced by G.3.2.2.
A.1.2.5.1.3 A.2.2.5.1.3 A.3.2.5.1.3	General and Network Security Management	G.3.2.3.1 G.3.2.3.2 G.3.2.3.3	A.1.2.5.1.3, A.2.2.5.1.3 and A.3.2.5.1.3 are replaced by G.3.2.3.1, G.3.2.3.2 and G.3.2.3.3.
A.1.2.5.2.3 A.2.2.5.2.3 A.3.2.5.2.3	Active power output as a function of grid frequency Requirements for primary control based on network security	G.3.2.4	A.1.2.5.2.3, A.2.2.5.2.3 and A.3.2.5.2.3 are each replaced by G.3.2.4.
A.1.2.7.2.3 A.2.2.7.2.3 A.3.2.7.2.3	Island/sub-network operation capability	G.3.2.5	A.1.2.7.2.3, A.2.2.7.2.3 and A.3.2.7.2.3 are replaced by G.3.2.5 with regard to sub-network operability.
A.1.2.7.3.3	Dynamic network support	G.3.2.7.1	A.1.2.7.3.3, A.2.2.7.3.3 and A.3.2.7.3.3 are

A.2.2.7.3.3 A.3.2.7.3.3		G.3.2.7.2 G.3.2.7.3	replaced by G.3.2.7.1, G.3.2.7.2 and G.3.2.7.3.
A.1.2.9.1.3 A.2.2.9.1.3 A.3.2.9.1.3	Requirements for simulation models	G.3.2.6.1 G.3.2.6.2 G.3.2.6.3	A.1.2.9.1.3, A.2.2.9.1.3 and A.3.2.9.1.3 are replaced by G.3.2.6.1, G.3.2.6.2 and G.3.2.6.3.
Remarks			

G.1.4 COMPONENT CERTIFICATE

Chapters A.1.2.4.2.2, A.2.2.4.2.2 and A.3.4.2.2 are replaced by G.3.3.1.1, G.3.3.1.2 and G.3.3.1.3.

G.1.5 INDIVIDUAL VERIFICATION PROCEDURE (SYSTEM CERTIFICATE C)

Specific features regarding the application of system certificate C/C1 for power generating systems within the scope of the FNN Guideline [1] are listed in Chapter G.2.2.1.

G.1.6 DECLARATION OF CONFORMITY

Chapters A.1.1.5, A.2.1.5 and A.3.1.5 are supplemented as follows:

If the system certificate for verifying the static voltage holding behaviour of the entire system states that this is to be demonstrated metrologically within the framework of the declaration of conformity in accordance with Procedure (A) [1], the metrological test must be carried out in accordance with the requirements of Section 5.7.2 [1] by a testing institute accredited in accordance with DIN EN ISO/IEC 17025 [4]. The test is deemed to have been passed provided that, for all tests carried out, the step responses lie within the relevant tolerance bands and the control behaviour is damped within the tolerance bands. The assessment of the disturbance behaviour shall commence from a state following the initial response of the voltage source control (Type 2) or the voltage regulator (Type 1). If the measurements were carried out at an SCR < 10 and the tolerance specifications were not met, a simulation test in accordance with Chapter G.3.2.2 may be used for conformity assessment instead.

G.1.7 EXTENDED DECLARATION OF CONFORMITY

Chapters A.1.1.6, A.2.1.6 and A.3.1.6 are supplemented as follows:

Provided that the system certificate for verifying the static voltage holding behaviour of the entire system states that this is demonstrated metrologically within the scope of the declaration of conformity in accordance with Procedure (A) [1], the metrological test in accordance with the requirements of Section 5.7.2 [1] must be carried out by a testing institute accredited in accordance with DIN EN ISO/IEC 17025[4]. The test is deemed to have been passed provided that, for all tests carried out, the step responses lie within the relevant tolerance bands and the control behaviour is damped within the tolerance bands. The evaluation of the disturbance behaviour shall commence from a state following the initial response of the voltage source control (Type 2) or the voltage regulator (Type 1). If the measurements were carried out at an SCR < 10 and the tolerance specifications were not met, a simulation test in accordance with Chapter G.3.2.2 may be used for conformity assessment instead.

G.2 SCOPE OF EVALUATION FOR TYPE 1 UNITS

G.2.1 UNIT CERTIFICATE

G.2.1.1 General and transferability

Proof of conformity is type-based and comprises (i) a manufacturer's declaration, (ii) selected measurements on the reference type, and (iii) the validation of a simulation model of the electrical characteristics.

Principle of type testing and family transferability

1. **Type-based approach:** Not every power or variant level of a series needs to be metrologically tested. A reference type is defined and metrologically examined for each type family.
2. **Transferability within the family:** Measurement results for the reference type may – in whole or in part – be transferred to other family members if the following equivalence and size criteria are met and a validated simulation model complies with the specified model tolerances. In this case, the required evidence (including FRT and PCNB) may be provided on the basis of measurement equivalents generated by simulation.

TA documentation per type: For each type (or each type variant relevant to certification), the certification body must maintain complete documentation of the transient response time constants, including measurements or validation of the calculation method used to determine these constants. A prerequisite for the validation of the method is the traceability of the calculation method used by the manufacturer within the framework of a manufacturer's declaration. Traceability by the certification body is deemed to be established if the manufacturer's declaration contains the specification of the moment of inertia of the entire PGU powertrain based on a multi-body simulation model description, including the necessary parameter specifications or corresponding simulation reports. This must include the following:

- the moments of inertia of the individually defined component assemblies (e.g. torsional vibration damper, crankshaft, cylinder assembly, flywheel, flexible coupling, generator, etc.) of the complete shaft train,
- the topology of the model (e.g. multiple components connected by gearboxes),
- the rated speed of the individual components.

Conditions for transferability

The transferability of the measurement results of the reference type to other units is guaranteed if all of the following conditions are met:

1. **Technical equivalence**
   The design, control concept and the software/parameterisation determining the electrical characteristics are technically equivalent. Interchangeable components (e.g. excitation, AVR/PSS functions, protection concepts, transformers, measurement chains) must not cause any grid-relevant deviations. Changes to the control code between the measured reference type and the rest of the type family must be documented and assessed with regard to their effect on electrical behaviour.
2. **Power range / scaling**
   Measurement results are available for the smallest and largest power variants of the family, or the unit to be certified lies within the permissible scaling interval:

S_n of the unit to be certified must lie between $1/\sqrt{10}$ times and $\sqrt{10}$ times that of the calibrated unit.

Verification for FRT and PCNB via simulation model

The transferability for FRT (Fault-Ride-Through) and PCNB can be investigated using a model-based approach. To do so, the following requirements must be met:

1. **Validated simulation model**
   The unit model (time domain, appropriate model depth for synchronous generator + excitation/AVR, turbine/drive train where applicable, protection/limiter where applicable, provided this is necessary for the transfer of test results) must be validated against the measurement of the reference type. The validation criteria of the FNN Guideline [1] must be met for the PCNB and the start-up time constant.

2. **Parameterisation from manufacturer's documentation**
   Parameterisation (e.g. AVR/PSS parameters, limiters, saturations, short-circuit reactance, time constants, inertias, damping, protection thresholds) must be verifiable on the basis of data sheets and setting lists. Scaling and conversion of parameters between the actual unit and the simulation model are permitted.

If (1)–(2) are fulfilled, FRT and PCNB verifications for unmeasured family members may be provided entirely by simulation. Supplementary verification measurements are only required if the model lies outside the tolerances or if essential equivalence assumptions are not met.

Procedural model (process steps)

1. **Family definition & reference type:** Delineation of the type family, specification of the reference type, documentation of hardware/software versions.
2. **Reference type measurement programme:** Targeted measurements for model validation (including FRT-relevant transients, PCNB scenarios, quasi-steady-state points).
3. **Model development & validation:** Parameterisation based on manufacturer documentation; validation against measurement data in accordance with model tolerances.
4. **Equivalence test:** Evidence of technical equivalence of the family members in accordance with the manufacturer's declaration. Additional documents, such as parts lists, may be attached for further clarification.
5. **Scaling test:** Evidence that S_n of the unit to be certified lies within the permissible interval.
6. **Simulation-based FRT/PCNB evidence:** Simulation and evaluation of the required test scenarios using a validated model.
7. **TA compliance per type:** Consolidation of the manufacturer's declaration, justification of transferability and model evidence.
8. **Documentation & traceability:** Complete documentation of assumptions, parameters, software versions, measurement/simulation reports, comparison plots and conformity matrix.

Scope and special cases

- **Significant changes** between the reference type and the type family, or within the type family, invalidate the equivalence. In this case, a new measurement verification/model validation is required.
- **Network dependencies** (e.g. short-circuit power/impedance angle) must be taken into account in the model where necessary; the selected network dependencies must cover the evaluation steps defined in the FNN Guideline [1] and in the TCRs [7][8][9].

G.2.1.2 Behaviour under steep frequency gradients (RoCoF)

Requirement	Evidence	Applicable documents	Prerequisites
4.1.1.1 [1]	5.4.3.1 [1]	FNN Guideline: Grid-forming capabilities VDE-AR-N 4110 VDE-AR-N 4120 VDE-AR-N 4130	Manufacturer's declaration
Remarks			

In general:

No.	Evaluation criteria	Acceptance criterion
1	The RoCoF values required in accordance with Section 4.1.1.1 [1] can be maintained without disconnection from the grid. • ± 2.0 Hz/s for a sliding time window of 0.5 s, • ± 1.5 Hz/s for a sliding time window of 1 s and • ± 1.25 Hz/s for a sliding time window of 2 s. *Note: There is currently no recognised verification procedure for behaviour under steep frequency gradients. Work is currently underway on such a method. Once this is finalised, the acceptance criterion will be adjusted accordingly.*	A manufacturer's declaration to this effect has been provided.
2	If the evaluation criterion under No. 1 is not met, the framework conditions for meeting the requirements are specified.	True

G.2.1.3 Verification of the start-up time constant

Requirement	Evidence	Applicable documents	Prerequisites
4.1.1.2 [1]	5.4.3.2 [1]	FNN Guideline: Grid-forming capabilities TG 3	Test report, manufacturer's declaration
Remarks	Verification of moments of inertia / start-up time constants for grid-forming Type 1 units: • Generator with excitation system: Manufacturer's declaration • Additional flywheel mass (including generator-side coupling, if applicable): Manufacturer's declaration • Complete shaft train (generator, turbine, flywheel, etc.): measurement-based verification		

In general:

No.	Evaluation criteria	Acceptance criterion
Generator and additional flywheel mass		
1	The moments of inertia (kgm²) and time constants (T_A) for: • the generator with excitation system • the additional flywheel mass, including the generator-side coupling (if applicable) are presented in a technically verifiable manner. *Note:* $T_A = 2\,H$ *Note: The apparent power of the generator must be used as the reference value for the time constant.*	The information has been provided and is technically verifiable.
1.1	The mass inertia of the generator is either: • specified in a verifiable manner based on design and material parameters, or • determined by a run-down test in accordance with the applicable machine standards (e.g. IEC 60034-4-1). *Note: In the run-down test, the moments of inertia of the excitation system and other parts of the shaft train that are rigidly coupled in the phase-shift operation may be included.*	True
1.2	The procedure for determining the moments of inertia or start-up time constants of the generator is described. In the case of a run-down test, x-t diagrams	True

	are also provided. The components of the shaft train included in the determination of the start-up time constants are listed.	
2	Where reference is made to valid standards, the procedures are carried out in accordance with those standards.	Compliance with standards is ensured
Start-up time constant of the complete shaft train		
3	The metrological evaluation is described in a plausible manner.	True
4	Deviations from the manufacturer's specifications are assessed.	True
5	The manufacturer's specifications and metrologically determined values are shown. The metrologically determined values for the complete shaft assembly deviate by a maximum of 10% from the manufacturer's specifications, thereby confirming the manufacturer's specifications.	True $\left\|1-\frac{\text{Measured value}}{\text{Manufacturer information}}\right\| \leq 0{,}1$
5.1	The justification for the final determination of the value of T_{A} in the verification procedure is provided.	True

G.2.1.4 Behaviour at over- and under-frequency (primary control based on network security)

Requirement	Evidence	Applicable documents	Prerequisites
4.1.2 [1]	5.4.3.3.2 [1]	FNN Guideline: Grid-forming capabilities	Test report, manufacturer's declaration
Remarks	The following test points 1 to 10 must be evaluated for the reference type on the basis of the test report. For all non-measured units of the type family, test points 1, 2, 3, 4, 5, 7 to 8.3 must be tested using a validated simulation model.		

In general:

No.	Evaluation criteria	Acceptance criterion
Test conditions		
1	The switching state of the test object's coupling switch with the mains or mains emulator is not signalled to the test object.	True
2	All tests are performed using the default static settings.	True
3	Before the dome switch is opened in Measurement 1, the test specimen is at an operating point where $\cos\varphi \approx 1$ or $Q \approx 0$.	True

4	The voltage control of the PGU is parameterised in such a way that the load changes to be carried out result in the smallest possible transient voltage deviations and ensure a damped response. The voltage-induced self-regulation effect is less than 5% of the PGU's rated active power, both in steady-state conditions and during the dynamic compensation process. Any exceedance of this limit is indicated. *Note: Any change in load power during the test should be limited to 5%.*	True
5	The specified initial active power is maintained with a tolerance of ± 5 % $P_{\mathrm{b\ inst}}$. The deviation is taken into account during evaluation.	True
6	A manufacturer's declaration confirms and describes (block diagrams, parameters) that the primary control based on network security is implemented with proportional frequency control.	Information provided
6.1	Passing measurements 1 to 4 confirms that the primary control based on network security is implemented using proportional frequency control.	True
Test 1 – Falling into the virtual island network		
7	It must be verified and demonstrated that the measurement was carried out in accordance with the following specifications: **Initial condition:** • Grid-connected operation at P_{binst} **Setting of the load of the virtual island network** <u>Base case</u>: lower limit of the control range according to Table 15 [1], but not exceeding 55 % P_{binst} at rated voltage. <u>Repetitions:</u> The load is set to • 65 % $P_{\mathrm{b\ inst}}$ of the test specimen, • 75% $P_{\mathrm{b\ inst}}$ of the test specimen, • 85% $P_{\mathrm{b\ inst}}$ of the test specimen and • $P_{\mathrm{Emin,E}}$ of the test specimen. In step 4, the operating point of the test specimen is set so that opening the coupling switch results in a power reduction of 45 % $P_{\mathrm{b\ inst}}$. **Condition** All the load points mentioned above are tested.	True

	Note: Test step 4 is only carried out if it has not already been tested in previous tests. The measurement has been carried out twice in each case with identical settings for the test specimen and the test setup.	
7.1	In the case of internal combustion engines with mixture formation, the following applies in deviation from No. 7: The load is set to the following before falling into the virtual island: • 100% $P_{\mathrm{binst}} - \Delta P$ (where $\Delta P \geq 5\% \ P_{\mathrm{b\ inst}}$), • 65% $P_{\mathrm{b\ inst}}$ of the test specimen, • 75% $P_{\mathrm{b\ inst}}$ of the test specimen, • 85% $P_{\mathrm{b\ inst}}$ of the test specimen and • $P_{\mathrm{Emin,E}}$ of the test specimen. The test specimen is adjusted in each case so that a jump of $\Delta P \geq 5\ \%\ P_{\mathrm{b\ inst}}$ occurs during the transition to the virtual island.	True
7.2	The frequency response of the test specimen meets the following criteria: • the frequency value 52.5 Hz is exceeded for a maximum of 0.1 s, • the frequency value 51.5 Hz is exceeded for a maximum of 10 s, and • the transient response of the measured frequency/speed meets the required damping ratio of $D \geq 0.06$. In the case of internal combustion engines with mixture formation, a maximum transient frequency of over 52.5 Hz or under 47.5 Hz may alternatively be permitted, depending on capability and resources.	True
Measurement 2 – Unrestricted control range		
8	The test takes place in the virtual island network. The load steps applied in the test steps comply with the specifications in Table 14 [1]. The steps are set with an accuracy of ±2 % $P_{\mathrm{b\ inst}}$.	True
8.1	The speed curve of the test specimen meets the requirements for the damping ratio of $D \geq 0.06$ in each case. The damping ratio is determined in accordance with the specifications.	True $D \geq 0.06$
8.2	The permissible transient frequency limits of 52.5 Hz and 47.5 Hz are not exceeded or fallen short of. In the case of internal combustion engines with mixture formation, a maximum transient frequency of over 52.5 Hz or under 47.5 Hz may alternatively be permitted, depending on capability and resources.	True

Measurement 3 - Frequency specification		
9	In Measurement 3, the measurement points are approached with an accuracy of ± 10 mHz.	True
9.1	The starting point for the measurements is $P_{\mathrm{b\ inst}}$ when the frequency is increased. Starting from the nominal frequency, the following frequency steps are simulated in the over-frequency range: • actual frequency + 300 mHz • actual frequency + 800 mHz • actual frequency + 1.3 Hz • actual frequency + 300 mHz • actual frequency + 0 Hz . The starting point for the measurements is $P_{\mathrm{Emin,E}}$for frequency reduction. Based on the mains frequency, the following frequency steps are simulated in the underfrequency range: • actual frequency - 300 MHz • actual frequency - 800 mHz • actual frequency - 2 Hz • actual frequency - 300 mHz • actual frequency – 0 Hz.	
9.2	The steady-state final values of active power deviate by a maximum of ±5 % of the expected power change or ±0.5 % $P_{\mathrm{b\ inst}}$ from the values resulting from the set steady-state conditions.	True
9.3	The determined control speeds of the limited control range correspond to at least the values given in Table 15 [1].	True
Measurement 4 - maximum insensitivity / reversal margin		
10	The maximum insensitivity is determined in accordance with FGW TG 3 Rev. 26 (or later), Chapter 7.2.1.6 or 7.2.2.3.3 [6] and corresponds to the required limit value of ±10 mHz with a maximum deviation of ±20% (or a maximum tolerance of ±2 mHz).	True

G.2.1.5 Simulation models

G.2.1.5.1 Requirements for simulation models

Requirement	Evidence	Applicable documents	Prerequisites
11.2.6 (TCR)	11.2.6 (TCR)	TG 4	Validated PGU models for the grid fault scenario and normal operation require measurement results in accordance with 11.2.4, 11.2.5, 11.2.7 and 11.2.10 of the applicable TCR.
5.4.2.2 [1]	5.4.2.2 [1]	FNN Guideline: Grid-forming capabilities	Validated PGU models for the correct representation of behaviour during over- and under-frequency as well as the start-up time constants of the entire wave train require measurement results in accordance with sections 5.4.3.3.2 and 5.4.3.2.3 [1].
Remarks	For Type 1 units intended for participation in the inertia market, the requirements for simulation models in accordance with TG 4 Rev. 10 [10] Chapter 8 must generally be met. In addition, the specifications for simulation models and model accuracies in accordance with Section 5.4.2.2.2 [1] or Section 5.4.2.2.1 [1] apply to the validation of PGU models for the correct representation of behaviour during over- and under-frequency (primary control based on network security) as well as the start-up time constants. The models must be validated in accordance with these sections, provided that the relevant system operator requires simulation models for the Type 1 unit.		

In general:

No.	Evaluation criteria	Acceptance criterion
General requirements		
1	The functional scope of the models shall comply with at least Section 11.2.6.2.	True
2	Models for network faults are implemented as RMS models. In special cases, the use of EMT models is permitted.	True. Where EMT models are used in justified cases, the calculation

		results have been checked for robustness.
2.1	Models for grid faults represent the phase, neutral and zero systems.	True. Unbalanced faults can be modelled.
2.2	Models for the network fault case can represent, from any quasi-steady-state operating point, the behaviour during a fault in the superimposed network and the return to quasi-steady-state operation.	True
2.3	Models for the network fault case include at least the PGU and protective devices, provided these are part of the PGU.	True
2.4	The time step is a maximum of 10 ms. When using automatic step size adjustment, the maximum step size is no more than 0.2 s.	True
3	Models for normal operation represent all setting times and accuracies with regard to active and reactive power in accordance with the respective requirements.	True
3.1	The difference between the 5-second moving averages for simulated and measured active and reactive power in normal operation remains within specified limits. Simulations were carried out in accordance with TG 4 and the corresponding tolerances can be met.	True
4	PGU models were subjected to plausibility tests in accordance with [10] for use at further operating points. Reproducible results must be ensured under identical initial load flow conditions.	True
5	The voltage regulator and its model must not be modified for transfer to other PGU units in accordance with 11.2.1.	True
6	The model documentation covers all functionalities, interfaces and key control variables of the PGU model, including permissible setting ranges.	True
7	Relevant control variables in the PGU's control system are documented.	True
8	The integration and application of the model in the simulation environment used are clearly described.	True
9	In the individual verification procedure, the PGU models are validated in accordance with TG 4. This	True

	validation forms part of the extended declaration of conformity.	
10	The requirements for the transferability of simulation models from 11.2.5.3 are met.	True

No.	Further evidence	Acceptance criterion
General model requirements		
A	Validation of the PGU models for the grid fault scenario based on measurements in accordance with 11.2.5 and 11.2.10, as specified in TG 4, is carried out by a certification body accredited in accordance with DIN EN ISO/IEC 17065 [3].	True
B	Validation of the PGU models for normal operation based on measurements in accordance with 11.2.4 and 11.2.7, in accordance with the requirements of TG 4, is carried out by a certification body accredited in accordance with DIN EN ISO/IEC 17065 [3].	True
Requirements for demonstrating the properties in accordance with [1]		
C	Validation of the PGU models for the correct representation of behaviour during over- and under-frequency (primary control based on network security) based on measurements in accordance with Section 5.4.3.3.2 [1] in accordance with Section 5.4.2.2.2 and, where necessary, TG 4 [10] or its Supplement 10.1, are carried out by a certification body accredited in accordance with DIN EN ISO / IEC 17065 [3].	Validation
D	Validation of the PGU models for the correct representation of the transient response of the entire shaft train based on measurements in accordance with Section 5.4.3.2.3 [1] in accordance with Section 5.4.2.2.1 [1] and, if necessary, TG 4 [10] or its Supplement 10.1, are carried out by a certification body accredited in accordance with DIN EN ISO / IEC 17065 [3].	True

G.2.1.5.2 Model validation of the PCNB and time constant

Requirement	Proof	Applicable documents	Prerequisites
5.4.2.2.1 [1] 5.4.2.2.2 [1]	-	FNN Guideline: Grid-forming capabilities TG 4 Supplement E.5.2 TG 3	Measurement report in accordance with [1] Model validation by the model developer

			Documentation of the simulation model in accordance with TG 4

Remarks	For grid-forming Type 1 units the requirements for simulation models and model accuracy with regard to the verification of the requirements for primary control based on network security in accordance with Section 5.4.3.3 [1], as well as the verification of the requirements for the response time constant in accordance with Section 5.4.3.2.3 [1], FGW TG 4 Rev. 10 [10] Chapter E.5.2 are to be applied. The required specifications for simulation models and model accuracy, which deviate from the standard procedure in accordance with FGW TG 8 Rev. 10, shall form the basis of the following evaluation criteria. The simulation model to be submitted by the manufacturer must be verified with regard to the modelling of primary control based on network security and the entire drive train on the operational system. For this purpose, defined tests must be carried out on the power generating unit (Sections 5.4.3.3.2 and 5.4.3.2.3). In principle, it must be ensured that the simulation model can be verified. On the basis of these tests, a model validation is carried out using the simulation model provided by the manufacturer with regard to the above-mentioned requirements. In doing so, the test results or test sequences must be compared with corresponding simulations based on the simulation model. It must be noted that simulations must be initialised to the absolute initial conditions of the tests in each case. The comparison of measurement and simulation must include both the steady-state initial condition and the steady-state final condition. The certification body must verify that the listed measurements have been fully carried out and documented. The certification body shall assess the above-mentioned requirements regarding the accuracy of the simulation models. The assessment by the certification body requires the full execution by the certification body of the validation steps relevant to primary control based on network security or the entire wave train. Furthermore, the certification body shall verify the plausibility of the model validation. The certification body's verification of the plausibility of the model validation is based on a 'documentation of PGU validation', which forms part of the unit certification and must be presented in a separate chapter.

In general:

No.	Assessment criteria	Acceptance criterion
Start-up time constant of the complete shaft train		

1	A plausible metrological evaluation is carried out in accordance with Section 5.4.3.2.3 [1].	True
2	The start-up time constant of the entire shaft train as specified by the manufacturer is used in the simulation model.	True, justification and details provided where applicable
2.1	In the event that the determined start-up time constant does not correspond to the manufacturer's value within the permissible tolerance, the deviations between the metrological value and the manufacturer's specification are assessed.	True
Over- and under-frequency behaviour (primary control based on network security)		
3	The test described in Section 5.4.3.3.2 [1] (Measurements 1 and 3) is carried out by simulation for the PGU model and evaluated in accordance with the specifications of Section 5.4.3.3.2.3 [1] and, additionally, in accordance with Section 5.4.2.2.2 [1].	True
4	The initialisation of the PGU simulation model is performed with regard to active power output, speed, reactive power injection and generator voltage at the starting point of the measurements.	True
4.1	The relevant intermediate variables (such as the output signal of the primary controller and the position of the actuators) – provided these are represented in the model – lie within the permissible tolerances specified in FGW TG 4 Rev. 10, Chapter E.5.2.1.1.	True
4.2	The operating mode of the generator control system and the drive unit control system are selected in accordance with the measurement conditions specified in Section 5.4.3.3.2.2 [1].	True
5	The static value of the simulation model is determined in accordance with the specifications in Section 5.4.2.2.2 [1]. The static value corresponds to the value set in the PGU with a maximum deviation of ± 5 %.	True
6	The active power control speeds of the limited control range correspond at least to the characteristic values in Table 15 [1].	True
7	The damping of the simulated transient response of the frequency or speed is determined in accordance with the specifications in Section 5.4.2.2.2 [1]. The simulated damping ratio of the PCNB and the frequency of the speed transient response correspond to the metrologically determined value, with a maximum	True

	deviation of ± 15 % from the metrologically determined value. As an alternative to the damping ratio, the corresponding amplitude ratio may also be evaluated directly, taking into account an accuracy of ± 15 % of the amplitude ratio determined by the measurement.	
7.1	If the procedure in accordance with FGW TG 4 Rev. 10, Chapter E.5.2.1.1, Point 2, Paragraph (3) is applied, the frequency of the simulation model of the grid-forming unit lies within the permissible tolerance band specified in FNN Guideline, Section 5.4.2.2.2.	True

G.2.2 - INDIVIDUAL VERIFICATION PROCEDURE

G.2.2.1 System certificate C/C1 - General procedure for assessment in accordance with GCRS

The evaluation and assessment of the PGU / PGS and their components is carried out, depending on the applicable GCRS, on the basis of Supplement A.1, A.2 or A.3 of the preliminary conformity study. It should be noted that, in some cases, the evaluation/assessment steps for the components must be taken into account.

The following evaluation/assessment steps are to be carried out on the basis of the manufacturer's specifications, notwithstanding the provisions in Supplement A.1, A.2, A.3 and G.2:

- A.1.2.2.1 / A.2.2.2.1 / A.3.2.2.1 Quasi-steady-state operation
- A.1.2.3.1 / A.2.2.3.1 / A.3.2.3.1 Rapid voltage changes
- A.1.2.3.2 / A.2.2.3.2 / A.3.2.3.2 Flicker
- A.1.2.3.3 / A.2.2.3.3 / A.3.2.3.3 Harmonics, inter-harmonics
- A.1.2.3.5 / A.2.2.3.5 / A.3.2.3.5 Asymmetries
- A.1.2.6.1 / A.2.2.6.1 / A.3.2.6.1 Black start capability
- A.1.2.6.2 / A.2.2.6.2 / A.3.2.6.2 Switch-on conditions
- A.1.2.7.2 / A.2.2.7.2 / A.3.2.7.2 |G.1.4 /G.2.3.2 (Note: The units and system section in accordance with [2] is replaced by G.X) Island and sub-network operation capability
- A.1.2.7.4 / A.2.2.7.4 / A.3.2.7.4 Contribution to short-circuit current; additionally, note TG 4 Supplement E.6.4.1.1
- G.2.1.2 Behaviour under steep frequency gradients (RoCoF)
- G.2.1.3 Verification of the start-up time constant

The following evaluation steps are to be carried out, deviating from the specifications in Supplement A.1, A.2, A.3 and G.2, on the basis of simulations using simulation models based on manufacturer's specifications:

- A.1.2.2.2 / A.2.2.2.2 / A.3.2.2.2 Phase swinging and grid oscillations (see also dynamic grid support); additionally TG 4 Supplement E.6.4.2.4
- A.1.2.4.1 / A.2.2.4.1 / A.3.2.4.1 |G.2.3.3.1 /G.2.3.3.2 /G.2.3.3.3 (Note: The section on installations in accordance with [2] is replaced by G.X) Provision of reactive power;

additionally, consult TG 4 Supplements E.6.4.1.2, E.6.4.2, E.6.4.2.1, E.6.4.2.1.1, E.6.4.2.1.2, E.6.4.2.1.3 and E.6.4.2.1.4

- A.1.2.5.1 / A.2.2.5.1 / A.3.2.5.1 |G.2.3.4.1 /G.2.3.4.2 /G.2.3.4.3 (Note: The supplement section following [2] is replaced by G.X) General and network security management; additionally, consult TG 4 Supplements E.6.4.2, E.6.4.2.2 and E.6.4.2.2.1
- A.1.2.5.2 / A.2.2.5.2 / A.3.2.5.2 |G.2.1.4 /G.2.3.1 (Note: The units and system sections in accordance with [2] are replaced by G.X) Active power output as a function of the grid frequency (primary control based on network security); Additionally, TG 4 Supplements E.6.4.2.2.1 and E.6.4.2.2.5 | consult FNN Guideline Section 5.4.3.3.3.3 [1]
- A.1.2.7.3 / A.2.2.7.3 /A.3.2.7.3 |G.2.3.5.1 /G.2.3.5.2 /G.2.3.5.3 (Note: The section of the supplement following [2] is replaced by G.X) Dynamic network support; also consult TG 4 E.6.4.2.1.5 and E.6.4.2.3.1
- A.1.2.7.2 / A.2.2.7.2 / A.3.2.7.2 |G.2.1.4 /G.2.3.2 (Note: The unit and system section following [2] is replaced by G.X) Island and sub-network operation capability

In addition to the provisions in Supplement A.1, A.2, A.3 and G.2, the following evaluation/assessment steps shall be carried out on the basis of simulations using simulation models based on manufacturer's specifications:

- TG 4 Supplement E.6.4.2.2.1 – Speed and power output control at the NCP
- TG 4 Supplement E.6.4.2.2.2 – Stability margin of speed and power control with reduced grid start-up time
- TG 4 Supplement E.6.4.2.2.3 – Provision and dynamics of primary control power
- TG 4 Supplement E.6.4.2.2.4 – Virtual island network operation capability (if the network operator requires simulation-based verification)
- TG 4 Supplement E.6.4.2.3 – (Verification of) critical fault clearance time

The remaining evaluation steps shall be carried out in accordance with Supplement A.1, A.2, A.3 and G.2 respectively.

The validation of the final simulation model, which was created as part of the final conformity study, is carried out on the basis of measurements in accordance with TG 3, as specified in TG 4 Supplement E.5 and FNN Guideline sections 5.4.3.3.3.2 and 5.4.2.3 [1].

If measurement data or already validated (partial) models are available from other projects, which have been positively assessed by a certification body and which can be used in the individual verification procedure, these shall be used in preference.

The results of the evaluation must be documented by the certification body in an evaluation report (Supplement B.2). The evaluation report in accordance with Supplement B.3 is therefore, as in system certificate A / B, an Supplement to the certificate in accordance with Supplement B.2. Consequently, the grid operator receives, via the certificate holder, comparable documents that comprehensively detail all evaluation steps, regardless of the verification procedure (system certificate A, B or C).

The requirements of Chapters A.4.2, A.4.3, A.4.5 and G.2.2 must be evaluated and assessed by the certification body, documented internally, and summarised and confirmed in the evaluation report in Chapter 3.1.2.3 'Basis of the evaluation'. Furthermore, as part of the extended declaration of conformity, the requirements of Chapters A.4.4, A.4.5, G.2.2.4 must also be documented internally by the certification body, positively assessed in the report on the extended declaration of conformity, and the errors in the simulation model must be identified.

G.2.2.2 Evaluation and assessment of the preliminary simulation model procedure for assessment in accordance with GCRS

G.2.2.2.1 Scope of the simulation model - Requirements for the model of the drive or turbine unit

Requirement	Evidence	Applicable documents	Prerequisites
11.6.2 [7], [8] 10.6.2 [9]	11.6.2 [7], [8]	TG 4 Supplement E.4.1.2 Model of the propulsion or turbine unit	Documentation of the simulation model in accordance with TG 4 in the preliminary and final conformity study simulation model
4.1.2 [1]	5.4.3.3.3.3 [1]		Documentation of the simulation model in accordance with TG 4 (supplemented by FNN Guideline [1]) in the preliminary and final conformity study simulation model
Remarks	Taking into account the fundamental requirements for the simulation model, the model components of an PGU or PGS to be considered are defined. The preliminary and final conformity studies must explain how these model components were implemented in the preliminary and final simulation models and describe their detailed function. The model description in accordance with TG 4 forms part of the preliminary or final conformity study. Furthermore, the conformity study must justify why standard models in accordance with IEEE may be used or why manufacturer-specific modifications to the IEEE models are necessary. The certification body must verify the completeness of the model components and their implementation in the preliminary and final simulation models. *Note: At the time of publication of this supplement, IEEE models do not represent the dynamic properties of the PCNB. Accordingly, no justification is required provided that these are not used.*		

In general:

No.	Evaluation criteria	Acceptance criterion
1	Speed behaviour based on speed/primary control.	True
1.1	Thermal power station: turbine including turbine stages, reheater, turbine valves and intervening controls.	True
1.2	Thermal power station with extraction condensing turbine and back-pressure turbine: Turbine including turbine stages, reheaters, turbine valves and control systems.	True

1.3	Gas turbine power system: IEEE standard model (up to approx. 125 MW) or custom model; behaviour of the compressor, turbine and turbine control with temperature and acceleration limits; extension of the gas turbine model to include system -specific conditions.	True
1.4	Gas and steam power stations / combined cycle plants.	True
1.5	Hydraulic power plants: Simplified or detailed description of water hammer, hydraulic system, control devices, primary controller, significant nonlinearities.	True
1.6	Internal combustion engines: generator-motor system with rigid shaft, or coupled two-mass system, primary control, fuel supply.	True
2	For the simulation-based verification of the PCNB: • Simulation model, including PGS controller where applicable, for the active power path of an PGU, and where necessary for the PGS (e.g. in combined cycle plants) • Input variables are power and speed deviations. • The output variable of the controlled actuator is the mechanical drive power. • The level of detail of the simulation model is based on the requirements of primary control based on network security and the tolerances to be observed in accordance with FGW TG 4 (Specifications for active power output) and FGW TG 8 in the closed-loop control system of the virtual island network. This applies in particular to the output variable of the primary controller. • If necessary to ensure model accuracy, additional variables such as controller output, valve position, mass flow, etc., may be included in the model comparison.	True

G.2.2.3 Evaluation and assessment of the preliminary conformity study

G.2.2.3.1 Content of the conformity study - verification of the replacement grid representation - dynamic state change, transient stability

Requirement	Evidence	Applicable documents	Prerequisites
11.6.2 [7], [8] 11.6 [9]	11.6.2 [7], [8] 11.6 [9]	TG 4 Supplement E.6.3.3.2 Verification of dynamic state changes, transient stability FNN Guideline [1]	Documentation of the simulation model in accordance with TG 4 in the preliminary and final conformity study
Remarks	On the basis of the preliminary conformity study and the preliminary simulation model, the certification body shall assess the requirements in accordance with Supplement A.1, A.2 and A.3, insofar as these apply within the scope of the relevant GCRS, and, subject to a positive assessment by the certification body, issue system certificate C. The simulations to be carried out within the conformity study to demonstrate compliance with grid connection conditions depend on the applicable GCRs. These vary according to the voltage levels at which the PGS is connected. The conformity study must demonstrate all points in accordance with Supplement A.1, A.2 and A.3, insofar as they are applicable within the scope of the relevant GCRs. In doing so, the determination and derivation of the individual points must be described in detail. The certification body must verify the plausibility of the presentation of the individual points on the basis of the description contained in the conformity study and check them for completeness with regard to the applicable GCRs.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	Medium-voltage network: Appropriate justification for the choice of connection configuration (A / B)	True
2	Medium-voltage network connection scenario B: Appropriate justification for simplified representation, based on S_{kV} and ψ_k	True
3	Medium-voltage network connection scenario A: Appropriate justification for the representation using a network generator	True
4	High-voltage network: Valid justification for the representation using an unregulated equivalent network generator	True
5	Extra-high voltage network: Agreement with the network operator	True

6	Simulated test environment to demonstrate the stability of primary control based on network security based on the virtual island network in accordance with Section 5.4.3.3.2.2 [1] (the test setup in Figure 7 must be replicated in a simulated environment).	True

G.2.2.3.2 Content of the conformity study - testing of the behaviour of Type 1 PGU / PGS

Requirement	Evidence	Applicable documents	Prerequisites
11.6.2 [7], [8] 11.6 [9]	11.6.2 [7], [8] 11.6 [9]	TG 4 Supplement E.6.3.5 Requirements for the behaviour of Type 1 PGU/PGS FNN Guideline [1]	Documentation of the simulation model in accordance with TG 4 in the preliminary and final conformity study
Remarks	On the basis of the preliminary conformity study and the preliminary simulation model, the certification body issues the System certificate C in accordance with the requirements of Supplements A.1, A.2 and A.3, insofar as these apply within the scope of the relevant GCRs and subject to a positive assessment by the certification body. The simulations to be carried out within the conformity study to demonstrate compliance with grid connection conditions depend on the applicable GCRs. These vary according to the voltage levels at which the PGS is connected. The conformity study must demonstrate all points in accordance with Supplements A.1, A.2 and A.3, insofar as they are applicable within the scope of the relevant GCRs. In doing so, the determination and derivation of the individual points must be described in detail. The certification body must verify the plausibility of the presentation of the individual points on the basis of the description contained in the conformity study and check them for completeness with regard to the applicable GCRs.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	Characteristic natural frequencies of the PGU / PGS	No assessment, for information only
2	Sufficient damping of generator oscillations.	True
3	Sufficient damping of the voltage regulator's step response.	True
4	Sufficient damping of the primary controller's step response.	True
5	Sufficient damping (in accordance with Supplement B.1, Table 14 [1]) and control speeds (limited control range in accordance with	True

	Table 15 [1]) of the primary control based on network security.	

G.2.2.4 Model validation and model accuracy requirements

G.2.2.4.1 Behaviour at over- and under-frequency (primary control based on network security)

Requirement	Evidence	Applicable documents	Prerequisites
4.1.2 [1]	5.4.3.3.3.3 [1]	FNN Guideline: Grid-forming capabilities [1] TG 4 Supplement E.5.2.5 TG 3	Test report in accordance with [1] Model validation by the model developer Documentation of the simulation model in accordance with TG 4 in the preliminary and final conformity study
Remarks	For Type 1 PGS within the scope of FNN Guideline [1], this chapter replaces Chapter A.4.4.7 [2] (Dynamic characteristics of the drive unit). The final simulation model to be submitted by the system constructor must be verified on the operational system. For this purpose, defined tests must be carried out on the power generating units or on the PGS – preferably in conjunction with the commissioning or acceptance of the system (Section 5.4.3.3.3.2 [1]). The tests to be carried out must be adapted and specified in detail in accordance with the type and technology of the power generating units. It must be ensured that the simulation model can be verified. Based on these tests, a model validation is carried out using the final simulation model. In doing so, the test results and test sequences must be compared with corresponding simulations based on the final simulation models. It must be noted that simulations must be initialised to the absolute initial states of the tests in each case. The comparison of measurement and simulation must include both the steady-state initial condition and the steady-state final condition. The certification body must verify that the listed tests have been fully carried out and documented. The requirements regarding the accuracy of the final simulation models must be assessed by the certification body on the basis of the final conformity study. The assessment by the certification body requires that it carries out the validation steps in full. Furthermore, the certification body must verify the plausibility of the model validation.		

	The certification body's verification of the model validation is based on a 'documentation of the PGU/PGS validation', which forms part of the conformity study and must be presented in a separate chapter.

In general:

No.	Evaluation criteria	Acceptance criterion
Requirements for the simulation model - General		
1	To demonstrate the PCNB as part of the individual verification procedure, a simulation model is created in accordance with the specifications in Section 5.4.2.3.2.1 [1].	True
Requirements for the simulation model - Adaptation to the simulation model (model identification)		
2	The static and dynamic active power behaviour of the PGU or PGS is determined in accordance with Section 5.4.2.3.2.2 of [1] , whereby the requirements for model accuracy specified therein are met.	True
Verification of the PCNB - General		
3	The switching state of the test object's coupling switch with the mains or mains emulator is not signalled to the test object.	True
4	The model is initialised at the start of the measurement. Intermediate values lie within the permissible tolerances.	True
5	The simulation is evaluated, the tolerances are presented, the results are displayed in a diagram, and reasons for any exceedances are provided.	True
6	In the event of unexplained tolerance exceedances, a sensitivity analysis is carried out for the final assessment, focusing on the impact on the electrical properties in accordance with FNN Guideline [1].	True
7	It is confirmed and documented that the primary control based on network security is implemented with proportional frequency control.	Information provided
7.1	Passing tests 1 to 4 confirms that the primary control based on network security is implemented with proportional frequency control (it must be established that no false control effect is visible (see also Supplement A.II)).	True
8	The required frequency limits in accordance with E.9 (VDE-AR-N 4110) or E.7 (VDE-AR-N 4120/4130) are met in all tests with a tolerance of max. ± 100 MHz	True
9	The speed curve of the test specimen during the transient response meets the requirement for the specified	True

	damping ratio $D \geq 0.06$ with a tolerance of -10%, i.e. $D \geq 0.054$.	$D \geq 0.054$
10	The steady-state final values of the active power deviate by a maximum of ± 5 % $P_{b\ inst}$ from the values resulting from the set static conditions. At least the active power settling times specified in Table 15 [1] are met.	True
Verification of the PCNB - definition of initial operating conditions		
11	For the simulation tests, initial operating conditions are defined in accordance with the requirements of Section 5.4.3.3.3.3.3 of [1].	True
Verification of the PCNB - Test 1 - Closed-loop damping		
12	The simulation test is carried out in accordance with the specifications in Section 5.4.3.3.3.3.3 [1] . The entire active power control range between the technical minimum power and the maximum power P_{rE} is tested on the basis of the step values defined in Table 14 [1].	True
13	The criteria in points 8 to 10 are met for all tested steps.	True
Evidence of PCNB Test 2 - Over frequency behaviour		
14	The simulation test is carried out in accordance with the specifications in Section 5.4.3.3.3.3.3 [1]. The required step-change load disconnections are tested based on the required operating points.	True
15	The criteria set out in points 8 to 10 are met for all tested stages.	True
16	If, following the effect of the PCNB, the operating point lies below the minimum technical output, it is determined that no instabilities occur.	True
Verification of the PCNB - Test 3 - Underfrequency behaviour		
17	The simulation test is carried out in accordance with the specifications in Section 5.4.3.3.3.3.3 [1].	True
18	The criteria set out in points 8 to 10 are met for all tested stages.	True
Evidence of PCNB Test 5 - Passing through an over- and under-frequency range		
19	The simulated test is carried out in accordance with the specifications in Section 5.4.3.3.3.3.3 [1].	True

20	The criteria set out in points 8 to 10 are met for all tested stages.	True
21	Passing through the PCNB dead band in relation to the power control element is performed smoothly.	True

G.2.2.5 System certificate C2 - General procedure for assessment in accordance with GCRs

The evaluation and assessment of the PGU / PGS and their components is carried out in accordance with the applicable GCRs, based on Supplements A.1, A.2 or A.3 of the preliminary conformity study. It should be noted that, in some cases, the evaluation/assessment steps for the components must be taken into account.

The following evaluation/assessment steps are to be carried out, deviating from the provisions in Supplements A.1, A.2, A.3 and G.2, on the basis of the manufacturer's data in accordance with VDE-AR-N 4110 [7] Table 20:

- A.1.2.2.1 / A.2.2.2.1 Quasi-steady-state operation
- A.1.2.4.1 / A.2.2.4.1 |G.2.3.3.1 /G.2.3.3.2 /G.2.3.3.3 (Note: The system section according to [2] is replaced by G.X) Reactive power provision
- A.1.2.6.1 / A.2.2.6.1 Black start capability
- A.1.2.7.2/ A.2.2.7.2 |G.2.1.4 /G.2.3.2 (Note: The unit and system parts following [2] are replaced by G.X) Island and sub-network operation capability
- A.1.2.7.3 / A.2.2.7.3 |G.2.3.5.1 /G.2.3.5.2 /G.2.3.5.3 (Note: The Supplement section following [2] is replaced by G.X) Dynamic network support
- A.1.2.5.1 / A.2.2.5.1 / A.3.2.5.1 |G.2.3.4.1 /G.2.3.4.2 /G.2.3.4.3 (Note: The supplements section following [2] is replaced by G.X) General and grid security management
- A.1.2.5.2 / A.2.2.5.2 / A.3.2.5.2 |G.2.1.4 /G.2.3.1 (Note: The units and system section following [2] is replaced by G.X) Active power output as a function of grid frequency (primary control based on network security)
- G.2.1.2 Behaviour under steep frequency gradients (RoCoF)
- G.2.1.3 Verification of the start-up time constant
- A.1.2.6.2 / A.2.2.6.2 Connection conditions
- A.1.2.7.4 / A.2.2.7.4 Contribution to short-circuit current
- A.2.2.11 Provision of control power

Notwithstanding the provisions in Supplements A.1, A.2, A.3 and G.2, the following evaluation/assessment steps are to be carried out only after commissioning of the PGS, on the basis of a measurement report in accordance with FGW TG 3 or the FNN Guideline [1]:

- A.1.2.3.1 / A.2.2.3.1 Rapid voltage changes
- A.1.2.3.2 / A.2.2.3.2 Flicker
- A.1.2.3.3 / A.2.2.3.3 Harmonics, inter-harmonics
- A.1.2.3.4 / A.2.2.3.4 Commutation dips
- A.1.2.3.5 / A.2.2.3.5 Asymmetries
- A.1.2.4.1 / A.2.2.4.1 Reactive power provision

- A.1.2.5.1 / A.2.2.5.1 / A.3.2.5.1 General and grid security management
- A.1.2.5.2 / A.2.2.5.2 / A.3.2.5.2 |G.2.1.4 /G.2.3.1 Active power output as a function of grid frequency
- G.2.1.3 Verification of the start-up time constant
- A.1.2.7.2 / A.2.2.7.2 / A.3.2.7.2 |G.2.1.4 /G.2.3.2 Island and sub-network operation capability
- A.2.2.11 Provision of control power

The remaining evaluation steps shall be carried out in accordance with Supplements A.1 or A.2.

If measurement data from other projects is available which has been positively assessed by a certification body and which can be used in the individual verification procedure, this data shall be used in preference.

The results of the evaluation must be documented by the certification body in an evaluation report (Supplement B.2). The evaluation report is thus, as in system certificate A / B, a supplement to the certificate in accordance with Supplement B.2. Consequently, the grid operator receives, via the certificate holder, comparable documents that contain all evaluation steps in a traceable manner, regardless of the verification procedure (system certificate A, B or C).

G.2.3 SYSTEM CERTIFICATE

G.2.3.1 Active power output as a function of the grid frequency

Requirement	Evidence	Applicable documents	Prerequisites
4.1.2 [1]	5.6.2.9 [1]	-	Equipment certificates
Remarks	The ability to supply active power as a function of the grid frequency is covered in the FNN Guideline on grid-forming capabilities through compliance with the requirements for primary control based on network security. This is a fundamental component of the control system of the Type 1 unit and is demonstrated exclusively at unit level (or, in the case of inseparably interconnected units, e.g. combined cycle systems, at system level (see G.2.2.4.1)). The requirements listed at G.2.1.4 must be applied, taking into account the prioritisation – in accordance with the applicable technical connection regulation – of the active power signals.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	Evidence of behaviour during over- and under-frequency (primary control based on network security) is provided in the unit certificates.	True

G.2.3.2 Sub-network operability

Requirement	Evidence	Applicable documents	Prerequisites
10.2.1.4 (TCR)	5.6.2.5 [1]	VDE-AR-N 4110 VDE-AR-N 4120 VDE-AR-N 4130	Equipment certificates

Remarks	
	The ability to operate within a sub-network is covered in the FNN Guideline on grid-forming capabilities through compliance with the requirements for primary control based on network security. This is a fundamental component of the control of the Type 1 unit and is verified exclusively at unit level (or, in the case of inseparably interconnected units, e.g. combined cycle plants, at system level (see G.2.2)). Control speeds and control ranges must be demonstrated within the framework of primary control based on network security on the basis of the specifications in Tables 14 and 15 of the FNN Guideline on grid-forming capabilities [1]. *Note: The conditions for a virtual island network operation remain valid as per A.1.2.7.2.3, A.2.2.7.2.3, A.3.2.7.2.3.* *Note: The requirements for sub-network operability in accordance with the applicable TCR are implicitly met by units which, as part of unit certification (or the individual verification procedure), have demonstrated compliance with the requirements for primary control based on network security. The capability is thus inherently fulfilled by the unit and does not require any additional commissioning by the system operator.*

In general:

No.	Evaluation criteria	Acceptance criterion
General requirements		
1	The operating concept allows the fed-in power to be reduced to the minimum technical power as per Table 15 [1].	True
2	Evidence of behaviour during over- and under-frequency (primary control based on network security) has been provided in the unit certificates.	True
2.1	Unless the entire active power control range is covered within the framework of primary control based on network security with the required amplitude as per Table 14 [1], a corresponding technical justification is provided and the procedure has been agreed with the system operator.	True Manufacturer's declaration including justification is available

G.2.3.3 Procedure for reactive power provision

G.2.3.3.1 VDE-AR-N 4110 (TCR MV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.2.4 (TCR)	11.4.11 (TCR)	Supplement E.9 [2]	Equipment certificate(s), submitted control concept
4.1.1.3 [1]	5.6.2.6 [1]	Supplement E.9 [2]	Equipment certificate(s), submitted control concept
Remarks	The assessment is identical to that for Type 2 installations and is carried out in accordance with Chapter G.3.2.2.1 .		

In general:

No.	Assessment criteria	Acceptance criterion
1	The evaluation is carried out in accordance with Chapter G.3.2.2.1.	-
1.1	For the evaluation a value of 30 s shall be assumed as the default value for the transition time of the control behaviour of the static voltage maintenance for Type 1 units, in accordance with Chapter G.3.2.2.1.	True
1.2	For the assessment a range of 15 s to 45 s shall be assumed as the setting range for the transition time of the control behaviour of the static voltage maintenance for Type 1 units, in accordance with Chapter G.3.2.2.1.	True

G.2.3.3.2 VDE-AR-N 4120 (TCR HV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.2.4 (TCR)	11.4.11 (TCR)	Supplement E.9 [2]	Equipment certificate(s), submitted control concept
4.1.1.3 [1]	5.6.2.6 [1]	Supplement E.9 [2]	Equipment certificate(s), submitted control concept
Remarks	The assessment is identical to that for Type 2 installations and is carried out in accordance with Chapter G.3.2.2.2.		

In general:

No.	Assessment criteria	Acceptance criterion
1	The assessment is carried out in accordance with Chapter G.3.2.2.2.	-
1.1	For the evaluation a value of 30 s shall be assumed as the default value for the transition time of the control behaviour of the static voltage maintenance for Type 1 units in accordance with Chapter G.3.2.2.2.	True
1.2	For the assessment a range of 15 s to 45 s shall be assumed as the setting range for the transition time of the control behaviour of the static voltage maintenance for Type 1 units in accordance with Chapter G.3.2.2.2.	True

G.2.3.3.3

G.2.3.3.4 VDE-AR-N 4130 (TCR EHV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.2.4 (TCR)	11.4.11 (TCR)	Supplement E.9 [2]	Equipment certificate(s), submitted control concept
Remarks	The assessment is carried out in accordance with FGW TG 8 Rev. 10 [2].		

G.2.3.4 General and grid security management

G.2.3.4.1 VDE-AR-N 4110 (TCR MV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.4.1 (TCR) 10.2.4.2 (TCR)	11.4.3 (TCR) 11.4.13 (TCR) 11.4.14 (TCR)		Equipment certificate(s), manufacturer’s declaration
8.1 (TCR)	TR 3 Rev. 26 Supplement 1	TG 3	Test report
Remarks	The assessment is carried out in accordance with Chapter A 1.2.5.1.3 [2]. An assessment of the criteria in accordance with Section 5.6.2.3 [1] is not applicable for Type 1 PGS.		

In general:

No.	Assessment criteria	Acceptance criterion
1	The assessment is carried out in accordance with Chapter A 1.2.5.1.3 [2].	-

G.2.3.4.2 VDE-AR-N 4120 (TCR HV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.4.1 (TCR) 10.2.4.2 (TCR)	11.4.3 (TCR) 11.4.13 (TCR) 11.4.14 (TCR)		Equipment certificate(s), manufacturer's declaration
8.1 (TCR)	TG 3 Rev. 26 Supplement 1	TG 3	Test report
Remarks	The assessment is carried out in accordance with Chapter A 2.2.5.1.3 [2]. An assessment of the criteria in accordance with Section 5.6.2.3 [1] is not applicable for Type 1 PGS.		

In general:

No.	Assessment criteria	Acceptance criterion
1	The assessment is carried out in accordance with Chapter A 2.2.5.1.3 [2].	-

G.2.3.4.3 VDE-AR-N 4130 (TCR EHV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.4.1 (TCR) 10.2.4.2 (TCR)	11.4.3 (TCR) 11.4.13 (TCR) 11.4.14 (TCR)		Equipment certificate(s), manufacturer's declaration
8.1 (TCR)	TG 3 Rev. 26 Supplement 1	TG 3	Test report
Remarks	The assessment is carried out in accordance with Chapter A 3.2.5.1.3 [2]. An assessment of the criteria in accordance with Section 5.6.2.3 [1] is not applicable for Type 1 PGS.		

In general:

No.	Assessment criteria	Acceptance criterion
1	The assessment is carried out in accordance with Chapter A 3.2.5.1.3 [2].	-

G.2.3.5 Dynamic grid support

G.2.3.5.1 VDE-AR-N 4110 (TCR MV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.3 (TCR)	11.4.12 (TCR) 5.6.2.7 [1]	TG 3 TG 4; DIN EN 60909-0 (VDE 0102) [13] VDE-AR-N 4110	Unit certificates for all PGU units of the PGS; component certificates for components relevant to FRT; validated models of the PGU units and, where applicable, of the components.
Remarks	The assessment is carried out in accordance with Chapter A 1.2.7.3.3 [2]. An assessment of the criteria in accordance with Section 5.6.2.7 [1] is not required for Type 1 PGS.		

In general:

No.	Assessment criteria	Acceptance criterion
1	The assessment is carried out in accordance with Chapter A 1.2.7.7.3 [2].	-

G.2.3.5.2 VDE-AR-N 4120 (TCR HV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.3 (TCR)	11.4.12 (TCR) 5.6.2.7 [1]	TG 3 TG 4; DIN EN 60909-0 (VDE 0102) [13] VDE-AR-N 4110	Unit certificates for all PGU units of the PGS; component certificates for components relevant to FRT; validated models of the PGU units and, where applicable, of the components.
Remarks	The assessment is carried out in accordance with Chapter A 2.2.7.3.3 [2]. An assessment of the criteria in accordance with Section 5.6.2.7 [1] is not required for Type 1 PGS.		

In general:

No.	Assessment criteria	Acceptance criterion
1	The assessment is carried out in accordance with Chapter A 2.2.7.7.3 [2].	-

G.2.3.5.3 VDE-AR-N 4130 (TCR EHV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.4.1 (TCR) 10.2.4.2 (TCR)	11.4.3 (TCR) 11.4.13 (TCR) 11.4.14 (TCR)		Equipment certificate(s), manufacturer's declaration
Remarks	The assessment is carried out in accordance with Chapter A 3.2.7.3.3 [2]. An assessment of the criteria in accordance with Section 5.6.2.7 [1] is not required for Type 1 PGS.		

In general:

No.	Assessment criteria	Acceptance criterion
1	The assessment is carried out in accordance with Chapter A 3.2.7.3.3 [2].	-

G.2.3.6 Requirements for simulation models

G.2.3.6.1 VDE-AR-N 4110 (TCR MV)

Requirement	Evidence	Applicable documents	Prerequisites
10.6.4 (TCR)	11.4.23 (TCR)		-
5.5.3.9 [1]	5.6.2.10 [1]		
Remarks	Where required by the grid operator, the connection holder must prepare an aggregated simulation model of the power generating system in accordance with 10.6 and submit it to the grid operator at the latest as part of the declaration of conformity.		

In general:

No.	Assessment criteria	Acceptance criterion
1	Does the network operator require an aggregated PGS model?	Information provided

2	The detailed simulation model of the power generating system is based on validated unit models. *Note: The distribution of open, executable models published by the manufacturer in a publicly accessible type library, including model-type mappings, corresponding descriptions and applicable parameters, is permitted at any time.*	True
3	A simulation model of the p power generating system is available, which includes at least the individual power generating units and the relevant elements (library models) for connection to the grid connection point. Reactive power compensation systems and system controllers shall only be included in the model if integration into the system's simulation model (software/interface issues) is possible and the integration of these components is necessary for assessing the requirements. Notwithstanding this, when selecting method B in accordance with 5.6.2.6 [1] and for PGS with PGU where verification of the PCNB is not a fundamental component of the control of the Type 1 unit, and is not carried out exclusively at unit level but for inseparably interconnected units, e.g. combined cycle plants, at system level (see G.2.2), the system controller must be modelled in the simulation model.	True

G.2.3.6.2 VDE-AR-N 4120 (TCR HV)

Requirement	Evidence	Applicable documents	Prerequisites
10.6.4 (TCR)	11.4.23 (TCR)		-
5.5.3.9 [1]	5.6.2.10 [1]		
Remarks	Where required by the grid operator, the connection holder must prepare an aggregated simulation model of the power generating system in accordance with 10.6 and submit it to the grid operator at the latest as part of the declaration of conformity.		

In general:

No.	Assessment criteria	Acceptance criterion
1	Does the network operator require an aggregated PGS model?	Information provided
2	The detailed simulation model of the power generating system is based on validated unit models. *Note: The sharing of open, executable models published by the manufacturer in a publicly accessible type library, including model-type- e mappings,*	True

	corresponding descriptions and applicable parameters, is permitted at any time.	
3	A simulation model of the power generating system is available, which includes at least the individual power generating units as well as the relevant elements (library models) for connection to the grid connection point. Reactive power compensation systems and system controllers shall only be included in the model if integration into the system's simulation model (software/interface issues) is possible and the integration of these components is necessary for the assessment of the requirements. Notwithstanding this, when selecting method B in accordance with 5.6.2.6 [1] and for PGS with PGU where verification of the PCNB is not a fundamental component of the control of the Type 1 unit and is not carried out exclusively at unit level but for inseparably interconnected units, e.g. combined cycle plants, at system level (see G.2.2), the system controller must be modelled in the simulation model.	True

G.2.3.6.3 VDE-AR-N 4130 (TCR EHV)

Requirement	Evidence	Applicable documents	Prerequisites
10.6.4 (TCR)	11.4.23 (TCR)		-
5.5.3.9 [1]	5.6.2.10 [1]		
Remarks	Where required by the grid operator, the connection holder must prepare an aggregated simulation model of the power generating system in accordance with 10.6 and submit it to the grid operator at the latest as part of the declaration of conformity. Where required by the grid operator, the connection holder must prepare a detailed simulation model of the power generating system using verified unit models that meet the requirements of Section 5.5.3 [1]. With regard to the submission of the models, the provisions of Section 5.5.3.9 [1] must be observed.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	Indication of whether the network operator requires an aggregated PGS model in addition to the detailed PGS model.	Information provided
2	Where the grid operator requires the system operator to provide an aggregated (simplified) simulation model of the power generating system, its accuracy relative to	True

	the simulation model used in the context of system certification must be demonstrated.	
3	Does the grid operator require a detailed PGS model?	Information provided
3.1	The detailed simulation model of the power generating system is based on validated unit models. Note: The distribution of open, executable models published by the manufacturer in a publicly accessible type library, including model-type mappings, corresponding descriptions and applicable parameters, is permitted at any time. Note: The distribution of EMT and RMS models containing controller code or otherwise encrypted components requires the consent of the respective manufacturer. Distribution to third parties for the purpose of using the models in the context of grid studies requires, in all cases, the conclusion of a standardised NDA between the third party and the grid operator.	If a detailed PGS model is required: True
4	A simulation model of the PGS is available which depicts all relevant characteristics such as Q(U) control or voltage/reactive power control, primary control, active power injection as a function of grid frequency (primary control based on network security), including any technological limitations where applicable.	True

G.2.3.7 Study to assess system compliance

G.2.3.7.1 VDE-AR-N 4130 (TCR EHV)

Requirement	Evidence	Applicable documents	Prerequisites
5.6.3.3 [1]	-	-	Qualified opinion
Remarks	For Type 1 installations, the 'extended installation certification procedure' introduced in Section 5.6.3 [1] including the qualified opinion, shall not apply.		

In general:

No.	Assessment criteria	Acceptance criterion
1	No evaluation is carried out.	-

G.2.4 COMPONENT CERTIFICATE

G.2.4.1 Procedure for reactive power provision

G.2.4.1.1 VDE-AR-N 4110 (TCR MV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.2.4 (TCR)	11.3.2 (TCR)	TG 3	Equipment certificate(s)
4.1.1.3 [1]	5.6.2.6 [1]		Test report, Manufacturer's documentation
Remarks	The assessment is identical to that for Type 2 systems and is carried out in accordance with Chapter G.3.3.1.1.		

In general:

No.	Assessment criteria	Acceptance criterion
1	The assessment is carried out in accordance with Chapter G.3.3.1.1.	-
1.1	For the evaluation a range of 15 s to 45 s shall be assumed as the adjustment range for the transition time of the static voltage maintenance control behaviour for Type 1 units in accordance with Chapter G.3.3.1.1.	True

G.2.4.1.2 VDE-AR-N 4110 (TCR MV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.2.4 (TCR)	11.3.2 (TCR)	TG 3	Equipment certificate(s)
4.1.1.3 [1]	5.6.2.6 [1]		Test report, Manufacturer's documentation
Remarks	The assessment is identical to that for Type 2 systems and is carried out in accordance with Chapter G.3.3.1.2.		

In general:

No.	Assessment criteria	Acceptance criterion

1	The assessment is carried out in accordance with Chapter G.3.3.1.2.	-
1.1	For the assessment a range of 15 s to 45 s shall be assumed as the adjustment range for the transition time of the static voltage maintenance control behaviour for Type 1 units in accordance with Chapter G.3.3.1.2.	True

G.2.4.1.3 VDE-AR-N 4130 (TCR EHV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.2.4 (TCR)	11.3.2 (TCR)	TG 3	Equipment certificate(s)
Remarks	The assessment is carried out in accordance with FGW TG 8 Rev. 10 [2] , Chapter A.3.2.4.2.2.		

G.3 SCOPE OF EVALUATION: GRID-FORMING TYPE 2 POWER GENERATING UNITS, POWER GENERATING AND STORAGE UNITS, STORAGE

G.3.1 UNIT CERTIFICATE

G.3.1.1 Virtual island network operation

G.3.1.1.1 Evaluation of the test procedure

Requirement	Supporting documents	Applicable documents	Requirements
4.2.1.1 [1]	5.5.4 [1]	FNN Guideline: Grid-forming capabilities	Test report
Remarks	Based on the metrological testing of the grid-forming unit in a virtual island network operation, the requirements for voltage source behaviour and behaviour during over- and under-frequency (primary control based on network security) are tested jointly within the unrestricted control range. The assessment of both requirements takes place separately in G.3.1.1.2 and G.3.1.1.3. In addition, the validity of the parameterised T_A is verified as part of the test of the voltage source behaviour. A positive assessment of the test procedure is a prerequisite for the assessment in accordance with G.3.1.1.2 and G.3.1.1.3.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	Starting from a stationary operating point in accordance with the specifications in Table 5 [1], the measurements specified therein are carried out in the virtual island network.	True
2	The operating conditions of the virtual island network are maintained for each measurement until a stable operating point is established, but for at least 50 seconds.	True
3	The measurements are carried out using the standard static value; however, for PGSU and storage systems, a static value of between 2% and 2.5% is set for the performance of measurement 1.4.	True

G.3.1.1.2 Voltage source behaviour

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.1 [1]	5.5.4 [1]	FNN Guideline: Grid-forming capabilities VDE-AR-N 4110 VDE-AR-N 4120 VDE-AR-N 4130	Test report
Remarks			

In general:

No.	Evaluation criteria	Acceptance criterion
1	Starting from an operating state at rated frequency, after the grid coupling switch (S_{Grid}) has been opened, a steady-state condition of the frequency and active power output of the grid-forming unit is achieved in accordance with the preset residual load, without the FRT limit curves: • according to Figure 14 (VDE-AR-N 4110) • according to Figure 12 (VDE-AR-N 4120) • according to Figure 12 (VDE-AR-N 4130) of the applicable Technical Connection Regulation, which would lead to the complete disconnection of the grid-forming unit.	True
2	For measurement 1.1, the value of T_{A} can be validated and corresponds to the set value with a tolerance of 50%.	True

G.3.1.1.3 Behaviour in the event of over- and under-frequency (primary control based on network security) in the unrestricted control range

Requirement	Evidence	Applicable documents	Prerequisites
4.2.2 [1]	5.5.4 [1]	FNN Guideline: Grid-forming capabilities	Test report, manufacturer's declaration
Remarks			

In general:

No.	Evaluation criteria	Acceptance criterion
1	Operations on the virtual island can be maintained in a stable manner.	True
1.1	For measurements 1.1 to 1.4 according to Table 5 [1], the following criteria are met: • the frequency value of 52.5 Hz is exceeded for a maximum of 0.1 s. • The frequency value of 51.5 Hz is exceeded for a maximum of 10 s. • the transient response of the measured frequency meets the required damping ratio according to Table 14 [1].	True
1.2	For measurement 2.1, the measured frequency response meets the requirement for the specified damping ratio according to Table 14 [1].	True
1.3	It is confirmed and documented that the primary control based on network security is implemented with proportional frequency control.	Information provided

G.3.1.2 Grid-synchronous operation

G.3.1.2.1 Angular step response

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.1 [1]	5.5.5.3 [1]	FNN Guideline Grid-forming capabilities	Test report
Remarks	As part of the assessment of step response performance, it must also be verified whether, in accordance with Section 4.2.3 [1], the voltage source behaviour is given higher priority than specifications by third parties or the grid operator’s NSM. If the manufacturer has provided for the voltage source control gain or the effective impedance of the grid-forming unit to be configurable, verification must be provided for the nominal value specified by the manufacturer in each case. For the minimum and maximum of the configurable values, verification must be provided by simulation in accordance with Chapter G.3.1.7.1.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	The tests are carried out starting from an operating point at 50 % P_{Emax} ± 5 % P_{Emax}. The reactive power injection at the start of the test is within a range of ± 5 % (relative to P_{Emax}). In this case, the active power is limited by the highest-priority limit specified in section 4.2.3 [1], with the result that the limited value is exceeded due to the angular step power that occurs.	True
2	Measurement method 1 or measurement method 2 is carried out in accordance with Section 5.5.5.3.2 [1].	True
2.1	If measurement procedure 1 is carried out, the following applies: Two measurements shall be carried out in accordance with the specifications in Section 5.5.5.3.2 [1] . The second measurement shall take place starting from the initial operating point of the first measurement ± 5 % P_{Emax} with an identical angle jump with a negative sign.	True
2.2	In the case of measurement procedure 2, the following applies: Two measurements are carried out in accordance with the specifications in Section 5.5.5.3.2 [1]. The second measurement is performed starting from the initial operating point of the first measurement ± 5 % P_{Emax} with an identical angle step $\Delta\theta_{\mathrm{setpoint}}$ ± 10 % with a negative sign.	True
3	The maximum active current change $\Delta i_{\mathrm{P,PGU}}$ in the marketed direction is at least 50% (70% for PGSU and storage systems) and in the non-marketed direction at least 5% of the determined maximum value $\Delta i_{\mathrm{P,PGU,max}}$. A tolerance of 1% of the nominal active current may be taken into account here. The angle jump power is not limited by the active power limit.	True
3.1	The higher prioritisation of the angle jump power over all external P-setpoint specifications cannot be deactivated.	True
4	For the direction not offered, the following applies as an alternative to No. 3: The maximum active power change is at least 5% of P_{Emax}.	True

G.3.1.2.2 Effective impedance

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.1 [1]	5.5.5.4 [1]	FNN Guideline Grid-forming capabilities	Test report
Remarks	If the manufacturer has designed the voltage source control gain or the effective impedance of the grid-forming unit to be configurable, verification must be provided for the nominal value specified by the manufacturer in each case. For the minimum and maximum configurable values, verification must be provided by simulation in accordance with Chapter G.3.1.7.2.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	The tests are carried out based on the initial operating conditions set out in Table 6 [1]: • an active power input > 55 % P_{Emax} • the two reactive power operating points of 10 % (± 5 %) and -10 % (± 5 %), each relative to P_{Emax} and • a short-circuit power ratio of SCR ≥ 3. If the short-circuit power ratio of the test setup does not permit values of SCR ≥ 3, the measurement may also be carried out with a lower SCR value. In the case of measurement method 1, however, SCR ≥ 1 applies. If the test was carried out at an SCR value < 3, this must be stated.	True
2	Measurement method 1 or measurement method 2 shall be carried out in accordance with section 5.5.5.4.2 [1].	True
2.1	In the case of measurement procedure 1, the following applies: The magnitude of the applied setpoint step shall be between ± 0.03 p.u. and 0.05 p.u.. The following sequence is tested: • 0.03 p.u. ≤ $\Delta u_{\mathrm{setpoint}}$ ≤ 0.05 p.u. • $\Delta u_{\mathrm{setpoint}} = 0$ • -0.05 p.u. ≤ $\Delta u_{\mathrm{setpoint}}$ ≤ -0.03 p.u. A steady-state condition is awaited between each of these states.	True
2.2	In the case of measurement procedure 2, the following applies: The values of the terminal voltage steps Δu_{I} and Δu_{II} differ from each other and from the initial value by at least 2 %.	
3	The measurements for the selected measurement procedure shall be repeated based on an active power output in the range of 15 % to 45 % *of* P_{Emax} and a reactive	True

	power injection of in the range of ± 10 % (relative to P_{Emax}). In the case of measurement procedure 1, the following applies: The voltage setpoint step shall be in the negative direction when the test is repeated.	
4	It is shown that no current limiting has been triggered.	True
5	The values of the calculated impedance $\lvert z_{w,1} \rvert$ comply with the requirements for the maximum value $z_{w,max}$ as specified in Section 4.2.1.1 [1], according to the following criteria: • without unit transformer (or on the low-voltage side of the unit): $\lvert z_{w,1} \rvert \leq 0.27$ p.u. • including unit transformer (or on the medium-voltage side of the unit): $\lvert z_{w,1} \rvert \leq 0.35$ p.u. • for double-fed induction generators, alternatively: the upper limit of the impedance is determined by the physical transient reactance of the induction generator plus the stator resistance of the induction generator and the impedance of the unit transformer.	True

G.3.1.2.3 Verification of passivity properties in the harmonic frequency range

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.3 [1]	5.5.5.5 [1]	FNN Guideline Grid-forming capabilities	Manufacturer's declaration
Remarks			

In general:

No.	Evaluation criteria	Acceptance criterion
1	The impedance of the grid-forming unit has a positive real part in the frequency range from 100 Hz to 2.5 kHz.	True, information provided
1.1	The magnitude and phase of the impedance in the positive and negative systems have been determined and reported in accordance with the procedure set out in Section 5.5.5.5 [1]. The method used by the manufacturer to determine the impedance values is transparent and clearly justified.	True
1.2	The technical verifiability of the manufacturer's declaration is ensured.	True

G.3.1.2.4 Voltage source regulation and FRT behaviour

G.3.1.2.4.1 Guidance behaviour

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.5 [1]	5.5.5.6.1 [1]	FNN Guideline Grid-forming capabilities	Test report
Remarks	If the manufacturer has designed the voltage source control gain or the effective impedance of the grid-forming unit to be configurable, verification must be provided for the nominal value specified by the manufacturer in each case. For other configurable values, verification must be provided by simulation in accordance with Chapter G.3.1.7.5.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	The test is carried out in the same way as measurement procedure 1 in section 5.5.5.4.2 [1]. If the short-circuit power ratio of the test setup does not permit values of SCR ≥ 3, the measurement may be carried out even with a lower SCR value. In this case, however, SCR ≥ 1 must apply. If the test was carried out at an SCR value < 3, this must be stated.	True
2	The determined rise time of the voltage u_1 (or, alternatively, of the current $i_{Q,1}$ is < 1 s.	Rise time < 1 s

G.3.1.2.4.2 Disturbance behaviour and linearity of the effective impedance

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.5 [1]	5.5.5.6.2 [1]	FNN Guideline Grid-forming capabilities	Test report
Remarks	If the manufacturer has designed the voltage source control gain or the effective impedance of the grid-forming unit to be configurable, verification must be provided for the nominal value specified by the manufacturer in each case. For other configurable values, verification must be provided by simulation in accordance with Chapter G.3.1.7.6.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	The test is carried out in the same way as measurement procedure 2 in section 5.5.5.4.2 [1]. The use of measurement procedure 1 in accordance with Section 5.5.5.4.2 [1] is only possible if sufficiently rapid setpoint processing takes place in the grid-forming unit.	True
2	If the grid-forming unit under test is not connected via a transformer assigned to the grid-forming unit (or via its own dedicated transformer windings), the following also applies: The behaviour of the grid-forming unit in conjunction with several units operated directly in parallel was tested by repeating the measurement procedure in accordance with Section 5.5.5.4.2 [1] with at least two grid-forming units in parallel.	True
Rise time of the apparent current		
3	The 5 ms moving average of the instantaneous value of the current $i_{\alpha\beta,5ms}$ shall have reached 90 % of the final value for the first time no later than 15 ms after the step change in voltage. In the case of testing with parallel grid-forming units, the test specimen also meets this criterion.	True
Settling time of the reactive current		
4	The reactive current $i_{Q,1}$ remains within the tolerance band (see Figure 10 [1]) for the reactive current in the period between 80 ms and 150 ms after the step change in voltage. In the case of testing with parallel grid-forming units, the test object also meets this criterion.	True
Attenuation of the reactive current		
5	The waveform of the reactive current component resulting from the step change in voltage (in accordance with the specifications of measurement method 2 in section 5.5.5.4.3 [1]) lies within the envelope curve shown in Figure 10 [1]. In the case of testing with parallel	True

	network-forming units, the test specimen also meets this criterion.	
Linearity of the effective impedance		
6	The linearity of the effective impedance is 0.85 ≤ L_Z ≤ 1,15. In the case of testing with parallel network-forming units, the test specimen also meets this criterion.	0.85 ≤ L_Z ≤ 1,15.

G.3.1.2.4.3 Robustness and voltage source control during short-term overvoltage and undervoltage events (O/UVRT robustness)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.1.2 (TCR) 10.2.3 (TCR)	11.2.5 (TCR) 11.2.9 (VDE-AR-N 4130 only)	VDE-AR-N 4110 VDE-AR-N 4120 VDE-AR-N 4130 TR 3 DIN EN 60034-1 (VDE 0530-1), Section 9.3.2	Test report, Manufacturer's declaration
4.2.1.6 [1]	5.5.5.6.3 [1]	FNN Guideline: Grid-forming capabilities	Test report, Manufacturer's declaration
Remarks	The short-circuit currents are calculated by the certification body based on the manufacturer's specifications and the results of the type tests in accordance with Section 11.2.5 (VDE-AR-N 41XX) and Section 5.5.5.6.3 [1], and are stated in the unit certificate. The metrological test conducted in accordance with Section 5.5.5.6.3 [1] fully replaces the tests required under Section 11.2.5.5 of the applicable Technical Connection Regulations.		

In general:

No.	Evaluation criteria	Acceptance criterion
General requirements for O/-UVRT robustness		
1	A list of all relevant components of the entire unit, including all associated parts which, according to the manufacturer, form part of the grid-forming unit, such as the auxiliary units, control and protection devices used during type testing, is available.	True

2	Internal protection permits operation between the lower and upper FRT limit curves in accordance with: • Figure 14 (VDE-AR-N 4110) • Figure 12 (VDE-AR-N 4120) • Figure 12 (VDE-AR-N 4130).	The tests required under 5.5.5.6.3 (FNN Guideline on grid-forming capabilities) have been successfully completed.
3	One FRT test is successfully carried out with maximum under-excitation and one with maximum over-excitation of reactive power in accordance with the manufacturer's specifications (or with cos φ ≤ 0.95 for over- or under-excitation, provided the unit's capacity is greater).	True
4	The behaviour of the grid-forming unit during sudden voltage changes is verified by a voltage step of at least 10 % U_n to a value > 110 % U_n for symmetrical voltage increases and to ≥ 110 % U_n as the maximum phase-to-phase voltage for asymmetrical voltage increases, with a duration of ≥ 5 s. For PGSU and storage systems, the measurement is carried out at the minimum possible DC voltage specified by the manufacturer.	Minimum duration ≥ 5 s
4.1	The manufacturer's declaration states that a symmetrical voltage surge of at least 0.15 p.u. to a value > 1.15 p.u. or ≥ 1.15 p.u. for ≥ 60 s is withstood.	Information has been provided
5	The manufacturer's declaration shall specify, at least, the assumptions regarding the relevant influencing factors and any restrictions under which compliance with the requirements according to: • Figure 12 (VDE-AR-N 4110) • Figure 10 (VDE-AR-N 4120) • Figure 10 (VDE-AR-N 4130) of the applicable Technical Connection Regulation is possible. *Note: If compliance with the requirements is demonstrated by a metrological test in accordance with TG 3 Rev. 26, Chapter 4.6.3.1, the requirements are deemed to have been met and the manufacturer's declaration is not required.*	Information has been provided

6	The grid-forming unit is subjected to symmetrical and asymmetrical voltage dips of the mains voltage by Δu_n to a value between: • 0.7 p.u. and 0.8 p.u. • 0.45 p.u. and 0.6 p.u. • 0.2 p.u. and 0.3 p.u. • < 0.05 p.u. (VDE-AR-N 4120 and 30) for a minimum duration in accordance with the limit line as per: • Figure 14 (VDE-AR-N 4110) • Figure 12 (VDE-AR-N 4120) • Figure 12 (VDE-AR-N 4130) subject to the applicable technical connection regulations.	True
7	The tests are carried out at steady-state operating points at full load (> 0.9 P_n for field tests and > 0.98 P_n for bench tests) and additionally at partial load (0.1 to 0.5 P_n).	True
8	The grid-forming unit remains connected to the grid during all tested voltage dips and swells, provided that all phase-to-phase voltages remain within the limits specified in: • Figure 14 (VDE-AR-N 4110) • Figure 12 (VDE-AR-N 4120) • Figure 12 (VDE-AR-N 4130) of the applicable Technical Connection Regulations.	True
9	All UVRT and OVRT tests are carried out in full.	True
Multiple errors		
10	The unit can withstand multiple faults in accordance with the requirements of 11.2.5.2 (VDE-AR-N 4110/20/30).	True
10.1	The unit is capable of dissipating the energy P_{Emax} for 2 s, without taking into account the energy fed into the grid. This can be demonstrated by calculation.	True
10.2	If the behaviour in the event of multiple faults in No. 10.1 has not been demonstrated by the manufacturer by calculation, the demonstration may alternatively be provided by measurement: Test sequence for multiple faults in accordance with:	True

	• Table 14 (VDE-AR-N 4110) • Table 11 (VDE-AR-N 4120) • Table 8 (VDE-AR-N 4130) at $P \geq 75\ \%\ P_{rE}$ run through without disconnection from the mains.	
10.3	A manufacturer's declaration must provide verifiable evidence that the unit is capable of withstanding a multiple fault again after 30 minutes.	Information provided
10.4	The following applies to units within the scope of VDE-AR-N 4120: For units with a double-fed asynchronous machine, the following applies to multiple faults where the onset of the second fault occurs earlier than 900 ms after the end of the preceding fault: After the end of the last fault, the active current must be increased by at least 20% of the rated current per second.	True
Rise time of the apparent current		
11	The 5 ms moving average of the instantaneous current value $i_{\alpha\beta,5ms}$ reaches 90% of the final value in the tests under partial load no later than 15 ms after the step change in voltage.	True
Settling time of the reactive current		
12	The reactive current remains within the tolerance band for reactive current in both the in-phase and anti-phase systems ($i_{Q,1}$and $i_{Q,2}$) no later than 80 ms after the step change in voltage (+20 % I_r and -10 % I_r for $\Delta i_Q > 0$ or -20 % I_r and +10 % I_r for $\Delta i_Q < 0$). *Note: In the event of mains voltage dips to a value < 0.05 p.u., the apparent current may also be used instead of the reactive current.*	True
Attenuation of reactive current		
13	From 80 ms after the onset of the step-like voltage change, a damping ratio of at least 0.3 is demonstrated for both the in-phase and out-of-phase components of the terminal voltage of the power-generating unit (u_1, u_2) (see Supplement B.IV [1]).	True

	In this context, only quantities with a value of $\Delta i_{Q,1,2,End} > 0.1$ p.u. (relative to I_r) are used to assess the damping. Alternatively, the requirement for reactive current damping is deemed to be met if the in-phase and anti-phase components of the reactive current ($i_{Q,1}$ and $i_{Q,2}$) lie within a band of ± 15 % of $\Delta i_{Q,End,1,2}$ and, in the period from 130 ms to 300 ms after the step voltage change within a band of ± 5 % of $\Delta i_{Q,1,2,End}$. *Note: For the evaluation of the damping, only quantities are considered whose value $\Delta i_{Q,1,2,End}$ is > 0.1 p.u. (relative to I_r).*	

No.	Further evidence	Acceptance criterion
A	The tests in accordance with TG 3 and FNN Guideline on grid-forming capabilities are carried out without disconnecting the unit from the grid. This simultaneously verifies the FRT capability of the auxiliary drives used during the measurement.	True

G.3.1.2.4.4 Behaviour upon reaching and leaving the current limit

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.5.4 [1]	5.5.5.6.4 [1]	FNN Guideline: Grid-forming capabilities TG 3	Test report
Remarks			

In general:

No.	Evaluation criteria	Acceptance criterion
1	The test is carried out in accordance with Section 5.5.5.6.3 [1] and ensures the requirements for measurement technology for measuring harmonics in accordance with Chapter 3.2.2 of TG 3 are met.	True
Maximum time for current clipping upon reaching the current limits in accordance with 4.2.1.1 [1]		
2	The determined THD of the current is not significant at the latest 100 ms after the onset of a	True

	sudden change in the amplitude of the terminal voltage. *Note: A value of ≤ 20 % is considered insignificant.* *Note: This applies provided that there is no mains-side cause for the continuous injection of harmonic current components (e.g. arcing, harmonic loads, inrush situations, resonance points, harmonics of the mains voltage) or saturation effects of the test equipment.*	
2.1	If the THD criterion is not met based on the evaluation of the current of the grid-forming unit, or if an evaluation is not possible for other reasons, the assessment may in such cases be based on a signal from the grid-forming unit that indicates the use of current clipping. In this case, for the failed or non-compliant THD assessment, the signal shall indicate operation without current clipping 40 ms after the sudden change in voltage amplitude.	True
Absolute current limitation (no reactive current prioritisation)		
3	The stability of the grid-forming unit during voltage dips to residual voltages of ≥ 0.2 p.u. is ensured.	True
4	The apparent current of the grid-forming unit, averaged over the duration of the voltage dip, shall not fall below 95 % of the unit's rated current. In the event that the current limit of the grid-forming unit is not reached, the following applies instead: The apparent current of the grid-forming unit, averaged over the duration of the voltage dip, shall not fall below 95 % of the expected apparent current resulting from the operating point prior to the measurement and the average of the effective impedances determined in Section 5.5.5.4 [1] .	True
5	In the event of a voltage dip to approx. 50% and 25% and initial conditions at full load, the active current shall not be less than 5% of the rated current. *Note: A current limit based on magnitude would lead to higher active currents at residual voltages higher than 0.2 p.u. Until further notice, this criterion is intended to prevent pure reactive current prioritisation without*	True

	imposing overly prescriptive requirements on active current behaviour.	
Immediate transition to the operating state without current limitation		
6	It is demonstrated that the unit transitions immediately to the operating state without current limitation when the need for current limitation no longer exists. Upon voltage recovery, 150 ms after the system voltage enters the voltage band of $U_n \pm 10\,\%\, U_{(n)}$, the reactive current does not exceed a transient tolerance of ± 10 % I_r around the steady-state final value of the reactive current. *Note: If inrush effects occur at the transformers in the test setup during the measurement, these may be taken into account when determining the times so that longer settling times may be accepted where necessary. Comparative simulations may also be used for this assessment.*	True

G.3.1.2.4.5 Behaviour upon return to the voltage band of $U_r \pm 10\,\%\, U_r$

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.5.5 [1]	5.5.5.6.5 [1]	FNN Guideline Grid-forming capabilities	Test report
Remarks	If the manufacturer has designed the voltage source control gain or the effective impedance of the grid-forming unit to be configurable, verification must be provided for the nominal value specified by the manufacturer in each case. For other configurable values, verification must be provided by simulation in accordance with Chapter G.3.1.7.7.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	The test is carried out in accordance with Section 5.5.5.6.3 [1].	True
Behaviour regarding active current recovery after fault clearance		
2	The pre-fault active current is restored after 1 s (after fault termination).	True
2.1	If the active current cannot reach this time due to technical restrictions, this must be justified.	Information provided
Behaviour regarding transient overvoltage after voltage recovery		
3	After power restoration, the calculated system-wide overvoltage u_1 does not exceed 2.5% of the steady-state final voltage value $u_{1,\text{End}}$. If the unit is commissioned by 31 December 2027, a value of 5.0% applies instead of 2.5%.	True

G.3.1.2.4.6 Verification of the behaviour of limited voltage source control during grid faults

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.5.3 [1]	5.5.5.6.6 [1]	FNN Guideline Grid-forming capabilities	Test report
Remarks			

In general:

No.	Evaluation criteria	Acceptance criterion
1	All necessary tests in accordance with FGW TG 3 Rev. 26, taking into account the tests specified in Table 7 [1] regarding limited voltage source control, have been carried out.	True
2	The voltage source regulation is maintained for all mains voltage dips below 0.8 U_n for a period of 150 ms.	True
3	The maximum apparent current (of the three phase currents) does not exceed 20% of the rated current I_r for all mains voltage dips below 0.8 U_n after a maximum of 210 ms.	True
4	The maximum apparent current (of the three phase currents) for all mains voltage dips below 0.8 U_n does not exceed 10% of the rated current I_r after a maximum of 250 ms.	True

G.3.1.2.4.7 Fast protection at high voltages

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.7 [1]	5.5.5.6.7 [1]	FNN Guideline Grid-forming capabilities	Manufacturer's declaration
Remarks			

In general:

No.	Evaluation criteria	Acceptance criterion
1	When a sinusoidal voltage is applied to the terminals of the grid-forming unit, and there is a sudden change in the amplitude of this voltage to a value greater than 1.35 p.u,, the power-generating unit is permanently transitioned within 40 ms of the sudden amplitude change into a state in which the root mean square (RMS) value of the current in each conductor is limited to a maximum of 5 % of the rated current. The half-cycle values of the currents following the application of the voltage are shown for each conductor.	The information has been provided
2	Compliance with the requirements for fast protection at high voltages does not undermine the requirements for OVRT robustness as set out in Section 4.2.1.	This has been specified
3	The criteria used to justify the shutdown are set out.	True

G.3.1.2.5 Behaviour at steep frequency gradients (RoCoF)

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.10 [1]	5.5.5.7 [1]	FNN Guideline: Grid-forming capabilities VDE-AR-N 4110 VDE-AR-N 4120 VDE-AR-N 4130	Manufacturer's declaration
Remarks			

In general:

No.	Assessment criteria	Acceptance criterion
1	The RoCoF values required in accordance with Section 10.2.4.3 of the applicable Technical Connection Regulations can be passed through without disconnecting from the grid. The frequency curve shown in Figure 4 in Section 4.2.1.14 [1] must be maintained without disconnecting the system from the grid.	Information has been provided
2	If the assessment criterion under No. 1 is not met, the framework conditions for meeting the requirements are specified.	True
3	With regard to frequency measurement and the determination of the RoCoF, section 4.2.2.7 [1] has been observed.	True

G.3.1.2.6 Damping of frequency-power oscillations

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.12 [1]	5.5.5.8 [1]	FNN Guideline Grid-forming capabilities	Test report
Remarks	It is required that measurement-based verification of the attenuation of frequency-power oscillations be carried out at $T_{A,min}$ and $T_{A,max}$. Metrological tests of further values of T_A are permitted at the manufacturer's request.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	The behaviour of the grid-forming unit at $T_{A,min}$ and $T_{A,max}$ is checked.	True
2	The individual tests listed in Table 8 [1] are carried out.	True
3	The tests are carried out at the terminals of the grid-forming unit with an SCR = 3. The use of results from measurements carried out at a lower short-circuit ratio than SCR = 3 is permitted, but this must be documented.	True
4	The tests are carried out based on an active power output of 50% to 75% of P_{Emax}. The power factor cos φ was set to 1.0 for each test.	True
5	Measurement method 1 or measurement method 2 is carried out in accordance with section 5.5.5.8.2 [1].	True
6.1	In the case of measurement method 1, the following applies: Excitation is provided by a step-like frequency change of approximately 250 mHz to 500 mHz. The excitation does not result in a limitation of the current of the grid-forming unit. If the excitation was implemented by applying a signal, the frequency change also affects the primary control based on network security.	True
6.2	In the case of measurement procedure 2, the following applies: The magnitude of the phase jump results in a change in active power of 15% to 30% P_{Emax} in the offered direction or 2% to 4% P_{Emax} in the non-offered direction of inertia. The excitation does not lead to a limitation of the storm of the grid-forming unit.	True
7	The determined damping ratio does not fall below the value of 0.5 specified in Section 4.2.1.12 [1] by more than 10% for all T_A values parameterised in the unit. *Note: If, for a value of T_A, the metrological test was not passed at an SCR < 3, or could not be carried out due to the unknown SCR value of the test facility, a simulation-based verification is permitted as an alternative, which is to be assessed in accordance with G.3.1.7.3.*	$D(T_A) \geq 0.45$

7.1	If a total of three peaks and troughs are discernible in the course of the co-system active power, the following applies: The two determined amplitude ratios of the successive troughs and peaks (AV_{21} and AV_{32}) are less than 0.2. If fewer than three peaks and troughs are discernible in the course of the co-system active power, the test is also deemed to have been passed.	$AV_{21} < 0.2$, $AV_{32} < 0.2$ Or Fewer than 3 peaks/troughs

G.3.1.2.7 Time constant, inertia power and energy

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.12 [1] 4.2.1.13 [1]	5.5.5.9 [1]	FNN Guideline: Grid-forming capabilities	Test report
Remarks	As part of the assessment of the start-up time constant and inertia power, it must also be verified whether the higher prioritisation of inertia power required under Section 4.2.3 [1] takes precedence over specifications by third parties or the grid operator's NSM.		

In general:

No.	Assessment criteria	Acceptance criterion
1	The behaviour of the grid-forming unit at $T_{A,min}$ and $T_{A,max}$ is checked.	True
2	Measurement procedures 1 and 2 of section 5.5.5.9.2 [1] are carried out.	True
2.1	When carrying out measurement procedure 1, the following applies: The measurements are carried out in accordance with the specifications in Table 9. The measurements are carried out based on a reactive power of 0 ± 5 % relative to P_{Emax}. For grid-forming power generating units, measurements 1.1 and 1.2 were carried out with a constant primary energy supply.	True
2.1.1	The values $P_{limitneg,min}$, $P_{limitneg,max}$ and $P_{min,dyn}$ are determined and reported.	Information is available

2.1.2	For measurements 1.1 to 1.4, there is a limiting specification for active power via the highest-priority limiting specification in accordance with Section 4.2.3 [1], such that the limited value is exceeded due to the inertia power occurring. The inertia power is not restricted by the limit specification.	True
2.2	When carrying out measurement procedure 2, the following applies: The measurements are carried out in accordance with the specifications in Table 10. The measurements are carried out based on a reactive power of 0 ± 5 % relative to P_{Emax}. For grid-forming power generating units, measurements 2.1 and 2.2 are carried out at a constant primary energy supply.	True
2.2.1	The values $P_{\mathrm{limitpos,min}}$, $P_{\mathrm{limitpos,max}}$ and $P_{\mathrm{max,dyn}}$ are determined and reported.	Data is available
2.2.2	For measurements 2.1 to 2.4, there is a limit specification for active power based on the highest-priority limit specification in accordance with Section 4.2.3 [1], meaning that the limited value is exceeded due to the inertia power occurring. The inertia power is not restricted by the limit specification.	True
Test procedure 1 – Trading of negative or symmetrical inertia		
3	The grid-forming unit remains connected to the grid during the test. If the PGU disconnection protection is triggered due to the frequency settings, these may be widened and the measurement repeated.	True
4	The measured power remains within the required tolerance bands for the periods specified in Section 5.5.5.9.3.2 [1] following the start of the respective segment.	True
5	The measured power for T_A > 10 s in segment (1) (where applicable, with an adjusted active power operating point) reaches 95% of the expected inertia power.	If T_A > 10 s: True
6	If the start-up time constant is determined in accordance with Section 5.5.5.9.3.3 (based on the evaluation of internal signals), the following applies:	If T_A was determined on the basis of internal signals: True

	The determined value of T_A deviates by no more than 5 % from the agreed value.	
7	The inertia power is not limited by the active power limit (prioritisation).	True
8	The evaluation of point 3) of measurement procedure 1 shows that $\Delta E_{pos} \leq 1{,}5\ \Delta E_{neg}$.	$\Delta E_{pos} \leq 1{,}5\ \Delta E_{neg}$
Measurement procedure 1 - Marketing of positive inertia		
9	The grid-forming unit remains connected to the grid during the test. If the PGU disconnection protection is triggered due to the frequency settings, these may be widened and the measurement repeated.	True
10	The evaluation of the measurement yields: $(\lvert\Delta E_{pos,12}\rvert + \lvert\Delta E_{neg,3}\rvert + \lvert\Delta E_{pos,4}\rvert + \lvert\Delta E_{neg,4}\rvert) \leq 1{,}5 \cdot(\lvert\Delta E_{neg,12}\rvert + \lvert\Delta E_{pos,3}\rvert)$.	True
Measurement procedure 2 - Marketing of positive or symmetrical inertia		
11	The grid-forming unit remains connected to the grid during the test.	True
12	The measured power remains within the required tolerance bands for the periods specified in clause 5.5.5.9.3.2 following the start of the respective segment.	True
13	The measured power for T_A > 10 s in segment (1) (where applicable, at an adjusted active power operating point) reaches 95% of the expected inertia power.	If T_A > 10 s: True
14	If the start-up time constant is determined in accordance with Section 5.5.5.9.3.3 (based on the evaluation of internal signals), the following applies: The determined value of T_A deviates by no more than 5 % from the agreed value.	If T_A was determined on the basis of internal signals: True
15	The inertia power is not limited by the active power limitation (prioritisation).	True
16	The evaluation of point 3) of measurement procedure 2 shows that $\Delta E_{neg} \leq 1{,}5\ \Delta E_{pos}$.	$\Delta E_{pos} \leq 1{,}5\ \Delta E_{neg}$
Measurement procedure 2 - Marketing of negative inertia		
17	The grid-forming unit remains connected to the grid during the test. If the PGU disconnection protection is	True

	triggered due to the frequency settings, these may be widened and the measurement repeated.	
18	The evaluation of the measurement yields: $(\lvert\Delta E_{neg,12}\rvert + \lvert\Delta E_{pos,3}\rvert + \lvert\Delta E_{neg,4}\rvert + \lvert\Delta E_{pos,4}\rvert) \leq 1{,}5 \cdot (\lvert\Delta E_{pos,12}\rvert + \lvert\Delta E_{neg,3}\rvert)$.	True
Prioritisation requirements		
19	The higher prioritisation of inertia power over all external P-setpoint specifications cannot be deactivated.	True

G.3.1.2.8 Behaviour in the event of over- and under-frequency (primary control based on network security) within the limited control range

Requirement	Evidence	Applicable documents	Prerequisites
4.2.2 [1]	5.5.5.10 [1]	FNN Guideline: Grid-forming capabilities	Test report
Remarks			

In general:

No.	Evaluation criteria	Acceptance criterion
1	Measurement procedures 1 and 2 are carried out for all PGU technologies.	True
1.1	When carrying out measurement procedure 1, the following applies: The measurements are carried out with an active power output in the range of 75% to 100% P_{Emax}. A steady state is reached before each frequency step is activated.	
1.2	When carrying out measurement procedure 2, the following applies: The measurements are carried out starting from minimum power. A steady state is reached before each frequency step is activated.	True
2	The steady-state final values of active power p_1 deviate by a maximum of ± 5 % of the expected power change	True

	or ± 0.5 % P_{Emax} from the values resulting from the set static conditions.	
3	At least the active power control rates specified in Table 15 shall be maintained. If no minimum requirements for the grid-forming unit are specified in Table 15, verification of the control rates is provided by stating them.	True

G.3.1.3 General and Grid Security Management

G.3.1.3.1.1 VDE-AR-N 4110 (TCR MV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.4.1 (TCR)	11.2.7	TG 3	Test report Manufacturer's declaration
4.2.3 [1]	5.5.6.1 [1]	TG 3 FNN Guideline: Grid-forming capabilities	Test report
Remarks	If the active power gradient control function is implemented at the PGS controller level, assessments 1 to 2 may be omitted with reference to the PGS controller to be used. If the function of prioritising grid security management over primary control based on network security, as well as prioritising this over setpoint specifications by third parties, is not implemented exclusively at the PGU level but using components beyond the PGU (e.g. PGS controllers), compliance with the prioritisation requirements must be demonstrated for the respective combination of unit and component. If the functions to be prioritised – namely grid security management, primary control based on network security and setpoint specifications by third parties – cannot all be implemented or activated within the component or the PGU, the behaviour of the existing/activated functions shall be documented. The assessment of the compliant implementation of prioritisation is carried out separately for: • the prioritisation of primary control based on network security during an underfrequency event in accordance with Section 4.2.3 of [1], in accordance with the criteria of this chapter • the prioritisation of voltage source behaviour (in accordance with points 3 and 2 of Section 4.2.3 [1]) or behaviour based on the start-up time constant (in accordance with points 4 and 3 of Section 4.2.3 [1]) in accordance with the criteria of Chapters G.3.1.2.1 and G.3.1.2.7.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	Power gradient for increasing and reducing active power.	0.33% P_{rE}/s ≤ Gradient ≤ 0.66% P_{rE}/s (Slower if setpoint specifications are provided by third parties, but not slower than 4% P_{rE}/min when increasing power)
2	Smooth progression of power increase/reduction.	True
3	Interfaces to active power specifications (grid operator, direct marketer) implemented separately and conceptually checked to ensure that a lower but higher-priority active power value is adopted (even in the case of overlapping specifications).	True
4	Prioritisation of grid security management over primary control based on network security, as well as the prioritisation of this over setpoint specifications by third parties, has been implemented. If not all functions are active or present in the PGU, the behaviour is reported. For the combination of PGU and components extending beyond the PGU (e.g. PGS controller), the prioritisation requirements are met. *Note: If components beyond the PGU are used to implement the prioritisation of the NSM over primary control based on network security or the prioritisation of the latter over specifications by third parties, specific components or minimum requirements for these components must be specified in the unit certificate. Compliance with the requirements must be confirmed as part of the system certification through an approved combination of unit and component.*	True
4.1	The prioritisation of primary control based on network security during an underfrequency event in accordance with point 5, section 4.2.3 [1] is tested in accordance with the requirements of TG 3 Supplement 26.1, supplementing section 5.5.6.1 [1].	True
4.2	The setpoint for grid security management and the setpoint for the active power requirement specified by third parties are fed directly to the power generating unit to implement the prioritisation.	True
5	Control deviation is displayed at PGU terminals.	True and deviation ≤ 5 % P_{inst}
6	The maximum active power output is reported as an average over 200 ms, 1 minute and 10 minutes.	True
7	If active power output depends on environmental conditions (temperature, air pressure), these dependencies	True

	have been documented in the form of a manufacturer's declaration.	
8	If the power gradient is implemented at the PGS controller level, the settling time of the PGU must be determined by a step change in active power from 90% to 10% P_{rE} and from 10% to 90% P_{rE} .	No evaluation, pure display
9	An interface for implementing a power setpoint for the PGU in the range 0% $P_{b\ inst}$ to 100% $P_{b\ inst}$ with a resolution of 1% steps has been implemented.	True
10	An interface for the remote deactivation of the primary control based on network security has been implemented.	True

G.3.1.3.1.2 VDE-AR-N 4120 (TCR HV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.4.1 (TCR)	11.2.7	TG 3	Test report Manufacturer's declaration
4.2.3 [1]	5.5.6.1 [1]	TG 3 FNN Guideline: Grid-forming capabilities	Test report
Remarks	If the active power gradient control function is implemented at the PGS controller level, assessments 1 to 2 may be omitted with reference to the PGS controller to be used. If the function of prioritising grid security management over primary control based on network security, as well as prioritising this over setpoint specifications by third parties, is not implemented exclusively at the PGU level but using components beyond the PGU (e.g. PGS controllers), compliance with the prioritisation requirements must be demonstrated for the respective combination of unit and component. If the functions to be prioritised – namely grid security management, primary control based on network security and setpoint specifications by third parties – cannot all be implemented or activated within the component or the PGU, the behaviour of the existing/activated functions shall be documented. The assessment of the compliant implementation of prioritisation is carried out separately for: • the prioritisation of primary control based on network security during an underfrequency event in accordance with Section 4.2.3 [1] and in accordance with the criteria of this chapter. • the prioritisation of voltage source behaviour (in accordance with points 3 and 2 of Section 4.2.3 [1]) or behaviour based on the start-up time constant (as per points 4 and 3		

	of Section 4.2.3 [1]) in accordance with the criteria of Chapters G.3.1.2.1 and G.3.1.2.7.

In general:

No.	Evaluation criteria	Acceptance criterion
1	Power gradient for increasing and reducing active power.	0.33% $P_{b\ inst}$/ s ≤ Gradient ≤ 0.66% $P_{b\ inst}$/ s (Slower if setpoint specifications are provided by third parties, but not slower than 4% $P_{b\ inst}$/ min when increasing power.)
2	Smooth progression of power increase/reduction.	True
3	Interfaces for active power specifications (grid operator, direct marketer) implemented separately and conceptually checked to ensure the lowest active power value is adopted (even where specifications overlap in time).	True
4	Prioritisation of grid security management over primary control based on network security, as well as the prioritisation of this over setpoint specifications by third parties, has been implemented. If not all functions are active or present in the PGU, the behaviour is documented. For the combination of the PGU and components extending beyond the PGU (e.g. PGS controller), the prioritisation requirements are met. *Note: If components beyond the PGU are used to implement the prioritisation of the NSM over primary control based on network security or the prioritisation of the latter over specifications by third parties, specific components or minimum requirements for these components must be specified in the unit certificate. Compliance with the requirements must be confirmed as part of the system certification through an approved combination of unit and component.*	True
4.1	The prioritisation of primary control based on network security during an underfrequency event as per point 5, section 4.2.3 [1] is tested in accordance with the requirements of the TG 3 Supplement 26.1, supplementing section 5.5.6.1 [1].	True
4.2	The setpoint for grid security management and the setpoint for the active power requirement from third parties are fed directly to the power generating unit for prioritisation	True
5	Control deviation displayed at PGU terminals.	True and deviation ≤ 5 % P_{inst}

6	The maximum active power output is reported as an average over 200 ms, 1 minute and 10 minutes.	True
7	If active power output depends on environmental conditions (temperature, air pressure), these dependencies have been documented in the form of a manufacturer's declaration.	True
8	If the power gradient is implemented at the PGS controller level, the settling time of the PGU must be determined by a step change in active power from 90% to 10% P_{rE} and from 10% to 90% P_{rE}.	No evaluation, purely for reporting purposes
9	An interface for the remote deactivation of primary control based on network security has been implemented.	True

G.3.1.3.1.3 VDE-AR-N 4130 (TCR EHV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.4.1 (TCR)	11.2.7	TG 3	Test report Manufacturer's declaration
4.2.3 [1]	5.5.6.1 [1]	TG 3 FNN Guideline: Grid-forming capabilities	Test report
Remarks	If the active power gradient control function is implemented at the PGS controller level, assessments 1 to 2 may be omitted with reference to the PGS controller to be used. Whether the capacity of the PGU is sufficient to meet the basic requirements must be assessed. If the function of prioritising grid security management over primary control based on network security, as well as prioritising this over setpoint specifications by third parties, is not implemented exclusively at the PGU level but using components beyond the PGU (e.g. PGS controllers), compliance with the prioritisation requirements must be demonstrated for the respective combination of unit and component. If the functions to be prioritised – namely grid security management, primary control based on network security and setpoint specifications by third parties – cannot all be implemented or activated within the component or the PGU, the behaviour of the existing/activated functions shall be documented. The assessment of the compliant implementation of prioritisation is carried out separately for: the prioritisation of primary control based on network security during an underfrequency event as per Point 5 Section 4.2.3 [1], in accordance with the criteria of this chapter. the prioritisation of voltage source behaviour (in accordance with points 3 and 2 of Section 4.2.3 [1]) or behaviour based on the start-		

	up time constant (as per points 4 and 3 of Section 4.2.3[1]) in accordance with the criteria of Chapters G.3.1.2.1 and G.3.1.2.7.

In general:

No.	Evaluation criteria	Acceptance criterion
1	Power gradient for increasing and reducing active power.	0.33% $P_{b\ inst}$/s ≤ gradient ≤ 0.66% $P_{b\ inst}$/s (Slower for setpoint specifications by third parties, but not slower than 4% $P_{b\ inst}$/min when increasing power.)
2	Smooth progression of power increase/reduction.	True
3	Interfaces for active power specifications (grid operator, direct marketer) implemented separately and conceptually verified to ensure the lowest active power value is adopted (even where specifications overlap in time).	True
4	Prioritisation of primary control based on network security over grid security management, as well as prioritisation of grid security management over setpoint specifications by third parties, has been implemented. If not all functions are active or present in the PGU, the behaviour is reported. For the combination of PGU and components extending beyond the PGU (e.g. PGS controller), the prioritisation requirements are met. *Note: If components beyond the PGU are used to implement the prioritisation of NSM over primary control based on network security or the prioritisation of the latter over third-party specifications, specific components or minimum requirements for these components must be specified in the unit certificate. Compliance with the requirements must be confirmed as part of the system certification through an approved combination of unit and component.*	True
4.1	The prioritisation of primary control based on network security during an underfrequency event, as per point 5 of section 4.2.3 [1], is assessed in accordance with the requirements of TG 3 Supplement 26.1, which supplements section 5.5.6.1 [1].	True
4.2	The setpoint for grid security management and the setpoint for the active power requirement specified by third parties are fed directly to the power generating unit to implement the prioritisation	True
5	Control deviation displayed at PGU terminals.	True and deviation ≤ 5 % P_{inst}
6	The maximum active power output is reported as an average over 200 ms, 1 minute and 10 minutes.	True

7	If active power output depends on environmental conditions (temperature, air pressure), these dependencies have been documented in the form of a manufacturer's declaration.	True
8	Proof of the maximum active power gradient is provided by a step change in the active power setpoint from 90 % P_{rE} to 10 % P_{rE}.	True
9	The proof of the minimum active power gradient was provided for a setpoint jump from at least 60% P_{rE} to 50% P_{rE}. For the increase in active power, the jump in the active power setpoint was carried out in the opposite direction.	True
10	The unit certificate must state whether the gradient procedure is implemented in the power generating unit or in the PGS controller	No assessment, purely for reporting purposes
11	An interface for the remote deactivation of primary control based on network security has been implemented.	True

G.3.1.4 Phase swinging or grid oscillations

Requirement	Evidence	Applicable documents	Prerequisites
10.2.1.3 (TCR)	11.2.3.2 11.2.3.3 (TCR)	-	Manufacturer's declaration
Remarks	For grid-forming units, no verification of the requirements for phase swinging oscillations in accordance with 10.2.1.3 of the applicable TCR is required, as this has already been provided by the verification of frequency-power oscillations in accordance with Chapter G.3.1.2.6.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	Network oscillation: Evidence of the damping of frequency-power oscillations in accordance with Chapter G.3.1.2.6 has been successfully provided.	True

G.3.1.5 Setting ranges (decoupling protection)

G.3.1.5.1 VDE-AR-N 4110 (TCR-MS)

Requirement	Evidence	Applicable documents	Prerequisites
10.3.4.2.2 10.3.5.3.2	11.2.10 (TCR)	FNN Guideline: Grid-forming capabilities	Manufacturer's declaration Test report
Remarks	The requirement for primary control based on grid security set out in the FNN guidance on grid-forming capabilities (see Sections 2 and 4.2.2.2, in particular point 12) implicitly requires the adjustment of the protection settings for the disconnection protection on grid-forming units with regard to frequency increase protection (*f* >).		

In general:

No.	Evaluation criteria	Acceptance criterion
1	A type test is available for the protective devices integrated in the network-forming unit, covering the setting ranges required in Tables 11 and 13 [7] in accordance with FGW TG 3 Rev. 26 or later. For frequency increase protection (*f* >), the following applies to Tables 11 and 13 [7] instead of the value required by VDE-AR-N 4110:2023-09 for the 'Recommended protection setting': 51.5 Hz→ 10 s.	True
2	Any additional protection devices of the PGU with a setting range are specified.	True

G.3.1.5.2 VDE-AR-N 4120 (TCR HV)

Requirement	Evidence	Applicable documents	Prerequisites
10.3.4.5 10.3.4.6 10.3.4.7	11.2.10 (TCR)	FNN Guideline: Grid-forming capabilities	Manufacturer's declaration Test report
Remarks	The requirement for primary control based on network security set out in the FNN Guideline on grid-forming properties (see Section 4.2.2.2, in particular point 12) and Section 2) implicitly requires the adjustment of the protection settings for the disconnection protection on grid-forming units with regard to frequency increase protection (f >).		

In general:

No.	Evaluation criteria	Acceptance criterion
1	A type test is available for the protective devices integrated in the grid-forming unit, covering the setting ranges required in Table 8 [8] in accordance with FGW TG 3 Rev. 26 or later. For frequency increase protection (f >), the following applies to Table 8 [8] instead of the value required by VDE-AR-N 4120:2018-11 for the 'Recommended protection setting': 51.5 Hz→ 10 s.	True
2	Any additional protection devices of the PGU with an adjustment range are specified.	True

G.3.1.5.3 VDE-AR-N 4130 (TCR EHV)

Requirement	Evidence	Applicable documents	Prerequisites
10.3.2	11.2.10 (TCR)	FNN Guideline: Grid-forming capabilities	Test report
Remarks	The requirements of VDE-AR-N 4120, Sections 10.3.4.5, 10.3.4.6 and 10.3.4.7, serve as the basis for assessment. The requirement for primary control based on network security set out in the FNN Guideline on grid-forming capabilities (see Section 4.2.2.2, in particular point 12) and Section 2) implicitly requires the adjustment of the protection settings for the disconnection protection on grid-forming units with regard to frequency increase protection (f >).		

In general:

No.	Evaluation criteria	Acceptance criterion
1	A type test is available for the protective devices integrated in the network-forming unit within the setting ranges required in Table 6-34 in accordance with FGW TG 3 Rev. 26 or later. For frequency increase protection (f>), the following ‘Recommended protection setting value’ applies as an exception: 51.5 Hz→ 10 s.	True
2	Any additional protection devices of the PGU with a setting range are specified.	True

G.3.1.6 Simulation models

G.3.1.6.1 Requirements for simulation models

Requirement	Evidence	Applicable documents	Prerequisites
5.5.3.1 5.5.3.2 5.5.3.3 5.5.3.4 5.5.3.5	5.5.3.6 5.5.3.7 5.5.3.8 5.5.3.9	FNN Guideline: Grid-forming capabilities TG 4	Validated PGU models for the grid fault scenario and normal operation require measurement results in accordance with 11.2.4, 11.2.5, 11.2.7 and 11.2.10 of the applicable TCR, as well as 5.5.4 and 5.5.5 [1]. Manufacturer’s declaration
Remarks			

In general:

No.	Evaluation criteria	Acceptance criterion
General model requirements		
1	The functional scope of the controlls shall comply at least with Section 11.2.6.2 of the applicable Technical Connection Regulation and Section 5.5.3.2 [1]. The following model types shall be provided: • EMT model (may be provided as a black-box model) • Detailed RMS model (may be provided as a black-box model)	True

	• RMS-type model. RMS-type models shall be provided as white-box models and presented on the basis of a block diagram. All state variables, signals, parameters or characteristics shall be accessible. For new technologies for which no suitable models as per 1) [1] are publicly available yet, the manufacturer may alternatively provide an RMS type model with encrypted components, state variables, internal signals, parameters and characteristics which need not be accessible. However, signals used for evaluation in the verification process must be accessible. For these models, the publication requirement under point 1) [1] does not apply. This applies provided that the relevant Technical Connection Rule does not impose any other requirements in this regard.	
1.1	The power section of the respective model is not included in the black-box model. Where present, the unit transformer, filter or other electrical components are explicitly represented in the simulation model within the simulation environment. If the unit transformer is equipped with an automatic tap changer, the associated tap changer control is represented in the simulation model and implemented in a separate, switchable model section.	True
1.2	Protection functions that trigger the disconnection of the grid-forming unit, when grid conditions arise that lead to the grid-forming unit no longer meeting the requirements for remaining on the grid, are, where possible, implemented in a detachable model section; at the very least, however, these can be deactivated by re-parameterisation.	True
1.3	If the average internal demand (under normal operating conditions without sporadic/occasional loads (according to the manufacturer's specifications)) is ≥ 3 % P_{Emax} and, for units with a P_{Emax} ≥ 50 kW, this is modelled. The average internal demand may be modelled in a simplified manner, e.g. as an impedance load.	True, information is available and is documented in a traceable manner
1.4	The model has the necessary input signals for control by an PGS controller.	True
1.5	Any number of instances of the model for the same unit can be run in parallel independently of one another. Unit models – including DLL-based models – can be instantiated multiple times. Corresponding plausibility tests in accordance with TG 4 Supplement	True

	10.1 have been carried out and passed in compliance with the guidelines.	
1.6	All simulation models (with the exception of DLL-based models) are structured modularly on the basis of sub-models, so that sub-functions (protection, PCNB, etc.) can be disabled and parameter changes easily carried out.	True
1.7	The models can depict the behaviour in the event of a fault in the superimposed network, and the return to quasi-steady-state operation from any quasi-steady-state operating point.	True
1.8	The simulation models represent all settling times and accuracies with regard to active and reactive power in normal operation (11.2.4 and 11.2.7 [7] [9][8]) in accordance with the respective requirements.	True
1.9	The models have been subjected to plausibility tests for use at further operating points. Reproducible results must be ensured for identical initial load flow conditions.	True
EMT model		
2	The functional scope of the EMT model complies at least with Section 5.5.3.3 [1].	True
2.1	The EMT model represents the currents and voltages of the grid-forming unit as phase values. The modelling of electrical and control components that are effective in a frequency range up to 1 kHz (if possible up to 2.5 kHz) in accordance with the manufacturer's specifications is depicted. Measuring elements are taken into account. The level of detail of the simulation model is selected such that model validation can be successfully carried out in accordance with Section 5.5.3.6 [1].	True
2.2	The relevant original controller code is used – e.g. in the form of a DLL. An output signal from the controller is provided in the form of a setpoint for pulse pattern generation. *Note: This serves to enable a simplified representation of the power section (power electronic switching elements) for a simplified time-continuous representation of the pulse pattern generation. It is not*	True

	required that the pulse pattern generation and the power section can be switched on.	
2.3	The model is sufficiently detailed to represent the entire operating range of the unit between $P_{\mathrm{Emin,E}}$ and $P_{\max}$ or $Q_{\min}$ and $Q_{\max}$ in the steady-state initial condition, as well as during transient settling processes. The scope of the model covers all operating states and operating points within the unit's design parameters. Corresponding plausibility tests in accordance with TG 4 Supplement 10.1 were carried out and passed in compliance with the guidelines.	True
2.4	It is established whether the initialisation of the model is supported in such a way that the currents and voltages resulting from the load-flow calculation can be automatically predefined as setpoint signals. Provided the simulation environment permits this, the model has a function (model snapshot) that can save steady-state conditions and read or activate them again without re-initialisation.	If specified, True
2.5	Parameter settings for the grid-forming unit that are defined as adjustable in accordance with the requirements (e.g. PCNB statics) can be changed. The adjustment ranges are documented in each case.	True
2.6	All signals and states required for replicating the tests to verify the requirements for the grid-forming unit, as well as for validating the simulation model, are observable by the user.	True
Detailed RMS model		
3	The functional scope of the detailed RMS model complies at least with Section 5.5.3.4 [1].	True
3.1	The detailed RMS model is based on a root mean square representation of currents and voltages of the grid-forming unit in the phase, neutral and zero-sequence systems, including the modelling of electrical and control components and protection functions. Aspects of the primary side (e.g. mechanics, chemistry) are modelled to the extent that they are necessary for model validation. The level of detail of the simulation model is selected such that model validation can be successfully carried out in accordance with Section 5.5.3.6 [1].	True

3.2	The controller functions are implemented as an equivalent, time-continuous model of the original controller code. *Note: Unlike time-continuous models, clocked models cannot be efficiently solved by simulation within a complex and extensive network environment (see note in Section 5.5.3.1* [1]*) as the step sizes that must be adhered to individually for each model would result in unacceptable computation times and adaptive step sizes could not be applied.*	Information available
3.3	The detailed RMS model can be used with a simulation step size of ≥ 1 ms. The simulation step size is specified in the model documentation and was applied during model validation. Should a smaller step size be required for the calculation of sub-transient processes, the model should be designed such that, once the sub-transient processes have decayed, step size adaptations down to at least 15 ms are possible.	True
3.4	The model is sufficiently detailed to represent the entire operating range of the unit between $P_{\mathrm{Emin,E}}$ and $P_{\max}$ or $Q_{\min}$ and $Q_{\max}$ in the steady-state initial condition, as well as during transient settling processes. The scope of the model covers all operating states and operating points within the unit's design parameters. Corresponding plausibility tests in accordance with TG 4 Supplement 10.1 were carried out and passed in compliance with the guidelines.	True
3.5	The initialisation of the grid-forming unit model is carried out within the model itself on the basis of the voltages and currents determined at the terminals of the grid-forming unit in a load-flow calculation. This ensures that the derivatives of state variables remain below the selected simulation errors ('flat run' i.e. no noticeable transient response is observed). If an operating state was selected during the load flow calculation that is not represented by the simulation model, corresponding messages are issued during model initialisation.	True
3.6	Parameterisations of the grid-forming unit that are defined as adjustable in accordance with the requirements (e.g. PCNB statics) can be changed. The adjustment ranges are documented in each case.	True
3.7	All signals and states required for replicating the tests to verify the requirements for the grid-forming unit and for validating the simulation model are observable by the user.	True

3.8	The detailed RMS model is provided for all common simulation environments used by German transmission system operators to carry out system studies. *Note: Specifications for the simulation environments to be supported can be found in the Technical Connection Conditions (TAB) of the German transmission system operators.*	True
RMS-type model		
4	The functional scope of the RMS-type model complies at least with Section 5.5.3.5 [1]. *Note: The model behaviour may be simplified compared to the simulation model described in Section 5.5.3.4* [1] *and may refer to a generalised representation (e.g. as a VSM or droop model). If the behaviour of a unit cannot be modelled with the required accuracy using an existing, publicly available model, the manufacturer is free to design a suitable model and include it in the type library.*	True
4.1	The RMS type model is implemented as a time-continuous model. *Note: The aim of the RMS type model is to enable its use in system studies. Accordingly, it is important to keep simulation times as short as possible. Unlike time-continuous models, discrete-time models cannot be efficiently solved by simulation within a complex and extensive network environment (see note in Section 5.5.3.1* [1]*) as the step sizes that must be adhered to individually for each model would result in unacceptable computation times and adaptive step sizes could not be applied.*	True
4.2	The simplified or typified model meets all requirements for the grid-forming unit (e.g. phase-step power, settling time constant, damping behaviour with regard to frequency-power oscillations, current limiting, FRT behaviour) and thus exhibits behaviour comparable to that of the detailed RMS simulation model described in Section 5.5.3.4 [1].	True
4.3	The model is sufficiently detailed to represent the entire operating range of the unit between $P_{\mathrm{Emin,E}}$ and $P_{\max}$ or $Q_{\min}$ and $Q_{\max}$ in the steady-state initial condition, as well as during transient settling processes. The scope of the model covers all operating states and operating points within the unit's design parameters. Corresponding plausibility tests in accordance with TG 4 Supplement 10 were carried out and passed in compliance with the guidelines.	True

4.4	The RMS-type model has been validated against the detailed RMS simulation model in accordance with Section 5.5.3.4. In doing so, the tolerance specifications in Section 5.5.3.6 [1] were observed.	True
4.5	The detailed RMS model can be used with a simulation step size of ≥ 1 ms. The simulation step size is specified in the model documentation and was applied during model validation. Should a shorter step size be required for the calculation of sub-transient processes, the model is designed such that once the sub-transient processes have decayed, step size adaptations of up to 15 ms are supported where possible.	True
4.6	The initialisation of the grid-forming unit model is performed within the model itself on the basis of the voltages and currents determined at the terminals of the grid-forming unit in a load flow calculation. This ensures that the derivatives of state variables remain below the selected simulation errors ('flat run' i.e. no noticeable transient response is observed). If an operating state was selected during the load flow calculation that is not represented by the simulation model, corresponding messages are issued during model initialisation.	True
4.7	If the selected tool environment supports the calculation of eigenvalues, the model is designed, where possible, to allow linearisation via the eigenvalue calculation function.	True

G.3.1.6.2 Model validation – General requirements

Requirement	Evidence	Applicable documents	Prerequisites
5.5.3.6 [1]	-	FNN Guideline: Grid-forming capabilities TG 4	Validated PGU models for the grid fault scenario and normal operation require measurement results in accordance with 11.2.4, 11.2.5, 11.2.7 and 11.2.10 of the applicable TCR, as well as 5.5.4 and 5.5.5 [1].
Remarks			

In general:

No.	Evaluation criteria	Acceptance criterion
1	The validation of the unit models is carried out for grid fault cases on the basis of measurements in accordance with 11.2.5 and 11.2.10 of the applicable Technical Connection Regulations, in accordance with the requirements of TG 4 and Sections 5.5.4 and 5.5.5 [1], by a certification body accredited in accordance with DIN EN ISO/IEC 17065 [9].	True
2	The validation of the unit models for normal operation shall be carried out on the basis of measurements in accordance with 11.2.4 and 11.2.7 of the applicable Technical Connection Regulation in accordance with the requirements of TG 4 by a certification body accredited in accordance with DIN EN ISO/IEC 17065 [9].	True
3	The EMT model, the detailed RMS model and the RMS type model are validated in accordance with the requirements of 5.5.3.6.1 [1].	True
3.1	The EMT model is validated on the basis of the measurement results.	True
3.2	The detailed RMS model is validated based on the survey results.	True
3.3	The RMS-type model is validated based on the validated detailed RMS model.	True
3.4	The signals required for the respective tests are available for model validation. *Note, these include:*	True

	1) All signals specified in the tests on the behaviour of the grid-forming unit. *2) The magnitude and phase of the internal voltage of the grid-forming unit, as well as the internally generated frequency.* *3) Signal inputs, insofar as they are required for the tests.* If the value of the start-up time constant has been determined metrologically on the basis of the evaluation of internal signals, the signals required for this are included in the model validation. *Note: These may include internal state variables, speed or frequency, and the internal phase angle of the voltage source of the grid-forming unit.*	
4	The models are validated for the tests required in accordance with Section 5.5.3.6.2 [1]. In doing so, the test setup used in each case is simulated. For the simulation models, compliance with the requirements of Sections 5.5.4 and 5.5.5 [1] can be demonstrated within the specified tolerances. Exceedances of model tolerances are permissible if: • The tolerances regarding T_{Amin} , T_{Amax} in accordance with Section 5.5.5.9 [1], as well as the damping of frequency power oscillations in accordance with Section 5.5.5.8 [1] are met, • it is possible to successfully demonstrate compliance with all requirements using the respective simulation models, and • The actual tolerances are stated.	True

G.3.1.6.3 Model validation – EMT and detailed RMS model

Requirement	Evidence	Applicable documents	Prerequisites
5.5.3.6.2.2 [1]	-	FNN Guideline: Grid-forming capabilities TG 4	Validated PGU models for the grid fault scenario and normal operation require measurement results in accordance with 11.2.4, 11.2.5, 11.2.7 and 11.2.10 of the applicable TCR, as well as 5.5.4 and 5.5.5 [1].
Remarks			

In general:

No.	Evaluation criteria	Acceptance criterion
Initialisation of the simulation model		
1	The system voltage, active power and reactive power determined by simulation must remain within a tolerance band of ± 0.25% relative to the respective rated value for each simulation test, within a 1 second time window prior to the start of the test.	True
2	The model is initialised to the steady-state starting point (in particular, the average value of the associated system voltage over 1 s) of the respective test, as determined in accordance with No. 1. All transient settling processes have eased before the start of the test.	True
Voltage source behaviour in accordance with the test in 5.5.4 [1]		
3	The test described in Section 5.5.4 [1] is performed in the same way for both the EMT and the detailed RMS model using simulation and is evaluated in accordance with the specifications of Section 5.5.4.4.1 [1].	True
4	The initialisation of voltage and current, or active and reactive power, of the grid-forming unit is carried out as per Section 5.5.3.6.2.2.2 [1].	True
5	The maximum deviations between the respective values determined by simulation and measurement are adhered to.	True

	In the event of model tolerances being exceeded, the specifications in point 4) of Chapter G.3.1.6.2 must be observed.	
5.1	The terminal voltage of the grid-forming unit, which stabilises after the system has fallen into the virtual island, deviates by a maximum of ± 3 % relative to its nominal value from the value determined during measurement. Deviations must also be reported in the event of exceedances. *Note: The course of the transient transition into the virtual island network is not checked.*	True
Start-up time constant, inertia power and energy in accordance with the test in Section 5.5.5.9 [1]		
6	The test described in Section 5.5.5.9 [1] is carried out in the same way for both the EMT and the detailed RMS model using simulation and is evaluated in accordance with the specifications of Section 5.5.5.9 [1]. In the respective EMT or detailed RMS simulation model, the required start-up time constant T_A is set as per the manufacturer's specifications.	True
7	The initialisation of voltage and current, or active and reactive power, of the grid-forming unit is carried out as per Section 5.5.3.6.2.2.2 [1].	True
8	If mechanical vibrations have been eliminated from the active power curve, both active power curves (without and with the elimination of the influence of mechanical vibrations) are shown. The method for eliminating mechanical vibrations is specified. *Note: In wind power units, the active power curve may be influenced by the excitation of mechanical resonances. The active power superimposed by mechanical vibrations can be extracted using Prony analysis in accordance with Supplement A.V* [1].	True
9	The power determined by simulation remains within the required tolerance bands for the periods specified in Section 5.5.5.9.3 [1] following the start of the respective segment.	True
10	The maximum deviations between the respective values determined by simulation and metrology are adhered to.	True

	In the event of model tolerances being exceeded, the specifications in point 4) of Chapter G.3.1.6.2 must be observed.	
10.1	In the event of transient processes occurring in the active power between the respective segments to be traversed as shown in Figure 4 [1], the frequency of the active power transients in the simulation model deviates by a maximum of ± 40 % from the results determined by measurement. The deviations must also be reported in the event of exceedances.	True
10.2	In the event that no steady-state conditions could be determined within the specified time periods, the transient time constant may be determined by evaluating the internal signals. In this case, the following applies: The determined transient time constant deviates by a maximum of 5% from the agreed value. Deviations must also be reported in the event of exceedances.	True
Behaviour of the PCNB in accordance with the test specified in Sections 5.5.4 and 5.5.5.10 [1]		
11	The test described in Sections 5.5.4 and 5.5.5.10 [1] is carried out in the same way for both the EMT and the detailed RMS models using simulation and is evaluated in accordance with the specifications of Section 5.5.5.9 [1].	True
12	The initialisation of voltage and current, or active and reactive power, of the grid-forming unit is carried out as per Section 5.5.3.6.2.2.2 [1].	True
13	The value of the static parameter determined by simulation corresponds to the value set in the grid-forming unit with a maximum deviation of ± 5 %.	True
14	At least the active power control speeds specified in Table 15 [3] are adhered to. Provided that Table 15 does not impose any minimum requirements on the PGS technology of the grid-forming unit, verification of the control speeds is provided by their specification.	True
15	The maximum deviations between the respective values determined by simulation and metrology are complied with.	True

	In the event of model tolerances being exceeded, the specifications in point 4) of Chapter G.3.1.6.2 must be observed.	
15.1	The simulation-determined damping ratio of the PCNB and the frequency of the transient response correspond to the measured value with a maximum deviation of ± 15 %. Deviations must also be reported in the event of exceedances.	True
15.2	If the procedure is applied as per FGW TG 4 Rev. 10, Chapter E.5.2.1.1, the frequency of the simulation model of the grid-forming unit lies within the tolerance band $\varepsilon_{\mathrm{dyn}}$ of ± 15 % relative to the steady-state frequency deviation. Deviations must also be reported in the event of exceedances. *Note: For $\varepsilon_{\mathrm{dyn}}$, see equations E-3 to E-6 and paragraph (3) of Section 2 in FGW TG 4 Rev. 10, Chapter E.5.2.1.1.*	True
Step response in accordance with the test in Section 5.5.5.3 [1]		
16	The test described in Section 5.5.5.3 [1] is carried out in the same way for the EMT model using simulation.	True
17	The maximum deviations between the respective values determined by simulation and metrology are adhered to. In the event that model tolerances are exceeded, the specifications in point 4) of Chapter G.3.1.6.2 must be observed.	True
17.1	The maximum value of the angular step power of the EMT model of the grid-forming unit, as determined by simulation, corresponds to the maximum value determined by measurement in the marketed direction with a maximum deviation of –10% or +25% relative to the measured value, and of a maximum of ±25% in the non-marketed direction. Deviations must also be reported in the event of exceedances.	True
18	The transient response with regard to damping and frequency is additionally carried out in accordance with Section 5.5.5.8 [3]. The values for damping and frequency of the active power transient response are reported.	True

Effective impedance in accordance with the test in Section 5.5.5.4 [1]		
19	The metrological test carried out in accordance with Section 5.5.5.4.2 [1] is performed in the same way for the EMT model using simulation and is evaluated in accordance with Section 5.5.5.4.3 [1].	True
20	The maximum deviations between the respective values determined by simulation and metrologically are adhered to. In the event that model tolerances are exceeded, the specifications in point 4) of Chapter G.3.1.6.2 must be observed.	True
20.1	The simulated value of the impedance of the network-forming unit corresponds to the measured value with a maximum deviation of ± 5 %. Deviations must also be reported in the event of exceedances.	True
21	The effective impedance determined on the basis of the measurement is specified for the detailed RMS simulation model.	True
Control behaviour of the voltage source control in accordance with the test specified in Section 5.5.5.6.1 [1]		
22	The test described in Section 5.5.5.6.1 [1] is carried out in the same way by simulation for both the EMT and the detailed RMS models.	True
23	The maximum deviations between the respective values determined by simulation and measurement are adhered to. In the event of model tolerances being exceeded, the specifications in point 4) of Chapter G.3.1.6.2 must be observed.	True
23.1	The simulation-determined settling time of the voltage or reactive current corresponds to the respective measurement-determined settling time with a maximum deviation of ± 5 % or 50 ms. Deviations must also be reported in the event of exceedances.	True
23.2	The steady-state currents and voltages determined by simulation correspond to the respective currents and voltages determined by measurement with a maximum deviation of ± 5 %.	True

	Deviations must also be reported in the event of exceedances.	
Disturbance behaviour and linearity of the effective impedance in accordance with the test specified in Section 5.5.5.6.2 [1]		
24	The test described in Section 5.5.5.6.2 [1] is carried out in the same way by simulation for both the EMT and the detailed RMS model using simulation and is evaluated in accordance with Section 5.5.5.6.2.3 [1].	True
25	The maximum deviations between the respective values determined by simulation and measurement are adhered to. In the event that model tolerances are exceeded, the specifications in point 4) of Chapter G.3.1.6.2 must be observed.	True
25.1	The transient time of the reactive current determined by simulation using the EMT and the detailed RMS model corresponds to the transient time determined by measurement with a maximum deviation of ± 15 %, and the curve of the reactive current lies within the envelope curve shown in Figure 10 [1] at all times. Deviations must also be reported in the event of exceedances.	True
25.2	The damping of the transient response of the reactive current, determined by simulation using the EMT and detailed RMS models, corresponds to the damping determined by measurement with a maximum deviation of ± 15 %. Deviations must also be reported in the event of exceedances.	True
25.3	The steady-state currents and voltages determined by simulation correspond to the respective currents and voltages determined by measurement with a maximum deviation of ± 5 %. Deviations must also be reported in the event of exceedances.	True
O-/UVRT robustness of the voltage source control in accordance with the test specified in Section 5.5.5.6.3 [1]		
26	The test described in Section 5.5.5.6.3 [1] is carried out in the same way for both the EMT and the detailed RMS models using simulation and is evaluated in accordance with Section 5.5.5.6.3.3 [1].	True

27	The maximum deviations between the respective values determined by simulation and measurement are adhered to. In the event that model tolerances are exceeded, the specifications in point 4) of Chapter G.3.1.6.2 must be observed.	True
27.1	The simulation-determined settling time of the instantaneous current value corresponds to the measurement-determined settling time with a maximum deviation of ± 20 %. Deviations must also be reported in the event of exceedances.	True
27.2	The simulation-determined settling time of the system-coupled reactive current corresponds to the metrologically determined settling time with a maximum deviation of ± 20 %. Deviations must also be reported in the event of exceedances.	True
27.3	The damping of the transient response of the system-coupled reactive current, as determined by simulation, corresponds to the value determined by measurement with a maximum deviation of ± 20%. Deviations must also be reported in the event of exceedances.	True
Verification of behaviour upon reaching and leaving the current limits in accordance with the tests specified in 5.5.5.6.4 [1]		
28	The test described in section 5.5.5.6.4 [1] is carried out in the same way for both the EMT model using simulation and the detailed RMS model.	True
29	The simulation results using the EMT and the detailed RMS models show that the stability of the power-generating unit is ensured during voltage dips ≥ 0.2 p.u.	True
30	The simulation results using the EMT and the detailed RMS models show that the apparent current of the grid-forming unit, averaged over the duration of the voltage dip, is 95% of the rated current, or, in the event that the current limit of the grid-forming unit is not reached, does not fall below the expected apparent current of the unit resulting from the operating point prior to the measurement and the average of the effective impedances determined in Section 5.5.5.4 [1].	True

31	The active current determined by simulation for the tested voltage dip (of approx. 50% and 20%), based on an operating point at full load, is not less than 5% of the rated current.	True
Behaviour upon return to the voltage band of U_c± 10 % U_c in accordance with the tests specified in Section 5.5.5.6.5 [1]		
32	The test described in Section 5.5.5.6.5 [1] is carried out in the same way for both the EMT and the detailed RMS models using simulation.	True
33	The maximum deviations between the respective values determined by simulation and measurement are adhered to. In the event that model tolerances are exceeded, the specifications in point 4) of Chapter G.3.1.6.2 must be observed.	True
33.1	With regard to the behaviour for active current recovery, the following applies: the active current determined by simulation returns to the value of the pre-fault active current after 1 s, and the value determined by simulation does not deviate by more than 20% from the value determined by measurement; otherwise, if this target cannot be achieved within this time due to the effective T_A the time required to achieve the target shall be reported. Deviations must also be reported in the event of overshoots.	True
33.2	The value of the over-voltages determined by simulation deviates by no more than 20 % from the value determined by measurement. Deviations must also be reported in the event of exceedances.	True
34	With regard to behaviour during transient overvoltages following voltage restoration, the following applies: the system-wide overvoltages (overshoot) determined by simulation shall not exceed the steady-state final voltage value by more than 5%; notwithstanding this, a value of 2.5% of the steady-state final voltage value shall apply from 31 December 2027.	True
Fast protection at high voltages in accordance with the tests specified in Section 5.5.5.6.7 [1]		
35	The functionality of fast protection against high voltages (voltage amplitude jump to a value greater than 1.35 p.u.) is demonstrated by simulation results using	True

	the EMT and detailed RMS models in accordance with the requirements of Section 5.5.5.6.7 [1].	
35.1	The high-voltage fast protection functionality implemented in the RMS and EMT models of the grid-forming unit permanently transitions the grid-forming unit within 40 ms to a state in which the half-cycle rms value of the current determined by simulation in each conductor is limited to a maximum of 5% of the rated current.	True
35.2	The requirements for OVRT robustness are met despite the implemented high-voltage fast protection functionality.	True
Behaviour under steep frequency gradients in accordance with the test specified in Section 5.5.5.7 [1]		
36	The simulation results show that the RoCoF values required in accordance with Section 10.2.4.3 of the applicable Technical Connection Regulation can be passed by the grid-forming unit without the unit being disconnected from the grid or losing stability; or, if the manufacturer has specified other framework conditions for meeting the requirements, that the stated criteria are met under these framework conditions.	True
37	The simulation results show that the frequency responses of the grid-forming unit shown in Figure 4 [1] can be maintained without the unit being disconnected from the grid or losing stability.	True
Damping of frequency-power oscillations in accordance with the test specified in Section 5.5.5.8 [1]		
38	The test described in Section 5.5.5.8 [1] is carried out in the same way for both the EMT and the detailed RMS models using simulation. In this context, the short-circuit ratio at the terminals of the grid-forming unit in the simulation environment must be set to the value determined in the test environment, or the test environment used must be included in the model validation.	True
39	The maximum deviations between the respective values determined by simulation and metrology are adhered to. In the event that model tolerances are exceeded, the specifications in point 4) of Chapter G.3.1.6.2 must be observed.	True

39.1	The damping coefficient determined by simulation does not fall below the value of 0.5 by more than 10% in the frequency range from 0.05 Hz to 10 Hz ($D \geq 0.45$) and corresponds to the damping coefficient determined by measurement with a maximum deviation of ± 5%. Deviations must also be reported in the event of exceedances.	True
39.2	The frequency of the transient response (in the frequency range of the frequency power oscillations) of the active power determined by simulation corresponds to the frequency determined by measurement with a maximum deviation of ± 5%. Deviations must also be reported in the event of exceedances.	True
39.3	If the procedure is applied as per FGW TG 4 Rev. 10, Chapter E.5.2.1.1 (Point 2, Paragraph 3), the tolerances specified therein must be demonstrated. Deviations must also be reported in the event of exceedances. *Note: This is the case if the transient response of the power determined by measurement is strongly damped and a damping ratio cannot be determined. In this case, the transient behaviour of the simulation model's power, starting from the steady-state initial condition until the steady-state final condition is reached, is compared with the active power measured on the test specimen using the specified procedure.*	True
40	In the case of wind turbines, the following applies: The method to be used for filtering the active power curve to remove system-specific oscillations must be agreed between the manufacturer and the certification body and documented.	True

G.3.1.6.4 Model validation – RMS-type model

Requirement	Evidence	Applicable documents	Prerequisites
5.5.3.6.2.3 [1]	-	FNN Guideline: Grid-forming capabilities TG 4	Validation of the RMS type model requires a validated detailed RMS model in accordance with 5.5.3.6.2.2 [1]
Remarks			

In general:

No.	Evaluation criteria	Acceptance criterion
1	The model validation of the RMS-type model is carried out on the basis of a comparison with the detailed RMS model. In this process, the reported model tolerances for the EMT or detailed RMS model, in relation to the behaviour of the test specimen, are systematically applied to the comparative behaviour between the detailed RMS model and the RMS type model.	True
2	The maximum deviations between the respective values determined by simulation and measurement are adhered to. In the event of model tolerances being exceeded, the specifications in point 4) of Chapter G.3.1.6.2 must be observed.	True
2.1	The steady-state terminal voltages of the grid-forming unit determined for the RMS-type model deviate from the values determined for the detailed simulation model by no more than ±1% relative to the nominal voltage. The deviations must also be reported in the event of exceedances.	True
2.2	The maximum value of the angular step power determined for the RMS-type model deviates from that of the detailed RMS model by no more than ± 5 % relative to the nominal value. Deviations must also be reported in the event of exceedances.	True
2.3	The values determined for the RMS-type model for the damping of the frequency-power oscillations deviate from those of the detailed RMS- model by no	True

	more than ± 5 %. This also applies to the period of the frequency-power oscillations. Deviations must also be reported in the event of exceedances.	
2.4	The RMS-type model is compared with the behaviour of the detailed RMS model in terms of FRT behaviour.	True
2.4.1	The waveforms of the active and reactive currents occurring 100 ms after the fault occurs until the fault is cleared, and 100 ms after the fault is cleared until the steady-state condition is reached, lie within a tolerance band of ± 15 % around the corresponding values of the detailed RMS simulation model. The tolerance specification of 15 % is based on the determined value of the detailed RMS model. The minimum tolerance value is 2 % of the rated value. Deviations must also be reported in the event of exceedances.	
3	The RMS-type model complies with all requirements of the FNN Guideline [1].	True

G.3.1.6.5 Plausibility checking of simulation models

Requirement	Evidence	Applicable documents	Prerequisites
5.5.3.6.3 [1]	-	FNN Guideline: Grid-forming capabilities TG 4	Plausibility checking requires validation of the EMT, detailed RMS and RMS-type models 5.5.3.6.2 [1]
Remarks			

In general:

No.	Evaluation criteria	Acceptance criterion
1	The models provided are validated in accordance with FGW TG 4 Rev. 10, Chapter 9 and Supplement 10.1.	True

G.3.1.6.6 Model documentation

Requirement	Evidence	Applicable documents	Prerequisites
5.5.3.6.4 [1]	-	FNN Guideline: Grid-forming capabilities TG 4	Plausibility checking requires validation of the EMT, detailed RMS and RMS-type models 5.5.3.6.2 [1]
Remarks			

In general:

No.	Evaluation criteria	Acceptance criterion
1	The simulation model is documented in terms of its functionality and parameterisation. Information is provided on how the respective parameter is named and can be set in the actual device (e.g. conversion factors etc. must be taken into account).	True
1.1	The simulation model is documented in accordance with FGW TG 4 Rev. 10, Chapter 7.2. The operation of the grid-forming unit is described on the basis of the RMS-type model. Based on the EMT or RMS models, the grid-forming unit is presented in detail as a whole. This includes the power electronic components, the electrical components attributable to the grid-forming unit (e.g. filters), the control system, the internal demand (if relevant), the decoupling protection and the self-protection, insofar as it forms part of the simulation model.	True
1.2	The key simplifications and assumptions for the various simulation models are specified.	True
1.3	Based on a complete project definition, the tests carried out on the operational system, alongside the corresponding simulations using the validated model types (EMT, detailed RMS model and RMS type model), are to provide selected measured values or signals from the grid-forming unit, such as voltages and currents, as well as the intermediate variables identified as necessary, in standardised graphical representations in a comparative format.	True

1.4	All parameters for defining types of grid-forming units within a family, as well as their parameterisations and operating ranges (e.g. rated values, *PQ* and *UQ* diagrams), are described in tabular form. Intended or permissible parameter setting ranges, as well as any dependencies, are specified.	True
1.5	The simulation-based verifications required in accordance with Section 5.5.7 [1] for unmeasured values of the start-up time constant T_A are included in the model documentation, including any additional parameterisations that may become necessary.	True
1.6	The simulation-based verifications required in accordance with Section 5.5.7 [1] for unmeasured values of the parameterisable gain of the voltage source control – with the exception of the nominal value – or the effective impedance are included in the model documentation, including any additional parameterisations that may become necessary.	True
2	It is demonstrated that the requirements as per Section 4.2 have been verified by simulation within the test environment in accordance with the tests specified in Section 5.5.3.6.2 [1].	True

G.3.1.6.7 Simulation environment and tool independence

Requirement	Evidence	Applicable documents	Prerequisites
5.5.3.7 [1]	-	FNN Guideline: Grid-forming capabilities TG 4	Validated EMT, detailed RMS and RMS-type models in accordance with 5.5.3.6.2 [1] are available
Remarks			

In general:

No.	Assessment criteria	Acceptance criterion
1	The requirements for modelling software and the tool environment as set out in FGW TG 4 Rev. 10, Chapter 4, are observed. *Note: Should users (manufacturers, certification bodies and network operators) develop enhancements that simplify the process but have not yet been incorporated into new revisions of FGW TG 4, these must be taken into account.* *Such developments include:*	True

	• *Availability of controller code in the form of a universally usable DLL with input and output signals (C interface) for use in EMT and/or detailed RMS models in the agreed simulation environments or for flexible integration with other simulation tools in use.* • *Use of new de facto standards for the integration of controller code (e.g. FMI for CS, FMI for ME, IEEE/Cigre/IEC, etc.).* Deviations from the specifications of FGW TG 4 Rev. 10 are only permitted provided that requirements for modelling and its validation are not affected. However, they generally require an agreement between the certification body, the network operator and the manufacturer.	
2	The simulation models must be made available for the agreed simulation environment for the software versions supported by the simulation software manufacturer. See also No.3.8 in Chapter G.3.1.6.1 . *Note: The agreed simulation environment comprises commercially available programmes that are predominantly used by network operators and certification bodies.*	True

G.3.1.6.8 Manufacturer models for certification purposes

Requirement	Evidence	Applicable documents	Prerequisites
5.5.3.8 [1]	-	FNN Guideline: Grid-forming capabilities TG 4	Validated EMT, detailed RMS and RMS-type models in accordance with 5.5.3.6.2 [1] are available
Remarks			

In general:

No.	Evaluation criteria	Acceptance criterion
1	The level of detail of the manufacturer's model for the purpose of certification shall be selected such that the requirements for model accuracy are met for all simulation-based verifications based on a model that is uniform across the entire range of operating conditions and parameterised for a specified T_A.	True

	Where necessary, the parameter sets to be applied for different T_A values shall be documented. The signals listed in Section 5.5.2.1 [1] and the intended parameterisations shall be accessible, provided they are required for the relevant verifications.	

G.3.1.7 Simulation-based verifications

G.3.1.7.1 Simulation-based verification of active power response to a phase angle step

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.1	5.5.7.1	FNN Guideline: Grid-forming capabilities	Successful model validation
Remarks	A simulation test of the angle-step response must be carried out if the manufacturer has provided for the voltage source control gain or the effective impedance of the power-generating unit to be configurable. In this case, in addition to the measurement-based verification in accordance with Section 5.5.5.3 [1] (evaluation in accordance with Chapter G.3.1.2.1) – in which the nominal value of the voltage source control gain is specified – a simulation test in accordance with this chapter shall be evaluated for the minimum and maximum values.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	The simulated test environment replicates the real-world conditions of the metrological test.	True
2	The tests are carried out for the minimum and maximum values of the voltage source control gain and the effective impedance, respectively, in accordance with the manufacturer's specifications.	True
3	The measurement procedure tested in the metrological test (measurement procedure 1 or measurement procedure 2) is carried out by simulation in accordance with section 5.5.5.3.2 [1].	True
3.1	In the case of measurement procedure 1, the following applies: Two tests shall be carried out in accordance with the specifications in Section 5.5.5.3.2 [1]. The second test shall take place starting from the initial operating point	

	of the first test ± 5 % P_{Emax} with an identical angle step but with a negative sign.	
3.2	In the case of measurement procedure 2, the following applies: Two tests shall be carried out in accordance with the specifications in Section 5.5.5.3.2. The second test shall be carried out starting from the initial operating point of the first test ± 5 % P_{Emax} with an identical angle step $\Delta\theta_{\mathrm{setpoint}}$ ± 10 % with a negative sign.	
4	The maximum active current change $\Delta_{\mathrm{iP,PGU}}$ in the marketed direction is at least 50% (70% for PGSU and storage systems) and in the non-marketed direction at least 5% of the determined maximum value ΔiP,PGU,max. A tolerance of 1% of the nominal active current may be taken into account here.	True
5	The maximum active power change is at least 5 % P_{Emax} in the non-traded direction.	True
6	The angular step power is not limited by the active power limit.	True

G.3.1.7.2 Simulation-based verification of effective impedance

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.1	5.5.7.2	FNN Guideline: Grid-forming capabilities	Successful model validation
Remarks	A simulation test of the effective impedance must be carried out if the manufacturer has provided for the voltage source control gain or the effective impedance of the power-generating unit to be configurable. In this case, in addition to the measurement-based verification in accordance with Section 5.5.5.4 [1] (evaluation in accordance with Chapter G.3.1.2.2) – in which the nominal value of the voltage source control gain is specified – a simulation test in accordance with this chapter must be carried out for the minimum and maximum values.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	The simulated test environment replicates the real-world conditions of the metrological test.	True
2	The tests are carried out for the minimum and maximum values of the voltage source control gain and the effective impedance, respectively, in accordance with the manufacturer's specifications.	True

3	The measurement procedure tested in the metrological test (measurement procedure 1 or measurement procedure 2) is carried out by simulation in accordance with section 5.5.5.4.2 [1].	True
3.1	In the case of measurement procedure 1, the following applies: The magnitude of the applied setpoint step shall be between ± 0.03 p.u. and 0.05 p.u.. The following sequence is tested: • 0.03 p.u. ≤ $\Delta u_{\text{setpoint}}$ ≤ 0.05 p.u. • $\Delta u_{\text{setpoint}} = 0$ • -0.05 p.u. ≤ $\Delta u_{\text{setpoint}}$ ≤ -0.03 p.u. A steady-state condition is awaited between each of these states.	True
3.2	In the case of measurement procedure 2, the following applies: The values of the terminal voltage steps Δu_{I} and Δu_{II} differ from each other and from the initial value by at least 2 %.	
4	The tests for the selected measurement procedure shall be repeated based on an active power output in the range of 15 % to 45 % *of* P_{Emax} and a reactive power injection in the range of ± 10 % (relative to P_{Emax}). In the case of measurement method 1, the following applies: The voltage setpoint step shall be in the negative direction when the test is repeated.	True
5	It is shown that no current limiting has been triggered.	True
6	The values of the calculated impedance $\lvert z_{\text{w,1,S}} \rvert$ comply with the requirements for the maximum value $z_{\text{w,max}}$ as specified in Section 4.2.1.1 according to the following criteria: • without a unit transformer (or on the low-voltage side of the unit): $\lvert z_{\text{w,1,S}} \rvert$ ≤ 0.27 p.u. • including the unit transformer (or on the medium-voltage side of the unit): $\lvert z_{\text{w,1,S}} \rvert$ ≤ 0.35 p.u. for double-fed induction generators, alternatively: the upper limit of the impedance is determined by the physical transient reactance of the induction generator plus the stator resistance of the induction generator and the impedance of the unit transformer.	True

G.3.1.7.3 Simulation-based verification of the damping of frequency-power oscillations

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.12	5.5.6.1	FNN Guideline: Grid-forming capabilities	Successful model validation
Remarks	Simulation-based assessment of the damping of frequency-power oscillations is required if one of the following conditions applies: a) For the grid-forming unit under test, the manufacturer has specified more than two parameterisations of the start-up time constants, i.e. exceeding $T_{A,min}$ and $T_{A,max}$, for which no metrological tests have been carried out. For each additional parameterisation, verification must be carried out and evaluated accordingly. b) For the grid-forming unit under test, the metrological test in accordance with Section 5.5.5.8.2 was failed due to low short-circuit power ratios, and the acceptance criterion for assessment in accordance with Chapter G.3.1.2.6 is therefore not met. c) The SCR value is unknown for the test facility used to test the grid-forming unit. In cases b) and c), the simulation test may only be evaluated if the test environment was included in the model validation in accordance with Chapter G.3.1.6.3 and this was successfully completed.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	The simulated test environment replicates the real-world conditions of the metrological test.	True
2	The simulation tests are carried out at an SCR = 3 using the detailed RMS model.	SCR = 3
3	The simulation tests are carried out based on an active power output of 50% to 75% P_{Emax}. The power factor cos φ must be set to 1.0 for each test.	True
4	The measurement procedure tested in the metrological test (measurement procedure 1 or measurement procedure 2) is carried out by simulation in accordance with Section 5.5.5.8.2. All tests in Table 8 are carried out as simulations.	True
4.1	In the case of the simulation of measurement procedure 1, the following applies: Excitation is provided by a step-like frequency change of approximately 250 mHz to 500 mHz. The excitation does not result in the current of the power-generating unit being limited. The simulated	True

	current waveforms have been analysed in this regard, and a comparison is made between the current profile and the respective limit values. In this case, the current determined by the simulation remains below this limit (no limitation has been applied). *Note: Typical signs of a limit:* • *The current rises sharply and then remains constant at a limit value.* • *The current exhibits clipping behaviour (flattening of the rise despite the frequency continuing to fall).* The frequency step is implemented in the simulation environment in the network equivalent.	
4.2	In the case of the simulation of measurement procedure 2, the following applies: The magnitude of the phase jump leads to a change in active power of 15% to 30% P_{Emax} in the supplied direction and 2% to 4% P_{Emax} in the unsupplied direction of inertia. The simulated current series were analysed in this regard and a comparison of the current curve with the respective limit values was carried out. In this case, the current determined by simulation remains below this limit (no limit has been triggered).	True
Simulation test for $T_{A,min}$ < T_A < $T_{A,max}$		
5	The simulation model was validated with regard to $T_{A,min}$ and $T_{A,max}$ on the basis of the metrological test, and this was assessed as having passed in accordance with G.3.1.2.6.	True
6	The determined damping ratio falls short of the value of 0.5 specified in Section 4.2.1.12 [1] by no more than 10% for all values of T_A parameterised in the unit.	$D(T_A) \geq 0.45$
7	If the damping was determined on the basis of the evaluation of the amplitude ratios, the following evaluation criteria apply to the respective parameterised value of T_A in addition to No. 6: If a total of three peaks and troughs are discernible in the course of the co-system active power, the following applies: The two determined amplitude ratios of the consecutive peaks and troughs (AV_{21} and AV_{32}) are less than 0.2.	$AV_{21} < 0.2$, $AV_{32} < 0.2$ or

	If fewer than three peaks and troughs are discernible in the course of the co-system active power, the test is also deemed to have been passed.	Fewer than 3 peaks/troughs
See G.3.1.2.6 alternative simulation test for $T_A = T_{A,min}$ and $T_A = T_{A,max}$		
8	The simulated test may also be carried out if the measurement-based verification in accordance with 5.5.5.8.2 [1] has not been passed due to low short-circuit power ratios, or if the SCR value of the test setup or the impedance is unknown.	True
9	The test environment of the metrological test in accordance with Section 5.5.5.8 [1] was included in the model validation in accordance with Chapter G.3.1.6.3 .	True
10	For all T_A values parameterised in the unit, the determined damping ratio does not fall below the value of 0.5 specified in Section 4.2.1.12 [1] by more than 10%.	$D(T_A) \geq 0.45$
11	If the damping was determined on the basis of the evaluation of the amplitude ratios, the following evaluation criteria apply to the respective parameterised value of T_A in addition to No. 10: If a total of three peaks and troughs are discernible in the course of the co-system active power, the following applies: The two determined amplitude ratios of the successive peaks and troughs (AV_{21} and AV_{32}) are less than 0.2. If fewer than three peaks and troughs are discernible in the course of the co-system active power, the test is also deemed to have been passed.	$AV_{21} < 0.2$ and $AV_{32} < 0.2$ or Fewer than 3 peaks/troughs

G.3.1.7.4 Simulation-based verification of the start-up time constant as well as inertia power and energy

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.13 4.2.1.14	5.5.7.4	FNN Guideline: Grid-forming capabilities	Successful model validation Manufacturer's declaration
Remarks	The simulation-based assessment of the start-up time constants, as well as inertia power and energy, is only required if the manufacturer has specified more than two parameterisations of the start-up time constants for the grid-forming unit being tested – i.e. parameterisations exceeding $T_{A,min}$ and $T_{A,max}$ – for which no metrological tests have been carried out. For each additional parameterisation, verification must be carried out and evaluated accordingly.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	The simulation model was validated with regard to $T_{A,min}$ and $T_{A,max}$ on the basis of metrological tests, and these were assessed as having passed in accordance with G.3.1.2.7.	True
2	The simulation test environment replicates the real-world test conditions of the metrological test.	True
3	The simulation test is carried out using the detailed RMS model	True
4	Measurement procedures 1 and 2 in accordance with section 5.5.5.9.2 [1] are carried out in a simulated manner.	True
5.1	The following applies to the simulation of measurement procedure 1: The simulations are carried out in accordance with the specifications in Table 9 [1]. The simulations are carried out based on a reactive power of 0 ± 5 % relative to P_{Emax}. For grid-forming power generating units, simulations 1.1 and 1.2 were carried out with a constant primary energy supply. The frequency response shall be specified via the grid equivalent in the simulation environment.	True Information is available

	The values $P_{limneg,min}$, $P_{limneg,max}$ and $P_{min,dyn}$ are determined by the manufacturer and stated in the manufacturer's declaration.	
5.2	The following applies to the simulation of measurement procedure 2: The simulations are carried out in accordance with the specifications in Table 10 [1]. The simulations are carried out based on a reactive power of 0 ± 5 % relative to P_{Emax}. For grid-forming power generating units, measurements 2.1 and 2.2 [1] are simulated with a constant primary energy supply. The values $P_{limitpos,min}$, $P_{limitpos,max}$ and $P_{max,dyn}$ are determined by the manufacturer and stated in the manufacturer's declaration	True Information is available
Marketing of negative or symmetrical inertia		
6	The grid-forming unit remains synchronised with the grid during the simulation test.	True
7	The power determined by simulation remains within the required tolerance bands within the times specified in Section 5.5.5.9.3.2 [1] following the start of the respective segment.	True
8	The power determined by simulation for T_A > 10 s in segment (1) (where applicable, at an adjusted active power operating point) [1] reaches 95% of the expected inertia power.	If T_A > 10 s: True
9	Provided that the start-up time constant has been determined in accordance with Section 5.5.5.9.3.3 [1] (based on the evaluation of internal signals), the following applies: The determined value of T_A deviates by no more than 5% from the agreed value.	If T_A was determined on the basis of internal signals: True
10	The evaluation of point 3) of measurement procedure 1 [1] shows that $\Delta E_{pos} \leq 1.5\,\Delta E_{neg}$.	$\Delta E_{pos} \leq 1.5\,\Delta E_{neg}$
Marketing of positive inertia		
11	The grid-forming unit remains synchronised with the grid during the test.	True
12	The evaluation of the measurement yields:	True

	$(\lvert\Delta E_{pos,12}\rvert + \lvert\Delta E_{neg,3}\rvert + \lvert\Delta E_{pos,4}\rvert + \lvert\Delta E_{neg,4}\rvert) \leq 1.5 \cdot (\lvert\Delta E_{neg,12}\rvert + \lvert\Delta E_{pos,3}\rvert)$.	
Marketing of positive or symmetrical inertia		
13	The grid-forming unit remains synchronised with the grid during the test.	True
14	The power determined by simulation remains within the required tolerance bands within the times specified in Section 5.5.5.9.3.2 [1] following the start of the respective segment.	True
15	The power determined by simulation for T_A > 10 s in segment (1) (where applicable, at an adjusted active power operating point)[1] reaches 95% of the expected inertia power.	If T_A > 10 s: True
16	Provided that the start-up time constant has been determined in accordance with Section 5.5.5.9.3.3 [1] (based on the evaluation of internal signals), the following applies: The determined value of T_A deviates by no more than 5% from the agreed value.	If T_A was determined on the basis of internal signals: True
17	The evaluation of point 3) of measurement procedure 2 [1] shows that $\Delta E_{neg} \leq 1.5\,\Delta E_{pos}$.	$\Delta E_{pos} \leq 1.5\,\Delta E_{neg}$
Marketing of negative inertia		
18	The grid-forming unit remains synchronised with the grid during the test.	True
19	The evaluation of the simulation yields: $(\lvert\Delta E_{neg,12}\rvert + \lvert\Delta E_{pos,3}\rvert + \lvert\Delta E_{neg,4}\rvert + \lvert\Delta E_{pos,4}\rvert) \leq 1.5 \cdot (\lvert\Delta E_{pos,12}\rvert + \lvert\Delta E_{neg,3}\rvert)$.	True

G.3.1.7.5 Simulation-based verification of the control behaviour of the voltage source control

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.5	5.5.7.5	FNN Guideline: Grid-forming capabilities	Successful model validation
Remarks	The simulation test must always be evaluated for the nominal value of the voltage source control gain or the effective impedance specified by the manufacturer. The simulation test must also be evaluated if the manufacturer has designed the voltage source control gain or the effective impedance of the grid-forming unit to be configurable. In this case, in addition to the measurement-based verification in accordance with Section 5.5.5.6.1 [1] (evaluation in accordance with Chapter G.3.1.2.4.1) – in which the nominal value of the voltage source control gain is		

	specified – the parameterisable values must be evaluated in accordance with this section.

In general:

No.	Evaluation criteria	Acceptance criterion
1	The simulation model was validated on the basis of metrological tests, which were assessed as having passed in accordance with G.3.1.2.4.1 .	True
2	The simulation test environment replicates the real-world conditions of the metrological test.	True
3	The simulation test is carried out using the detailed RMS model at network impedances of Z_{Netz} = 0.05 p.u. and 0.3 p.u. relative to S_{Emax}. *Note: The specified network impedance corresponds to an SCR value of 20 or 3 at the power-generating unit.*	True
4	The setpoint change of the voltage regulator is selected such that it results in a reactive power change of at least 50% of the reactive power control range of the grid-forming unit. *Note: A reactive power change of more than 30% relative to P_{Emax} is not required in this case.*	True
5	The determined settling time of the simulated voltage $u_{1,\mathrm{S}}$ (or, alternatively, of the simulated current $i_{\mathrm{Q},1,\mathrm{S}}$) is < 1 s.	True

G.3.1.7.6 Simulation-based verification of the disturbance behaviour of the voltage source control

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.4	5.5.7.6	FNN Guideline Grid-forming capabilities	Successful model validation
Remarks	The simulation test must always be evaluated for the nominal value of the voltage source control gain or the effective impedance specified by the manufacturer. The simulation test must also be evaluated if the manufacturer has designed the voltage source control gain or the effective impedance of the grid-forming unit to be configurable. In this case, in addition to the measurement-based verification in accordance with Section 5.5.5.6.2 [1] (evaluation in accordance with Chapter G.3.1.2.4.2) – in which the nominal value of the voltage source control gain is specified – the parameterisable values must be evaluated in accordance with this section.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	The simulation model was validated on the basis of metrological tests, which were assessed as having been passed in accordance with G.3.1.2.4.2 .	True
2	The simulation test environment replicates the real-world conditions of the metrological test.	True
3	The simulation test is carried out using the detailed RMS model at network impedances of Z_{Netz} = 0.05 p.u. and 0.3 p.u. relative to S_{Emax} . *Note: The specified network impedance corresponds to an SCR value of 20 or 3 at the power-generating unit.*	True
4	If the grid-forming unit being tested is not connected via a transformer assigned to the grid-forming unit (or its own dedicated transformer windings), the following applies: In a second test step, the simulation test environment is extended so that a second grid-forming unit of the same type is operated in parallel with the first unit. The connection to the test setup shown in Figure 9 is made in accordance with a standard configuration as specified by the manufacturer.	True
5	First test step without additional parallel grid-forming units: The setpoint change is selected such that it results in a reactive power change of at least 50% of the reactive power control range of the power-generating unit. *Note: A reactive power change of more than 30% relative to P_{Emax} is not required.*	True
6	If a second test step with a parallel grid-forming unit of the same type is necessary: The test is repeated with a parallel grid-forming unit of the same type.	True
Rise time of the apparent current		
7	The 5 ms moving average of the instantaneous value $i_{\alpha\beta,5\text{ms},S}$ of the simulated current reaches 90% of the final value for the first time no later than 15 ms after the step change in voltage.	True
Settling time of the reactive current		

8	The simulated reactive current $i_{Q,1,S}$ remains within the tolerance band for reactive current no later than 80 ms after the step change in voltage.	True
Damping of the reactive current		
9	The curve of the reactive current component determined by simulation lies within the envelope curve shown in Figure 10 as a result of the step change in voltage (in accordance with the specifications of measurement method 2 in Section 5.5.5.4.3)[1].	True
Linearity of the effective impedance		
10	The simulated linearity of the effective impedance is 0,85 ≤ $L_{Z,S}$ ≤ 1,15 ≤ 1.15 (see Section 5.5.5.6.2.3 [1]).	0.85 ≤ $L_{Z,S}$ ≤ 1.15

G.3.1.7.7 Simulation-based verification of behaviour upon return to the voltage band of U_r ± 10 % U_r

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.5.5	5.5.7.7	FNN Guideline: Grid-forming capabilities	Successful model validation
Remarks	The simulation test must be evaluated provided that the manufacturer has designed the voltage source control gain or the effective impedance of the network-forming unit to be configurable. In this case, in addition to the measurement-based verification in accordance with Section 5.5.5.6.5 [1] (evaluation in accordance with Chapter G.3.1.2.4.5) – in which the nominal value of the voltage source control gain is specified – an evaluation must be carried out for the configurable values in accordance with this section.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	The simulated test environment replicates the real-world conditions of the metrological test.	True
2	The tests are carried out for the minimum and maximum values of the voltage source control gain and the effective impedance, respectively, in accordance with the manufacturer's specifications.	True
3	The measurement procedure tested in the metrological test (measurement procedure 1 or measurement	

	procedure 2) in accordance with Section 5.5.5.6.5.2 [1] is carried out by simulation.	
Behaviour regarding active current recovery after fault clearance		
4	The pre-fault active current is restored after 1 s (after the fault ends).	True
4.1	If the active current cannot reach this time due to technical restrictions, this must be justified.	Information provided
Behaviour regarding transient overvoltages after voltage recovery		
5	After voltage restoration, the determined system-wide over-voltages $u_{1,S}$ do not exceed 2.5% relative to the steady-state final value $u_{1,End,S}$ of the voltage. For units commissioned by 31 December 2027, a value of 5.0 % applies instead of 2.5 %.	True

G.3.1.7.8 Simulation-based verification of the decay of the DC component

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.1 [1]	5.5.7.9 [1]	FNN Guideline: Grid-forming capabilities	Successful model validation
Remarks	The simulation test must be assessed for units commissioned after 1 January 2028.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	The test is carried out on the basis of the EMT simulation model of the grid-forming unit, which has been validated in accordance with Chapter G.3.1.6.3.	True
2	The test environment consists of the grid-forming unit, which is connected directly to a hypothetical NCP at the voltage level intended for the grid-forming unit. The unit transformer is taken into account, but transformer saturation is not.	True
3	The test is carried out in accordance with Section 5.5.7.9.3 [1].	True
3.1	The nominal operating condition is selected as the initial operating state at P_{rE}, $\underline{Q}$ = 0 and nominal voltage.	True

3.2	A three-phase short circuit at the NCP is simulated with a short-circuit impedance of 0 Ω, whereby the short circuit occurs at a zero-crossing of phase a.	True
3.3	The simulation duration after the fault ends is 150 ms. *Note: An explanation of the fault is not required.*	True
4	The verification is deemed to have been performed if it can be established for all mean values of phases a, b and c at the 100 ms time point that their magnitude does not exceed 10% of the rated current.	True

G.3.1.7.9 Simulation-based verification of the damping behaviour in the sub- and super-synchronous frequency range

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.2 [1]	5.5.7.8 [1]	FNN Guideline: Grid-forming capabilities	Test report
Remarks			

In general:

No.	Evaluation criteria	Acceptance criterion
1	The EMT model validated in accordance with Section 5.5.3.6.2.2 [1] is used for the simulation test.	True
2	The test conditions in accordance with Section 5.5.7.8.2 [1] are met.	True
3	The amplitude and phase of the transfer function $G_{PGU}(s)$ of the EMT model of the grid-forming unit are shown in the frequency range from 3 Hz to 50 Hz.	True
4	The respective phase margin at the ±90° edges is shown in the test report.	True
5	The key parameters are plotted on x-t diagrams.	True
6	The Bode plots show the resonance points and phase margin for the frequency range from 3 Hz to 50 Hz.	True
7	Where mechanical resonances have been taken into account for wind turbines, these are shown in the Bode plot with the corresponding tolerance band.	True

G.3.1.7.10 Grid-parallel operation capability

Requirement	Evidence	Applicable documents	Prerequisites
4.2.1.10 [1]	5.5.6.5 [1]	FNN Guideline: Grid-forming capabilities	Test report
Remarks			

In general:

No.	Evaluation criteria	Acceptance criterion
1	The results of the simulation test are documented and reported in a comprehensible manner.	True
2	If behaviour deviating from the requirements is detected in the form of instabilities or unsystematic behaviour, this is reported.	If applicable: True

G.3.2 SYSTEM CERTIFICATE

G.3.2.1 Phase swinging or grid oscillations

Requirement	Evidence	Relevant documents	Requirements
10.2.1.3 (TCR)	11.4.8.2 (TCR)	VDE-AR-N 4110 VDE-AR-N 4120 VDE-AR-N 4130	Equipment certificate(s)
Remarks	-		

The following applies to Type 2 PGS:

No.	Evaluation criteria	Acceptance criterion
1	Successful testing of the attenuation of frequency-power oscillations in accordance with Chapter G.3.1.2.6 in the unit certificate.	True

G.3.2.2 Procedure for reactive power provision

G.3.2.2.1 VDE-AR-N 4110 (TCR MV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.2.4 (TCR)	11.4.11 (TCR)	Supplement E.9 [2]	Equipment certificate(s), submitted control concept
4.2.1.4 [1]	5.6.2.6 [1]	Supplement E.9 [2]	Equipment certificate(s), submitted control concept

Remarks	
	Concept review in the system certificate; functional test in the declaration of conformity Setpoints need only be implemented within the ranges specified in Figure 5 and Figure 6 (requirements for reactive power capacity in the rated load and partial load ranges). To demonstrate the control behaviour of the entire system with regard to static voltage maintenance, a choice may be made between the following procedures. The certification body shall assess which procedures are feasible and determine this in consultation with the connection customer. Procedure A) Measurement-based verification of the behaviour of the entire system within the scope of the declaration of conformity (see chapter G.1.6 or G.1.7). Procedure B) Simulated verification taking into account the unit models and the PGS controller model. Procedure C) Verification of the control behaviour of the grid-forming unit with the associated PGS controller as part of component certification (see Chapter G.3.3.1.1). Procedure D) Assessment of control behaviour based on the component and unit certificates and corresponding manufacturer documentation. The assessment criteria set out in this chapter apply to the grid-forming units of a Type 2 PGS or to Type 2 PGSs consisting solely of grid-forming units. For Type 2 PGS with grid-forming and grid-following installations, the evaluation criteria must be taken into account on a type-specific basis (for grid-forming units in accordance with this chapter; for grid-following units in accordance with the relevant chapter of TG 8 Rev. 10 (Procedure for reactive power control)). *Note: The specifications of the grid operator questionnaire apply. Any deviations must be agreed with the grid operator.*

In general:

No.	Evaluation criteria	Acceptance criterion
1	The control methods specified by the network operator in accordance with Supplement E.9 can be implemented by the PGS	True
1.1	If the network operator does not specify any requirements, it is possible to implement a constant displacement factor $\cos \varphi = 1$ at the NCP.	True
2	The concept for reactive power provision, including the necessary communication links with a description of all interfaces and the associated transit times, is shown schematically.	True
2.1	It must be demonstrated that the requirements for reactive power provision by the power generating system are not adversely affected by any conflicting control of the consumption part of the customer's installation. *Note: If a reactive current compensation system is present for the consumption part of the customer's installation, the measurement of the values relevant for the control of the reactive current compensation system must be positioned in such a way that the reactive power of the power generating system does not influence the control of the reactive current compensation system, thereby preventing a mutual cancellation of the reactive power and therewith the desired effect.*	True
3	Remote and/or manual switching between control methods (if required by the system operator in accordance with Supplement E.9) is possible.	True
3.1	When switching between control methods, the new setpoint must be reached no faster than the transmission behaviour required in accordance with [1], and no slower than within 4 minutes.	True
4	The transition time of the static voltage maintenance control behaviour is set to the value required by the system operator (or, if no specification is given, to 20 s) for all control methods. In this case, the control behaviour for the reference and disturbance responses lies within the tolerances derived from a PT1 behaviour in accordance with B.IX [1], taking into account the set transition time $t_{ü}$. The transition time is adjustable in accordance with the specifications in Table 2 [1].	$t_{ü}$ =20 s with behaviour within the tolerance specifications The transition time is adjustable within the required range.
4.1	The method (A), B), C) or D) selected to verify the control behaviour shall be specified. In the case of verification by method A) verification of the control behaviour is not required within the scope	True

	of the system certificate and must be provided within the scope of the declaration of conformity. A condition to this effect must be included in the system certificate.	
4.2	In the case of verification via method C), compliance with the requirements for the control behaviour for the properties of the NCP is demonstrated on the basis of the component certificates.	True
4.3	In the case of verification via method D), compliance with the requirements for the PGS is demonstrated on the basis of the performance characteristics of the PGS controller and its parameterisation, taking into account the properties of the NCP.	True
4.4	If, during the verification process, the tolerance band is exceeded – in the case of low SCR[1] values – an alternative acceptance criterion may be established in consultation with the network operator (e.g. based on a suitable minimum attenuation; see also Supplement A.I [1]). In this case, the procedure agreed with the network operator is documented and confirmation from the network operator regarding compliance with the requirements based on this procedure is available.	If applicable, the procedure is specified and the network operator's confirmation is available
5	Tolerance after the reactive power value has settled. Exceedances of limit values caused by dynamic voltage changes in the grid must be assessed by the certification body.	±2 % P_{inst} ; for installations with $S_{A,max}$ < 300 kVA: ± 4 % P_{inst}
6	In the event of a complete or partial failure of the control system, the PGU may be operated using the value or procedure specified by the grid operator in accordance with Supplement E.9.	True
7	In the event of a control failure, it is ensured that equipment no longer operating under control for reactive power provision (e.g. capacitor banks or SVCs) can be switched off.	True
8	In the event of a failure of the telecontrol system, the PGS can be operated using the value or procedure specified by the system operator in accordance with Supplement E.9.	True
Reactive power-voltage characteristic curve (*Q(U)*)		
9	Interface for the reference voltage $U_{Q\,0}$ / U_c available.	Information has been provided
10	Voltage dead band adjustable in steps of no more than 0.5% U_c within the range of ±0% ... ±5% U_c.	True
10.1	If the network operator does not specify any requirements, the default value of ±0 % U_c can be set.	Information has been provided

[1] SCR = Short Circuit Ratio; definition according to FNN guidance [1]

11	$Q(U)$ characteristic curve / slope m can be defined via value pairs.	Specified
11.1	If the grid operator does not provide any specifications, the default values can be set: Default value pairs (U_{max} / U_n ; $Q_{max\text{-}under\text{-}excited}$ / $P_{b\ inst}$) as well as $U_{Q0,ref}$ / U_c	(1.04; 0.33) and 1.00 (or the grid operator's specification)
12	After adjusting the reference voltage $U_{(Q\ 0)}$,the resulting setpoint must be approached within the limit value.	≤ 4 min
13	If the telecontrol link fails for a period of more than 1 minute, the following behaviour is possible.	Continue with the last valid value for U_{Q0} / U_n or with cos φ = 1 (as specified by the grid operator)
Reactive power-active power characteristic curve (*Q(P)*)		
14	$Q(P)$ characteristic curve definable using at least 10 data points / value pairs $Q_{EA,setpoint}$/ $P_{b\ inst}$.	True
Reactive power with voltage limiting function		
15	Interface available for specifying the reactive power value Q_{ref} / $P_{b\ inst}$.	Information has been provided
16	Procedure definable via four value pairs P1, P2, P3 and P4. The setting of the reactive power value Q_{ref} / $P_{b\ inst}$ can be specified in steps of 1% Q / $P_{b\ inst}$.	Specified
16.1	If the grid operator does not provide any specifications, the default values can be set.	P1 (0.94; -0.33) P2 (0.96; 0) P3 (1.04; 0) P4 (1.06; +0.33) (or as specified by the network operator)
17	For the slope m ≤ 24 applies.	True
18	After adjusting the reactive power value Q_{ref} / $P_{b\ inst}$, the resulting setpoint must be reached within the limit value.	≤ 4 min
Shift factor cos φ		
19	If the grid operator does not provide any specifications, the default value can be set.	cos φ = 1 (or as specified by the grid operator)

No.	Further evidence	Acceptance criterion
Simulation-based verification of control behaviour according to Method B)		
A	The simulation test is carried out using the RMS model of the power generating system, taking into account the PGS controller model, for an SCR value of 20 and the SCR value specified for the power generating system's NCP.	True
B	The simulation test includes verification of the control and disturbance behaviour (see Section 5.7.2.1.2 [1]).	True
C	The simulation test is carried out in accordance with the specifications in Section 5.6.2.6.2 [1].	True
D	All tests carried out show that the step responses lie within the relevant tolerance bands and that the control behaviour exhibits damped behaviour within the tolerance bands. The state following the initial response of the voltage source control is taken as the starting point for the evaluation of the disturbance response.	True

G.3.2.2.2 VDE-AR-N 4120 (TCR HV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.2.4 (TCR)	11.4.11 (TCR)	Supplement E.7 [2]	Equipment certificate(s), control concept submitted
4.2.1.4 [1]	5.6.2.6 [1]	Supplement E.7 [2]	Equipment certificate(s), control concept submitted
Remarks	Concept review in the system certificate; functional test in the declaration of conformity. Setpoints need only be implemented within the ranges specified in Figure 5 and Figure 6 (requirements for reactive power capacity in the rated load and partial load ranges). To demonstrate the control behaviour of the entire system with regard to static voltage maintenance, a choice may be made between the following procedures. The certification body shall assess which procedures are feasible and determine this in consultation with the connection customer. Procedure A) Measurement-based verification of the behaviour of the entire system within the scope of the declaration of conformity (see Chapter G.1.6 or G.1.7). Procedure B) Simulatory verification taking into account the unit models and the PGS controller model.		

	Procedure C) Verification of the control behaviour of the grid-forming unit with the associated PGS controller as part of component certification (see Chapter G.3.3.1.2). Procedure D) Assessment of control behaviour based on the component and unit certificates and corresponding manufacturer documentation. The assessment criteria of this chapter apply to the grid-forming units of a Type 2 PGS or Type 2 PGS consisting solely of grid-forming units. For Type 2 PGS with grid-forming and grid-following installations, the assessment criteria must be taken into account on a type-specific basis (for grid-forming units in accordance with this chapter; for grid-following units in accordance with the relevant chapter of TG 8 Rev. 10 (Procedure for reactive power control)). *Note: The specifications of the grid operator questionnaire apply. Any deviations must be agreed with the grid operator.* For power generating systems in which the installed capacity of the grid-forming Type 2 units exceeds 10% P_{Amax} or is less than 90% P_{Amax}, a concept for static voltage maintenance of the entire power generating system (grid-forming and non-grid-forming parts) must be agreed and submitted as part of the system certification. If the grid operator requires verification of the overall system behaviour, this must be carried out using measurement techniques.

In general:

No.	Evaluation criteria	Acceptance criterion
1	The control methods specified by the network operator in accordance with Supplement E.7 can be implemented by PGS.	True
1.1	If the network operator does not specify any requirements, it is possible to implement a constant displacement factor $\cos \varphi = 1$ at the NCP.	True
2	The concept for reactive power provision, including the necessary communication links with a description of all interfaces and the associated transit times, is shown schematically.	True
3	Telecontrol and/or manual switching between control methods (if required by the network operator in accordance with Supplement E.7) is possible.	True
3.1	When switching between control methods, the new setpoint must not be reached faster than the transfer response required by [1] and not slower than within 4 minutes.	True

4	The transition time of the static voltage control behaviour is set to the value required by the system operator (or, if no specification is given, to 20 s) for all control methods. In this case, the control behaviour for tracking and disturbance response lies within the tolerances derived from a PT1 response in accordance with B.IX [1], taking into account the set transition time $t_{ü}$. The transition time is adjustable in accordance with the specifications in Table 2 [1].	$t_{ü}$=20 s with behaviour within the tolerance specifications; the transition time is adjustable within the required range.
4.1	The method (A), B), C) or D) selected to verify the control behaviour shall be specified. In the case of verification via method A), verification of the control behaviour is not required within the scope of the system certificate and must be provided within the scope of the declaration of conformity. A requirement to this effect must be included in the system certificate.	True
4.2	In the case of verification via method C), compliance with the control behaviour requirements for the properties of the NCP is demonstrated on the basis of the component certificates.	True
4.3	In the case of verification via method D), compliance with the requirements for the PGS is demonstrated on the basis of the performance specified for the PGS controller and its parameterisation, taking into account the properties of the NCP.	True
4.4	If, during the verification process, the tolerance band is exceeded – in the case of low SCR values – an alternative acceptance criterion may be defined in consultation with the grid operator (e.g. based on a suitable minimum attenuation; see also Supplement A.I [1]). In this case, the procedure agreed with the grid operator is documented and confirmation from the grid operator regarding compliance with the requirements based on this procedure is available.	If applicable, the procedure is specified and the grid operator's confirmation is available
4.5	For power generating systems in which the installed capacity of the grid-forming Type 2 units exceeds 10% P_{Amax} or is less than 90% P_{Amax}, the following applies: The concept for static voltage maintenance of the entire power generating system, agreed with the system operator, is available and has been documented. If the grid operator requires verification of the overall system behaviour, proof of the overall behaviour is provided in this case as part of the declaration of conformity	If applicable, the concept is available and has been documented.

	via the assessment of the metrological evidence (Procedure A).	
5	Tolerance as per the steady-state of the reactive power value that exceeds the limit value due to dynamic voltage changes in the grid must be assessed by the certification body.	±2 % $P_{AV,E}$; for power levels < 10 % $P_{AV,E}$: ±4 % $P_{AV,E}$
6	In the event of a complete or partial failure of the control system, the PGU may be operated using the value or procedure specified by the grid operator in accordance with Supplement E.7.	True
7	In the event of a control failure, it is ensured that equipment no longer operating under control for reactive power provision (e.g. capacitor banks or SVCs) can be switched off.	Concept is in place, true
8	In the event of a failure of the telecontrol system, the PGS can be operated using the value or procedure specified by the system operator in accordance with Supplement E.7.	True
Reactive power-voltage characteristic curve ($Q(U)$)		
9	An interface for the reference voltage $U_{Q\,0}$ / U_n is available.	Information has been provided
10	Voltage dead band adjustable in steps of no more than 0.5% U_n within the range of ±0% ... ±5% U_n.	True
10.1	If the network operator does not specify any requirements, the default setting of ±0 % U_n is possible.	True
11	$Q(U)$ characteristic curve / slope can be defined via a value pair.	Specification has been made
11.1	If the grid operator provides no specifications, the default values can be set: Default value pairs (U_{max} / U_n ; $Q_{max\text{-}under\text{-}excited}$ / $P_{b\ inst}$) and $U_{Q0,ref}$ / U_n	(1.05; 0.33) and 1.00 (or the grid operator's specification)
12	After adjusting the reference voltage $U_{Q\,0}$, the resulting setpoint must be approached within the limit value.	≤ 4 min
13	If the telecontrol link fails for a period of more than 1 minute, the following behaviour is possible.	Continue with the last valid value for U_{Q0} / U_n or with cos φ = 1 (as specified by the grid operator)
Reactive power with voltage limiting function		

14	An interface for specifying the reactive power value Q_{ref} / $P_{b\,inst}$ is available.	Specification has been made
15	The procedure can be defined using four value pairs: P1, P2, P3 and P4. The reference reactive power value Q_{ref} / $P_{b\,inst}$ can be set in increments of 1% *of* Q / $P_{b\,inst}$.	Specified
15.1	If the grid operator does not provide any specifications, the default values can be set.	P1 (0.94; -0.33) P2 (0.96; 0) P3 (1.04; 0) P4 (1.06; +0.33) (or as specified by the network operator)
16	For the gradient m ≤ 24 applies.	True
17	After adjusting the reactive power value Q_{ref} / $P_{b\,inst}$, the resulting setpoint must be reached within the limit value.	≤ 4 min
Shift factor cos φ		
18	If the grid operator does not provide any specifications, the default value can be set.	cos φ = 1 (or as specified by the network operator)

No.	Further evidence	Acceptance criterion
Simulation-based verification of control behaviour according to Method B)		
A	The simulation test is carried out using the RMS model of the power generating system, taking into account the PGS controller model, for an SCR value of 20 and the SCR value specified for the power generating system's NCP.	True
B	The simulation test includes verification of the tracking and disturbance behaviour (see Section 5.7.2.1.2 [1]).	True
C	The simulation test is carried out in accordance with the specifications in Section 5.6.2.6.2 [1].	True
D	All tests carried out show that the step responses lie within the relevant tolerance bands and that the control behaviour exhibits damped behaviour within the tolerance bands.	True

	The state following the initial response of the voltage source control is taken as the starting point for the evaluation of the disturbance response.	

G.3.2.2.3 VDE-AR-N 4130 (TCR EHV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.2.4 (TCR)	11.4.11 (TCR)	Supplement E.7 [2]	Equipment certificate(s), control concept submitted
4.2.1.4 [1]	5.6.2.6 [1]	Supplement E.7 [2]	Equipment certificate(s), control concept submitted
Remarks	Concept review in the equipment certificate; functional test in the declaration of conformity. Setpoints need only be implemented within the ranges specified in Figure 5 and Figure 6 (requirements for reactive power capacity in the rated load range). For Type 2 PGS, the requirements in Figure 7 (requirements for reactive power capacity in the partial load range) must also be observed. To demonstrate the control behaviour of the entire system with regard to static voltage maintenance, a choice may be made between the following procedures. The certification body shall assess which procedures are feasible and determine this in consultation with the connection customer. Procedure A) Measurement-based verification of the behaviour of the entire system within the scope of the declaration of conformity (see Chapter G.1.6 or G.1.7). Procedure B) Simulatory verification taking into account the unit models and the PGS controller model. Procedure C) Verification of the control behaviour of the grid-forming unit with the associated PGS controller as part of component certification (see Chapter G.3.3.1.3). Procedure D) Assessment of control behaviour based on the component and unit certificates and corresponding manufacturer documentation. The assessment criteria of this chapter apply to the grid-forming units of a Type 2 PGS or Type 2 PGS consisting solely of grid-forming units. For Type 2 PGS with grid-forming and grid-following installations, the assessment criteria must be taken into account on a type-specific basis (for grid-forming units in accordance with this chapter; for grid-following units in accordance with the relevant chapter of TG 8 Rev. 10 (Procedure for reactive power control)). *Note: The requirements of the grid operator questionnaire apply. Any deviations must be agreed with the grid operator.*		

	For power generating systems in which the installed capacity of the grid-forming Type 2 units exceeds 10% P_{Amax} or is less than 90% P_{Amax}, a concept for static voltage maintenance of the entire power generating system (grid-forming and non-grid-forming parts) must be agreed and submitted as part of the system certification. If the grid operator requires verification of the overall system behaviour, this must be carried out using measurement techniques.

In general:

No.	Evaluation criteria	Acceptance criterion
1	The concept for reactive power provision, including the necessary communication links with a description of all interfaces and the associated transit times, is shown schematically.	True
2	It must be demonstrated and verified that the power generating system reaches new reactive power setpoints within a maximum of 10 minutes.	True
3	The control methods specified by the system operator in accordance with Supplement E.7 can be implemented by the PGS.	True
3.1	If the grid operator does not provide any specifications, $Q(U)$ control should be implemented using the standard values given in Figure 8.	True
3.2	The setpoint specification option specified by the grid operator: • fixed setpoint • variable setpoint adjustable via a telecontrol system can be implemented by the PGS.	True
4	The concept for reactive power provision, including the necessary communication links with a description of all interfaces and the associated transit times, is shown schematically.	True
5	The procedure for reactive power provision required by the grid operator can be implemented by the power generating system, and a switch to other procedures is in principle possible. If the grid operator specifies several procedures to be applied, this requirement applies to all procedures specified by the grid operator.	True
5.1	If the $Q(U)$ characteristic procedure is specified by the grid operator, compliance with the required setting ranges for the voltage dead band and the	True

	characteristic slope (unless already specified in the component certificate of the PGS controller) as well as the oscillation behaviour of the power generating units based on the specified $Q(U)$ characteristic must be assessed within the power generating system.	
5.2	In the event of communication faults (input/output errors) or failure of the auxiliary power supply, the PGU may be operated using the value or procedure specified by the grid operator in accordance with E.7.	Information has been provided
6	The transition time of the control behaviour for static voltage maintenance is set to the value required by the system operator (or, if no specification is given, to 5 s). In this case, the control behaviour for the reference and disturbance response lies within the tolerances derived from a PT1 behaviour in accordance with B.IX [1], taking into account the set transition time $t_{ü}$.	$t_{ü}(Q(U))$ = 5 s, otherwise $t_{ü}$ = 5 s with behaviour within the tolerance specifications
6.1	The method (A), B), C) or D) selected to verify the control behaviour shall be specified. In the case of verification by method A), verification of the control behaviour is not required within the scope of the equipment certificate and must be provided within the scope of the declaration of conformity. A condition to this effect must be included in the equipment certificate.	True
6.2	In the case of verification via method C), compliance with the requirements for the control behaviour regarding the properties of the NCP is demonstrated on the basis of the component certificates.	True
6.3	In the case of verification via method D), compliance with the requirements for the PGS is demonstrated on the basis of the performance specified for the PGS controller and its parameterisation, taking into account the properties of the NCP.	True
6.4	If, during the verification process, the tolerance band is exceeded – in the case of low SCR values – an alternative acceptance criterion may be defined in consultation with the grid operator (e.g. based on a suitable minimum attenuation; see also Supplement A.I [1]). In this case, the procedure agreed with the network operator is documented and confirmation from the network operator regarding compliance with the requirements based on this procedure is available.	If applicable, the procedure is specified and the grid operator's confirmation is available
6.5	For power generating systems in which the installed capacity of the grid-forming Type 2 units is more than 10% P_{Amax} or less than 90% P_{Amax}, the following applies:	Where applicable, the concept is available and has been documented.

	The concept for static voltage maintenance of the entire power generating system, agreed with the grid operator, is available and has been documented. If the grid operator requires verification of the overall system behaviour, proof of this behaviour is provided in this case as part of the declaration of conformity through the assessment of the metrological evidence (Procedure A).	
7	Tolerance as per the steady-state of the reactive power value that exceeds the limit value due to dynamic voltage changes in the grid must be assessed by the certification body. *Note: In VDE-AR-N 4130, there is a contradiction between the requirements in Section 10.2.2.3 and the required evidence in Section 11.4.11. In case of doubt, the grid operator's project-specific specification applies.*	5 % $P_{AV,E}$ or 5 Mvar (whichever is lower shall apply); for power levels < 10 % $P_{AV,E}$ there are no requirements regarding the provision of regulated reactive power at the NCP.
8	In the event of a complete or partial failure of the control system, the PGU may be operated using the value or procedure specified by the system operator in accordance with Supplement E.7.	True
9	In the event of a control failure, equipment no longer operating under control for reactive power provision (e.g. capacitor banks or SVCs) can be switched off and this function has been confirmed.	Concept in place, true
10	In the event of a failure of the telecontrol system, the PGS can be operated using the value or procedure specified by the system operator in accordance with Supplement E.7.	True
Reactive power-voltage characteristic curve ($Q(U)$)		
11	Interface for the reference voltage U_{Q0}/ U_{ref} available. Reference voltage can be set in steps of 0.5% of U_{ref}. Setting via telecontrol system provided.	True
12	Voltage dead band adjustable in steps of no more than 0.5% U_{ref} (±0% ... ±5% U_{ref}). Setting provided in accordance with the grid operator's specifications (E7). If no specifications are available, the default value of 0 % U_{ref} is to be used.	True
13	The slope *m* of the characteristic curve for variant 1 (Figure 6*) is adjustable within the value range. **Note: Reference error in VDE-AR-N 4130*	$7 \leq m \leq 24$

14	The slope m of the characteristic curve for variants 2 and 3 (Figure 6*) is adjustable within the specified range. **Note: Reference error in VDE-AR-N 4130*	$6 \leq m \leq 20$
15	Setting of $Q(U)$ characteristic curve / slope m via value pair as specified by the network operator (E.7). If no specifications are available, the standard value pair (1.05; 0.33) and $U_{Q0,ref}$ / U_{ref} = 1.00 must be used	True
16	The transition time of the control behaviour is adjustable between 1 s and 45 s (see Table 2 [1]).	True
17	If the telecontrol link fails for a period of more than 1 minute, either: • operation continues using the last valid value or • a cos φ of approximately 1.	Specification has been made
18	Following an adjustment of the reference voltage U_{Q0}/ $U_{(ref)}$, the resulting setpoint must be reached within ≤ 4 minutes.	True
19	Maximum transition time for the value specified by the grid operator (1 s to 45 s) verified (with a maximum tolerance of ±5 % of the maximum reactive power output).	True
20	Maximum tolerance ±5 % of the maximum reactive power output	True
21	Maximum measurement error of the voltage input for the voltage at the NCP < 1 %	True
Reactive power with voltage limiting function		
22	Interface for specifying the reactive power value Q_{ref} / $P_{b\,inst}$ is available.	True
23	The remote setting of the reactive power value Q_{ref} / $P_{b\,inst}$ can be specified in steps of 1 % Q / $P_{b\,inst}$.	True
24	If the telecontrol link is lost for a period of more than 1 minute, depending on the grid operator's specification (E.7), operation will proceed with: • the last valid value or • a substitute value.	True
25	Procedure $Q_{U\,max}$ via value pairs (4 value pairs) as specified by the network operator (E.7).	True

26	For the gradient m ≤ 24 applies.	True
27	Following an adjustment of the reactive power value Q_{ref} / $P_{b\ inst}$, the resulting setpoint is reached within ≤ 4 min. *Note: Due to the lack of specification in VDE-AR-N 4130, the tolerance for the Q(U) method must be used as a fallback, i.e. maximum tolerance ±5 % of the maximum reactive power output*	True
28	The transition time of the control behaviour is adjustable between 5 s and 45 s (see Table 2 [1]).	True
29	Maximum measurement error of the voltage input for the voltage at the NCP < 1%.	True
Displacement factor cos φ		
30	The transition time of the control behaviour is adjustable between 5 s and 45 s (see Table 2 [1]).	True
31	The maximum permissible error tolerance (±2 % P_{inst}) is not exceeded. *Note: Limit value exceedances caused by dynamic voltage changes in the grid must be assessed by the certification body.*	True
32	The specification is made with a minimum step size of Δ cos φ = 0.005.	True
33	In the event of a telecontrol link failure lasting longer than 1 minute, depending on the grid operator's specifications (E.7), operation will proceed with: • a fixed setpoint or • the last value received.	True

No.	Further evidence	Acceptance criterion
Simulation-based verification of control behaviour according to Method B)		
A	The simulation test is carried out using the RMS model of the power generating system taking into account the PGS controller model for an SCR value of 20 and the SCR value specified for the power generating system's NCP.	True
B	The simulation test includes verification of the control and disturbance behaviour (see Section 5.7.2.1.2 [1]).	True
C	The simulation test is carried out in accordance with the requirements of Section 5.6.2.6.2 [1].	True
D	All tests carried out show that the step responses lie within the relevant tolerance bands and that the control behaviour exhibits damped behaviour within the tolerance bands. The state following the initial response of the voltage source control is taken as the starting point for the assessment of the disturbance behaviour.	True

G.3.2.3 General and Grid Security Management

G.3.2.3.1 VDE-AR-N 4110 (TCR MV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.4.1 (TCR) 10.2.4.2 (TCR)	11.4.3 (TCR) 11.4.13 (TCR) 11.4.14 (TCR)		Equipment certificate(s), manufacturer's declaration
8.1 (TCR) 4.2.3 [1]	TG 3 Rev. 26 Supplement 1 5.6.2 [1]	TG 3	Test report
Remarks	Concept review in the system certificate; functional test in the declaration of conformity The active, reactive and apparent power values resulting from the design of the PGS must be used for all further calculations in the system certificate.		

In general:

No.	Assessment criteria	Acceptance criterion
1	It is specified where the active power gradient is implemented.	True
1.1	The PGS can increase and decrease the active power within the minimum and maximum active power gradients.	0.33% $P_{b\,inst}$ / s ≤ gradient ≤ 0.66% $P_{b\,inst}$ / s (slower if setpoint specifications are provided by third parties, but not slower than 4% $P_{b\,inst}$/min when increasing power)
2	Concept for active power output, including the necessary communication links with a description of all interfaces and the associated response times is shown schematically.	True
2.1	An interface for implementing a power specification from the grid operator for the PGS in the range 0% $P_{b\,inst}$ to 100% $P_{b\,inst}$ with a resolution of 1% steps has been implemented.	True
2.2	The smallest active power specification in terms of magnitude is implemented.	True
2.3	The active power interfaces for the grid operator and for third parties are implemented separately.	True
2.4	Prioritisation of grid security management over primary control based on network security, as well as prioritisation of this over setpoint specifications by third parties, is implemented.	True
2.5	The prioritisation of voltage source behaviour (angle jump power and inertia power) over external P-setpoint specifications (including grid security management and $P_{AV,E}$-limitation) has been implemented in the grid-forming units.	True
2.6	The theoretically expected active power control deviation for setpoint specification is reported and lies below the limit value.	$\lvert P_{steady\text{-}state\ condition} - P_{set\text{-}point} \rvert$ ≤ 5 % P_{rE}
2.7	Active power setpoint data (time, duration, magnitude) can be stored/archived for 18 months.	True
3	The maximum active power output of the PGS as a P_{600} value (10-minute average) is displayed.	True
3.1	If active power output depends on environmental conditions (temperature, air pressure), these dependencies are shown.	True
4	In the event of a permanent active power limitation, an agreement has been reached with the grid operator regarding the maximum active power output (Sum PE	True

	max), and the agreed connected active and reactive power has been adjusted where necessary. In the case of power limitations intended to ensure that power feed-in is independent of the grid voltage, prior consultation with the grid operator is not required.	
4.1	If permanent active power limitation is implemented in the PGS controller, this is indicated.	True
5	The active power values of the PGS, averaged over 10 minutes (taking into account any permanent active power limitation), are displayed.	True
5.1	The displayed active power values (P_{inst}, sum of $P_{E\,max}$) do not exceed the grid operator's specifications for $P_{AV\,E}$. In the event of the active power being exceeded, a power limitation must be requested.	True
5.2	If a $P_{AV,E}$-protection device is used, its parameterisation must be ensured in such a way that for an active power operating point of the power generating system at $P_{AV,E}$ does not result in tripping when the angular step power required in accordance with [1] occurs in conjunction with the transient behaviour of the inertia power based on the set start-up time constant of the grid-forming unit. The parameterisation has been agreed with the grid operator.	True
6	The minimum technical output of the PGU has been specified (if applicable).	True
7	For storage systems: A concept for implementing the technical and accounting requirements is presented and evaluated.	True
8	During the design of the power generating system, care was taken to ensure that, whilst complying with the required reactive power provision in accordance with Section 10.2.2 of VDE-AR-N 4110, the ability to provide inertia is, as far as possible, not restricted. It is demonstrated to what extent the sum of the power ($\Sigma P_{limitneg,min}$, $\Sigma P_{limitpos,max}$) of the grid-forming units installed in the power generating system is restricted in terms of the full provision of inertia through reactive power provision at the NCP at nominal voltage, under maximum required over- or under-excited operating modes (in accordance with the grid operator questionnaire). *Note: This can be carried out on the basis of a load flow calculation using the respective PQ diagrams of the units.*	True, potential restriction is identified, not assessed

G.3.2.3.2 VDE-AR-N 4120 (TCR HV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.4.1 (TCR) 10.2.4.2 (TCR)	11.4.3 (TCR) 11.4.13 (TCR) 11.4.14 (TCR)		Equipment certificate(s), manufacturer's declaration
8.1 (TCR) 4.2.3 [1]	TG 3 Rev. 26 Supplement 1 FNN 5.6.2 [1]	TG 3	Test report
Remarks	Design review in the system certificate; functional test in the declaration of conformity. The active, reactive and apparent power values resulting from the design of the PGS must be used for all further calculations in the system certificate.		

In general:

No.	Assessment criteria	Acceptance criterion
1	It is specified where the active power gradient is implemented.	True
1.1	The PGS can increase and decrease the active power within the minimum and maximum active power gradients.	0.33% $P_{b\ inst}$ / s ≤ gradient ≤ 0.66% $P_{b\ inst}$ / s (slower if setpoint values are specified by third parties, but not slower than 4% $P_{b\ inst}$ / min) when increasing power)
2	Concept for active power output, including the necessary communication links with a description of all interfaces and the associated response times is shown schematically.	True
2.1	An interface for implementing a power specification from the grid operator for the PGS in the range 0% $P_{b\ inst}$ to 100% $P_{b\ inst}$ with a resolution of 1% steps has been implemented.	True
2.2	The smallest active power specification in terms of magnitude is implemented.	True
2.3	The active power interfaces for the grid operator and for third parties are implemented separately.	True
2.4	Prioritisation of grid security management over primary control based on network security, as well as prioritisation of this over setpoint specifications by third parties, is implemented.	True

2.5	The prioritisation of voltage source behaviour (angle jump power and inertia power) over external P-setpoint specifications (including grid security management and $P_{AV,E}$-limitation) has been implemented in the grid-forming units.	True
2.6	The theoretically expected active power control deviation for setpoint specification is reported and lies below the limit value.	$\lvert P_{steady\text{-}state\ condition} - P_{set\text{-}point} \rvert \leq 5\ \%\ P_{rE}$
2.7	Active power setpoint data (time, duration, magnitude) can be stored/archived for 18 months.	True
2.8	The PGS can increase and reduce active power within the minimum and maximum active power gradients.	Min. 4% $P_{b\ inst}$ per minute
3	The PGS's maximum active power output is reported as a P_{600} value (10-minute average).	True
3.1	If active power output depends on ambient conditions (temperature, air pressure), these dependencies are shown.	True
4	In the event of a permanent active power limitation, an agreement has been reached with the grid operator regarding the maximum active power output (sum of $P_{E\ max}$) and the agreed connected active and apparent power has been adjusted where necessary.	True
4.1	If the permanent active power limitation is implemented in the PGS controller, this is indicated.	True
5	The active power values of the PGS, averaged over 10 minutes (taking into account any permanent active power limitation), are displayed.	True
5.1	The displayed active and apparent power values correspond to the grid operator's specifications for P_{inst}, the sum of P_{Emax}, as well as $P_{AV,E}$ and $S_{AV,E}$.	True
5.2	If a $P_{AV,E}$-protection device is used, its parameterisation must be ensured in such a way that for an active power operating point of the power generating system, $P_{AV,E}$ does not result in tripping when the step-change power required in accordance with [1] occurs in conjunction with the transient behaviour of the inertia power, based on the set start-up time constant of the grid-forming unit. The parameterisation has been agreed with the grid operator.	True
6	The minimum technical output of the PGU has been specified (if applicable).	True
7	For storage systems: A concept for implementing the technical and accounting requirements has been presented and assessed.	True
8	During the design of the power generating system, care was taken to ensure that whilst complying with the required reactive power provision in accordance with	True, potential restriction is identified, not assessed

	Section 10.2.2 of VDE-AR- N 4120, the ability to provide inertia is, as far as possible, not restricted. It is demonstrated to what extent the sum of the power ($\sum P_{\text{limitneg,min}}$, $\sum P_{\text{limitpos,max}}$) of the grid-forming units installed in the power generating system is restricted in terms of the full provision of inertia through reactive power provision at the maximum required over- or under-excited operating mode (in accordance with the grid operator questionnaire) at the NCP at nominal voltage (). *Note: This can be carried out on the basis of a load flow calculation using the respective PQ diagrams of the units.*	

G.3.2.3.3 VDE-AR-N 4130 (TCR EHV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.4.1 (TCR) 10.2.4.2 (TCR)	11.4.3 (TCR) 11.4.13 (TCR) 11.4.14 (TCR)		Equipment certificate(s), manufacturer's declaration
8.1 (TCR) 4.2.3 [1]	TG 3 Rev. 26 Supplement 1 5.6.2 [1]	TG 3	Test report
Remarks	Concept review in the system certificate; functional test in the declaration of conformity. The active, reactive and apparent power values resulting from the design of the PGS must be used for all further calculations in the system certificate.		

In general:

No.	Assessment criteria	Acceptance criterion
1	It is specified where the active power gradient is implemented.	True
1.1	The PGS can increase and decrease the active power within the minimum and maximum active power gradients.	0.33% $P_{\text{b inst}}$ / s ≤ gradient ≤ 0.66% $P_{\text{b inst}}$ / s (slower if setpoint specifications are provided by third parties, but not slower than 4% $P_{\text{b inst / min}}$ when increasing power)
2	Concept for active power output, including the necessary communication links with a description of all interfaces	True

	and the associated response times is shown schematically.	
2.1	An interface for implementing a power specification from the grid operator for the PGS in the range 0% $P_{b\ inst}$ to 100% $P_{b\ inst}$ with a resolution of 1% steps has been implemented.	True
2.2	The concept for implementing the prioritisation of the active power specification is available and enables compliance with the requirements of Section 4.2.3 [1].	True
2.3	The active power requirement with the lowest value in each case is implemented (from Section 4.2.3 [1]: The lower-priority requirements must be implemented provided they do not conflict with the higher-priority requirements).	
2.4	The active power interfaces for network operators and for third parties are implemented separately.	True
2.5	Prioritisation of primary control based on network security over grid security management, as well as prioritisation of grid security management over setpoint specifications by third parties/operational setpoint specifications in the event of overlapping events, has been implemented.	True
2.6	The prioritisation of voltage source behaviour (angular step response and inertia power) over external P-setpoint requirements (including grid security management and $P_{AV,E}$-limitation) has been implemented in the grid-forming units.	True
2.7	Active power specifications (time, duration, magnitude) can be stored/archived for 18 months.	True
2.8	The theoretically expected control deviation of active power for a setpoint is shown and is below the limit value.	$\mid P_{steady\text{-}state\ condition} - P_{set\text{-}point} \mid \leq 5\ \%\ P_{rE}$ *Note: Limit value applies only to the PGU*
2.9	The PGS can increase and reduce active power within the minimum and maximum active power gradients.	Min. 4% $P_{b\ inst}$ per minute
3	The maximum active power output of the PGS as a P_{600} value (10-minute average) is shown.	True
3.1	If the permanent active power limitation is implemented in the PGS controller, this is displayed.	True
4	The active power values of the PGS, averaged over 10 minutes (taking into account any permanent active power limitation), are displayed.	True
4.1	The displayed active and apparent power values correspond to the grid operator's specifications for P_{inst}, the sum of P_{Emax}, as well as $P_{AV,E}$ and $S_{AV,E}$.	True
4.2	If a $P_{AV,E}$-protection device is used, its parameterisation must be ensured in such a way that, for an active power operating point of the power generating system, at $P_{AV,E}$ does not result in tripping when the step-change power	True

	required in accordance with [1] occurs in conjunction with the transient behaviour of the inertia power, based on the set start-up time constant of the grid-forming unit. The parameterisation has been agreed with the system operator.	
5	The minimum technical output of the PGU has been specified (if applicable).	True
6	During the design of the power generating system, care was taken to ensure that whilst complying with the required reactive power provision in accordance with Section 10.2.2 of VDE-AR- N 4120, the ability to provide inertia is, as far as possible, not restricted. It is demonstrated to what extent the sum of the power ($\sum P_{\text{limitneg,min}}$, $\sum P_{\text{limitpos,max}}$) of the grid-forming units installed in the power generating system is restricted in terms of the full provision of inertia through reactive power provision at the maximum required over- or under-excited operating mode (in accordance with the grid operator questionnaire) at the NCP at nominal voltage (). *Note: This can be carried out on the basis of a load flow calculation using the respective PQ diagrams of the units.*	True, potential restriction is identified, not assessed

G.3.2.4 Active power output as a function of grid frequency (primary control based on network security)

Requirement	Evidence	Applicable documents	Prerequisites
4.2.2 [1]	5.6.2.9 [1]		Equipment certificates
Remarks	The ability to supply active power as a function of the grid frequency is covered in the FNN Guideline on Grid-forming capabilities through compliance with primary control based on network security. This is a fundamental component of the control of grid-forming units and is verified exclusively at unit level. The requirements listed at G.3.1.1.3 and G.3.1.2.8 must be applied to the active power signals, taking into account the prioritisation – in accordance with the guidelines set out in the FNN Guideline [1], section 4.2.3.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	Evidence of behaviour during over- and under-frequency (primary control based on network security) is provided in the unit certificates.	True

2	Based on the control concept, it has been demonstrated that the setpoint for grid security management and the setpoint for the active power target are fed directly to the power generating unit by third parties for the purpose of prioritisation, and that primary control based on network security is carried out directly by the power generating unit.	True

G.3.2.5 Sub-network operability

Requirement	Evidence	Applicable documents	Prerequisites
10.2.1.4 (TCR)	5.6.2.5 [1]	VDE-AR-N 4110 VDE-AR-N 4120 VDE-AR-N 4130	Equipment certificates
Remarks	The capability for sub-network operation is covered in the FNN Guideline on grid-forming capabilities through compliance with the requirements for primary control based on network security. This is a fundamental component of the control of the Type 2 unit and is verified exclusively at unit level. Control speeds and control ranges must be demonstrated within the framework of primary control based on network security on the basis of the specifications in Tables 14 and 15 of the FNN Guideline on grid-forming capabilities. *Note: The conditions for a virtual island network operation remain valid as per A.1.2.7.2.3, A.2.2.7.2.3, A.3.2.7.2.3.* *Note: The requirements for sub-network operability in accordance with the applicable TCR are implicitly met by units which, as part of unit certification, have demonstrated compliance with the requirements for primary control based on network security. The capability is thus inherently fulfilled by the unit and does not require any additional commissioning by the system operator.*		

In general:

No.	Assessment criteria	Acceptance criterion
General requirements		
1	The operating concept allows the fed-in power to be reduced to the minimum technical power as specified in Table 15 of the FNN guideline on grid-forming capabilities.	True
2	Verification of behaviour during over- and under-frequency (primary control based on network security) has been provided in the unit certificates.	True

Special criteria for installations in accordance with VDE-AR-N 4110 and 4120		
3	A simulation model of the PGS is available, which includes at least the individual power generating units and the relevant elements (library models) for connection to the grid connection point. Reactive power compensation systems and system controllers need only be included in the model if integration into the system's simulation model (software/interface issues) is possible and the integration of these components is necessary for assessing the requirements. Notwithstanding this, when selecting procedure B in accordance with 5.6.2.6 [2], the system controller must be included in the simulation model.	True
Special criteria for systems in accordance with VDE-AR-N 4130		
4	A simulation model of the PGS is available which depicts all relevant characteristics such as $Q(U)$ control or voltage/reactive power control, primary control, active power injection as a function of grid frequency (primary control based on network security), including any technological limitations where applicable.	True

G.3.2.6 Requirements for simulation models

G.3.2.6.1 VDE-AR-N 4110 (TCR MV)

Requirement	Evidence	Applicable documents	Prerequisites
10.6.4 (TCR)	11.4.23 (TCR)		-
5.5.3.9 [1]	5.6.2.10 [1]		
Remarks	Where required by the grid operator, the connection owner must prepare an aggregated simulation model of the power generating system in accordance with 10.6 and submit it to the grid operator at the latest as part of the declaration of conformity. Where required by the grid operator, the connection owner must prepare a detailed simulation model of the power generating system based on suitable, validated unit models. With regard to the transfer of the models, the requirements of section 5.5.3.9 [1] must be taken into account.		

In general:

No.	Assessment criteria	Acceptance criterion
1	Does the network operator require an aggregated PGS model?	Information provided
2	Does the network operator require a detailed PGS model?	Information provided
2.1	The detailed simulation model of the power generating system is based on validated unit models that meet the requirements of Section 5.5.3 [1]. *Note: The sharing of open, executable models published by the manufacturer in a publicly accessible type library, including model-type mappings, corresponding descriptions and applicable parameters, is permitted at any time.*	If a detailed PGS model is required: True

G.3.2.6.2 VDE-AR-N 4120 (TCR HV)

Requirement	Evidence	Applicable documents	Prerequisites
10.6.4 (TCR)	11.4.23 (TCR)		-
5.5.3.9 [1]	5.6.2.10 [1]		
Remarks	Where required by the grid operator, the connection owner must prepare an aggregated simulation model of the power generating system in accordance with 10.6 and submit it to the grid operator at the latest as part of the declaration of conformity. Where required by the grid operator, the connection owner must prepare a detailed simulation model of the power generating system based on suitable, verified unit models. With regard to the handover of the models, the requirements of section 5.5.3.9 [1] must be observed.		

In general:

No.	Assessment criteria	Acceptance criterion
1	Does the network operator require an aggregated PGS model?	Information provided
2	Does the network operator require a detailed PGS model?	Information provided
2.1	The detailed simulation model of the power generating system is based on validated unit models that meet the requirements of Section 5.5.3 [1]. *Note: The sharing of open, executable models published by the manufacturer in a publicly accessible type library, including model-type mappings, corresponding*	If a detailed PGS model is required: True

	descriptions and applicable parameters, is permitted at any time.	

G.3.2.6.3 VDE-AR-N 4130 (TCR EHV)

Requirement	Evidence	Applicable documents	Prerequisites
10.6.4 (TCR)	11.4.23 (TCR)		-
5.5.3.9 [1]	5.6.2.10 [1]		
Remarks	Where required by the grid operator, the connection owner must prepare an aggregated simulation model of the power generating system in accordance with 10.6 and submit it to the grid operator at the latest as part of the declaration of conformity. Where required by the grid operator, the connection owner must prepare a detailed simulation model of the power generating system based on suitable, verified unit models. With regard to the transfer of the models, the requirements of section 5.5.3.9 [1] must be taken into account.		

In general:

No.	Assessment criteria	Acceptance criterion
1	Indication of whether the network operator requires an aggregated PGS model in addition to the detailed PGS model.	Information provided
2	Where the grid operator requires the system operator to provide an aggregated (simplified) simulation model of the power generating system, its accuracy relative to the simulation model used in the context of system certification must be demonstrated.	True
3	Does the grid operator require a detailed PGS model?	Information provided
3.1	The detailed simulation model of the power generating system is based on validated unit models that meet the requirements of Section 5.5.3 [1]. *Note: The sharing of open, executable models published by the manufacturer in a publicly accessible type library, including model-type mappings, corresponding descriptions and applicable parameters, is permitted at any time.*	If a detailed PGS model is required: True

G.3.2.7 Robustness and voltage source control during short-term overvoltage and undervoltage events (O/UVRT robustness)

G.3.2.7.1 VDE-AR-N 4110 (TCR MV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.3 (TCR) 4.2.1.5 [1]	11.4.12 (TCR) 5.6.2.7 [1]	TG 3 TG 4; DIN EN 60909 0 (VDE 0102) [13] VDE-AR-N 4110	Unit certificates for all PGU units of the PGS; component certificates for components relevant to FRT; validated models of the PGU units and, where applicable, of the components.
Remarks	Simulation models for PGS controllers serve, in the context of dynamic grid calculations, to ensure the correct initialisation of all PGU units of the PGS in accordance with the operational management concept, and to demonstrate that the PGS controller, via the static voltage maintenance function outside the quasi-steady-state operating range of the PGS, and within the FRT limit curves, does not impair the voltage source control of the grid-forming units and the UVRT/OVRT behaviour of the unit; PGS controller simulation models, however, do not directly influence the O-/UVRT robustness of the PGS during grid fault events. Component certificates for PGS controllers must be checked for statements indicating whether the component could be unduly affected by FRT events (e.g. loss of parameterisation, etc.). If no model of the PGS controller to be used is available that complies with the requirements set for it, or if it cannot be integrated due to interface problems, the conceptual behaviour of the PGS controller used may alternatively be taken into account. If the behaviour of the components cannot be described beyond doubt on the basis of the certificates submitted, the certification body is required to seek clarification through appropriate measures (e.g. conditions in the system certificate). The assessment criteria of this chapter apply to the grid-forming units of a Type 2 PGS or a Type 2 PGS consisting solely of grid-forming units. For Type 2 PGSs with both grid-forming and grid-following installations, the assessment criteria are type-specific (for grid-forming units in accordance with this chapter; for grid-following units in accordance with the relevant chapter of TG 8 Rev. 10 (dynamic grid support)). To this end, an additional assessment of the behaviour of the individual units at their terminals within the PGS may be required.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	The PGS remains within the specified grid voltages in the event of overvoltage and undervoltage.	True

2	The PGS can handle multiple faults (as demonstrated in equipment certificates).	True
3	Voltage increases due to voltage source control to >110% U_c at the NCP do not occur.	True; for exceedances > 50 ms, coordination with the network operator has taken place.
4	There are no potential effects of under-excited operation of the PGS on the functioning of the Q-U protection.	Information has been provided
5	Power generating systems connected to an isolated or compensated medium-voltage distribution network must not disconnect from the grid in the event of a single-pole fault (earth fault). Single-pole faults must not be simulated in these networks. For power generating systems connected to a network with rigid, low-impedance or temporarily low-impedance neutral-point earthing, single-phase fault cases in the same and upstream networks were calculated in accordance with the cases specified in Table A-1 for unbalanced faults.	True
6	For customer installations with Type 2 power generating units, the verifications regarding O/UVRT robustness in accordance with the FNN Guideline on grid-forming capabilities and dynamic grid support in accordance with the TCR are prepared separately in accordance with the requirements applicable to the respective types.	True
7	The UVRT and OVRT tests were carried out for faults in the upstream grid.	True
8	The behaviour of the PGS had to be verified for a symmetrical voltage increase caused by a voltage step from 100% U_c to a value > 110% U_c for symmetrical voltage increases, and to ≥ 110% U_c as the maximum phase-to-phase voltage for asymmetrical voltage increases lasting ≥ 5 s.	True
9	For the UVRT and OVRT tests carried out, there is no impermissible influence on the units by the PGS controller.	True

No.	Evaluation criteria	Acceptance criterion
6.1	The PGS does not disconnect from the grid during the LVRT and HVRT tests defined in Table A-2 for the minimum durations specified therein. For unbalanced fault conditions, a phase-to-phase voltage must be set to the value specified there in each case. The tolerance for the defined voltage increases is a maximum of ±2 % U_c. The intrinsic protection does not trip.	True
6.2	The variation of active and reactive current over time for the tests defined in Table A-2 is shown.	True
6.3	The behaviour of the PGS after the fault ended was recorded and evaluated for a mains voltage within the voltage band of ±15 % U_c over a period of 60 seconds. This is based on the UVRT and OVRT cases defined for this purpose in Table A-2.	True
6.4	It was determined whether, when the PGS is operated at 1.05 U_c (connection of the PGS to a medium-voltage busbar of a distribution transformer with *a power factor* of 0.95) or at 1.07 U_c (connection of the PGS to the medium-voltage network and operation with *a power factor* of 1.00) and at 0.95 U_c at the grid connection point (and operation of the PGS with cos φ of 1.00) the voltage conditions at the terminals of the power generating units exhibit a sufficiently large voltage difference (> 0.02 pu) compared to the criteria for the onset of a fault (voltages > 1.1 U_c or < 0.9 U_c).	If not: adjustment of the fault thresholds in consultation with the grid operator and disclosure in the system certificate
6.5	Evidence regarding the increase in active current after fault termination is provided in the unit certificate.	True
6.6	Reactive power and active power setpoints are largely the same before and after the fault. Subject to the influence of any inertia provided, the settling time should not exceed 1 s.	True
6.7	No Q-U protection trip occurs in the event of a symmetrical voltage dip to a value between 70% U_c and 80% U_c, an active power feed-in with P_{inst} and the maximum reactive power of the PGS as required by the grid operator.	True

6.8	In the case of a requirement for limited voltage source control: Proof of the necessary reducibility of the apparent current is provided in the PGU certificate for units commissioned from 1 January 2028. For commissioning prior to this date, the decoupling protection is alternatively parameterised in accordance with the grid operator's specifications. The feasibility of this mode and the effectiveness of the protective shutdown (see section 4.2.1.5.3[1]) have been assessed in the system certificate.	True
6.9	For commissioning from 01/01/2028 In the event of a requirement for limited dynamic grid support in accordance with Supplement E.9: The tests in accordance with evaluation criterion 6.1 were carried out using the limited voltage source control mode.	True
6.10	For commissioning from 1 January 2028 In the case of a requirement for limited voltage source control: Evidence of the required reducibility of the apparent current is provided in the PGU certificate.	True

Test No	U/U_c in % at the NCP	Proposal		Pre-error condition		Error type 3)
		U/U_c in % at the NCP 1)	Fault duration in ms 1)	Pre-error voltage U/U_c in % at NCP	Reactive power operating mode at the NCP 2)	
V2.1	20–30	25	557	100	max. under-excited	3-pole
V2.2	45–60	50	1575	100	max. over-excited	3-pole
V2.3	70–80	75	2593	100	max. under-excited	3-pole short-circuit
V2.4	90–95	92.5	3000	100	$Q = 0$ Mvar	3-pole short-circuit
V2.5*	20–30	25	683	100	max. under-excited	2-pole

V2.6	45–60	50	1842	100	max. under-excited	2-pole
V2.7	70–80	75	3000	100	max. over-excited	2-pole
V2.8	90–95	92.5	3000	100	Q = 0 Mvar	2-pole
V2.10	105->115	105->115	5000	105	max. over-excited	3-pole
V2.11	100->110	100->110	5000	100	max. over-excited	3-pole
V2.12**	70–80	75	2593	100	max. under-excited	3-pole
V2.13***	20–30	25	683	100	*Q = 0 Mvar*	1-pole
Remarks						

Table A-2: Tests on dynamic grid support for Type 2 PGS based on VDE-AR-N 4110 [1]

Notes:

The fault location is generally taken to be the same network (NCP).

**Test V2.5 must be carried out as a 2-pole short circuit with earth contact for networks with rigid or (temporary) low-impedance neutral earthing.*

***Test V2.12 is to be carried out differently, with the fault location in the upstream network.*

1) The fault duration corresponds to the FRT limit curve (Figure 14) for Type 2 PGS for the proposed voltage dip depths. If other dip depths are selected within the defined ranges, the fault duration must be adjusted in accordance with the limit curve.

The tolerance for voltage steps during tests V2.9–11 is ±2 % U_c.

2) Maximum reactive power values in accordance with the requirements for static voltage maintenance / reactive power provision in the network operator's data enquiry form.

3) The 2-pole short-circuits must always be carried out as 2-pole short-circuits without earth contact.

****Test V2.13 must not be carried out in isolated networks or networks with earth fault compensation. Single-pole short circuits must always be carried out as earth short circuits.*

G.3.2.7.2 VDE-AR-N 4120 (TCR HV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.3 (TCR) 4.2.1.5 [1]	11.4.12 (TCR) 5.6.2.7 [1]	TG 3 TG 4 DIN EN 60909 0 (VDE 0102) [13] VDE-AR-N 4120	Unit certificates for all PGU units of the PGS; component certificates for components relevant to FRT; validated models of the PGU units and, where applicable, of the components.
Remarks	Simulation models for PGS controllers serve, in the context of dynamic grid calculations, to ensure the correct initialisation of all PGU units of the PGS in accordance with the operational management concept, and to demonstrate that the PGS controller, via the static voltage maintenance function outside the quasi-steady-state operating range of the PGS and within the FRT limit curves, does not impair the voltage source control of the grid-forming units and the UVRT/OVRT behaviour of the unit; PGS controller simulation models, however, do not directly influence the O-/UVRT robustness of the PGS during grid fault events. Component certificates for PGS controllers must be checked for statements indicating whether the component could be unduly affected by FRT events (e.g. loss of parameterisation, etc.). If no model of the PGS controller to be used is available that complies with the requirements set for it, or if it cannot be integrated due to interface problems, the conceptual behaviour of the PGS controller used may alternatively be taken into account. If the behaviour of the components cannot be described beyond doubt on the basis of the certificates submitted, the certification body is required to seek clarification through appropriate measures (e.g. conditions in the system certificate). The assessment criteria of this chapter apply to the grid-forming units of a Type 2 PGS or a Type 2 PGS consisting solely of grid-forming units. For Type 2 PGSs with both grid-forming and grid-following installations, the assessment criteria must be applied on a type-specific basis (for grid-forming units in accordance with this chapter; for grid-following units in accordance with the relevant chapter of TG 8 Rev. 10 (dynamic grid support)). To this end, an additional assessment of the behaviour of the individual units at their terminals within the PGS may be required.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	The PGS remains within the specified voltage range in the event of overvoltage or undervoltage.	True
2	The PGS can withstand multiple faults (as verified in equipment certificates).	True

3	For the simulations, it is assumed that the medium-voltage network is stabilised at U_{MS} before the fault occurs.	True
4	Voltage increases due to voltage source control to >110% U_n at the NCP do not occur.	True, provided that (In versions V1.12, V1.13, V2.12 and V2.13, overshoots of more than 50 ms may occur)
5	There are no potential effects of under-excited operation of the PGS on the functioning of the Q-U protection.	Information has been provided
6	For customer installations with Type 2 power generating units, the verifications regarding O/UVRT robustness in accordance with the FNN Guideline on grid-forming capabilities and dynamic grid support in accordance with the TCR are prepared separately in accordance with the requirements applicable to the respective types.	True
7	The UVRT and OVRT tests were carried out for faults in the upstream grid.	True
8	The behaviour of the PGS was verified for a symmetrical voltage increase caused by a voltage step from 100% U_n to a value > 110% U_n for symmetrical voltage increases, and to ≥ 110% U_n as the maximum phase-to-phase voltage for asymmetrical voltage increases lasting ≥ 5 s.	True
9	For the UVRT and OVRT tests carried out, there is no impermissible influence on the units by the PGS controller.	True

For Type 2 PGS, the following applies:

No.	Evaluation criteria	Acceptance criterion
6.1	The PGS does not disconnect from the grid during the LVRT and HVRT tests defined in Table A-2 for the minimum durations specified therein. For unbalanced fault conditions, a phase-to-phase voltage must be set to the value specified there in each case. The tolerance for the defined voltage increases is a maximum of ±2 % U_n. The intrinsic protection does not trip.	True

6.2	The variation of active and reactive current over time for the tests defined in Table A-4 is shown.	True
6.3	The behaviour of the PGS after the end of the fault was recorded and evaluated for a mains voltage within the voltage band of ±15 % U_n over a period of 60 seconds. This is based on the UVRT and OVRT cases defined for this purpose in Table A-4, using two examples.	True
6.4	Verification regarding the increase in active current after fault clearance has been provided in the unit certificate.	True
6.5	Reactive power and active power setpoints are largely the same before and after the fault. Subject to the influence of any inertia provided, the settling time should not exceed 1 s.	True
6.6	No Q-U protection trip occurs in the event of a symmetrical voltage dip to a value between 70% U_n and 80% U_n, an active power feed-in between 20% and 30% $P_{inst,}$ and the maximum reactive power of the PGS as required by the grid operator being under-excited.	True; otherwise, this is indicated
6.7	The voltage conditions at the PGU terminals show a sufficiently large voltage difference in accordance with the criteria for the onset of a fault (voltages > 1.1 U_{MS} or < 0.9 U_{MS}).	True; otherwise, adjust the limits in consultation with the network operator

Test No	U/U_n in % at the NCP	Proposal		Pre-fault condition		Error type 3)
		U/U_n in % at the NCP 1)	Fault duration in ms 1)	Pre-fault voltage U/U_n as % at NCP	Reactive power operating mode at the NCP 2)	
V2.1	0–5	0	150	100	$Q = 0$ Mvar	3-pole
V2.2	20–30	25	988	100	max. under-excited	3-pole
V2.3	45–60	50	1826	100	max. over-excited	3-pole
V2.4****	70–80	75	2664	100	max. under-excited	3-pole

V2.5	90–95	92.5	3000	100	Q = 0 Mvar	3-pole
V2.6	0–5	0	220	100	Q = 0 Mvar	2-pole
V2.7*	20–30	25	1147	100	max. under-excited	2-pole
V2.8	45–60	50	2073	100	max. under-excited	2-pole
V2.9	70–80	75	3000	100	max. over-excited	2-pole
V2.10	90–95	92.5	3000	100	Q = 0 Mvar	2-pole
V2.12	110->115	110->115	5000	110	max. over-excited	3-pole
V2.13	100->110	100->110	5000	100	max. over-excited	2-pole
V2.14**	70–80	75	2664	100	max. under-excited	3-pole
V2.15***	0-5	0	220	100	Q = 0 Mvar	1-pole
Remarks						

Table A-4: Tests on dynamic grid support for Type 2 PGS based on VDE-AR-N 4120

Notes:

The fault location is generally taken to be the same network (NCP).

**Test V2.7 must be carried out as a 2-pole short circuit with earth contact for networks with rigid or (temporary) low-impedance neutral-to-earth connection.*

***Test V2.14 is to be carried out differently, with the fault location in the upstream network.*

1) The fault duration corresponds to the FRT limit curve (Figure 12) for Type 2 PGS for the proposed voltage dip depths. Should be adjusted within the defined ranges of the limit curve.

The tolerance for voltage steps during tests V2.11–13 is ±2 % U_n.

2) Maximum reactive power values in accordance with the requirements for static voltage maintenance / reactive power provision in the network operator's data questionnaire.

3) The 2-pole short-circuits must always be carried out as 2-pole short-circuits without earth contact.

****Test V2.15 must not be carried out in networks with earth fault compensation. Single-pole short circuits must always be carried out as earth short circuits.*

*****Test V2.4 must be carried out at an active power between 20% and 30% of $P_{b\ inst}$.*

G.3.2.7.3 VDE-AR-N 4130 (TCR EHV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.3 (TCR) 4.2.1.5 (FNN Guideline)	11.4.12 (TCR) 5.6.2.7	TG 3 TG 4 DIN EN 60909 0 (VDE 0102) [13] VDE-ARf-N 4130	Unit certificates for all PGU units of the PGS; component certificates for components relevant to FRT; validated models of the PGU units and, where applicable, of the components.
Remarks	Simulation models for PGS controllers serve, in the context of dynamic grid calculations, to ensure the correct initialisation of all PGU units of the PGS in accordance with the operational management concept, and to demonstrate that the PGS controller, via the static voltage maintenance function outside the quasi-steady-state operating range of the PGS and within the FRT limit curves, does not impair the voltage source control at the grid-forming units and the UVRT/OVRT behaviour of the unit; PGS controller simulation models, however, do not directly influence the O-/UVRT robustness of the PGS during grid fault events. Component certificates for PGS controllers must be checked for statements indicating whether the component could be unduly affected by FRT events (e.g. loss of parameterisation, etc.). If no model of the PGS controller to be used is available that complies with the requirements set for it, or if it cannot be integrated due to interface problems, the conceptual behaviour of the PGS controller used may alternatively be taken into account. If the behaviour of the components cannot be described beyond doubt on the basis of the certificates submitted, the certification body is required to seek clarification through appropriate measures (e.g. conditions in the system certificate). The assessment criteria set out in this chapter apply to the grid-forming units of a Type 2 PGS, or to Type 2 PGSs consisting solely of grid-forming units. For Type 2 PGSs comprising both grid-forming and grid-following installations, the assessment criteria must be applied on a type-specific basis (for grid-forming units in accordance with this chapter; for grid-following units in accordance with the relevant chapter of TG 8 Rev. 10 (dynamic grid support)). For this purpose, an additional assessment of the behaviour of the individual units at their terminals within the PGS may be required.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	The PGS remains within the specified voltage range in the event of overvoltage or undervoltage.	True

2	Voltage increases due to voltage source control to >110% U_n at the NCP must be agreed with the grid operator.	True
3	The potential effects of under-excited operation of the power generating system on the functioning of the Q-U protection are highlighted, and possible alternatives are presented. *Note 1: Any detected tripping of the Q-U protection does not constitute a malfunction of the power generating system.*	True
4	The PGS can withstand multiple faults (verified in equipment certificates).	True
5	For the assessment of the FRT limit curves, the lowest of the three phase-to-phase voltages at the grid connection point was used in the event of a voltage drop, and the highest of the three phase-to-phase voltages at the grid connection point was used in the event of a voltage rise.	True
6	Prior to the network fault, a quasi-steady-state voltage at the network connection point of 1.0 pu to 1.1 pu in the 380 kV network (or 1.0 pu to 1.118 pu in the 220 kV network) is assumed.	True
7	For customer installations with Type 2 power generating units, the evidence regarding O/UVRT robustness in accordance with the FNN Guideline on grid-forming capabilities and dynamic grid support in accordance with the TCR is prepared separately in accordance with the requirements applicable to the respective types.	True
8	The behaviour of the PGS has been verified for a symmetrical voltage increase caused by a voltage step of 100% U_n to a value > 110% U_n for symmetrical voltage increases, and to ≥ 110% U_n as the maximum phase-to-phase voltage for asymmetrical voltage increases lasting ≥ 5 s.	True
9	For the UVRT and OVRT tests carried out, there is no impermissible influence on the units by the PGS controller.	True

The following applies to Type 2 PGS:

No.	Evaluation criteria	Acceptance criterion
1	The voltage conditions at the PGU terminals show a sufficiently large voltage difference compared to the	True, otherwise adjust the limits in

	criteria for the onset of a fault (voltages > 1.1 U_{MS} or < 0.9 U_{MS}).	consultation with the network operator
2	Verification of the increase in active current after fault termination has been provided in the unit certificate.	True
3	Reactive power and active power setpoints are largely the same before and after the fault. Subject to the influence of any inertia provided, the settling time should not exceed 1 s.	True

Test No	U/U_n in % at the NCP	Proposal		Pre-error condition		Error type 3)
		U/U_n in % at the NCP 1)	Fault duration in ms 1)	Pre-fault voltage U/U_n in % at NCP	Reactive power operating mode at the NCP 2)	
V2.1	<5	2.5	150	100	$Q = 0$ $Q = max\ oe$ $Q = max\ ue$	3-pole
V2.2	20–30	25	988	100	$Q = 0$ $Q = max\ oe$ $Q = max\ ue$	3-pole
V2.3	45–60	50	1826	100	$Q = 0$ $Q = max\ oe$ $Q = max\ ue$	3-pole
V2.4	70–80	75	2664	100	$Q = 0$ $Q = max\ oe$ $Q = max\ ue$	3-pole
V2.5	90–95	92.5	5000	100	$Q = 0$ $Q = max\ oe$ $Q = max\ ue$	3-pole
V2.6	<5	5	220	100	$Q = 0$ $Q = max\ oe$ $Q = max\ ue$	2-pole
V2.7*	20–30	25	1147	100	$Q = 0$ $Q = max\ oe$ $Q = max\ ue$	2-pole
V2.8	45–60	50	2073	100	$Q = 0$ $Q = max\ oe$ $Q = max\ ue$	2-pole

V2.9	70–80	75	3000	100	*Q = 0* *Q = max oe* *Q = max ue*	2-pole
V2.10	90–95	92.5	5000	100	*Q = 0* *Q = max oe* *Q = max ue*	2-pole
V2.11	105	105	5000	100	*Q = 0* *Q = max oe* *Q = max ue*	3-pole
V2.12	120	120	5000	110	*Q = 0* *Q = max oe* *Q = max ue*	3-pole
V2.13	110	110	5000	100	*Q = 0* *Q = max oe* *Q = max ue*	2-pole
V2.14*	≥120	120	5000	105	*Q = 0* *Q = max oe* *Q = max ue*	3-pole
V2.15**	≥125	125	5000	110	*Q = 0* *Q = max oe* *Q = max ue*	3-pole

Table A-6: Tests on dynamic grid support for Type 2 PGS based on VDE-AR-N 4130

* Specification of the conditions under which the voltage step is possible, based on assumptions regarding the relevant influencing factors and any applicable restrictions. (U_{ref}= 400 kV)

*** Specification of the conditions under which a voltage jump is possible, based on assumptions regarding the relevant influencing factors and applicable restrictions. (U_{ref}= 220 kV)*

Notes:

The fault location is generally considered to be the same network (NCP).

**Test V2.14 serves to verify whether the k-factor specified by the NB can lead to the tripping of the Q-U protection. The test is to be carried out with an active power of 20% to 30% of $P_{b\ inst}$.*

1) The fault duration corresponds to the FRT limit curve (Figure 12) for Type 2 PGS for the proposed voltage dip depths. If other dip depths are selected within the defined ranges, the fault duration must be adjusted in accordance with the limit curve.

The tolerance for voltage steps during tests V2.11–13 is ±2% U_{ref}.

2) Maximum reactive power values in accordance with the requirements for static voltage maintenance / reactive power provision in the network operator's data enquiry form.

3) The 2-pole short-circuits must always be carried out as 2-pole short-circuits without earth contact.

G.3.2.8 Study on the assessment of system compliance

G.3.2.8.1 VDE-AR-N 4130 (TCR EHV)

Requirement	Evidence	Applicable documents	Prerequisites
5.6.3.3 (FNN Guideline)	-	-	Qualified opinion
Remarks	For the power generating system, the system certificate must be supplemented by a qualified opinion. In this assessment, the requirements for the power generating system set out in Section 4.2.4 [1] must be reviewed and evaluated by a qualified body on the basis of a simulation study in accordance with the following criteria. The qualified body must be commissioned by the connection customer, in consultation with the grid operator, to carry out the study. The qualified opinion drawn up by the qualified body must be submitted to the grid operator, who must review its content and approve it. Proof of compliance with these requirements is provided on the basis of a confirmation from the grid operator. During the certification process, the certification body merely verifies the existence of this valid confirmation from the grid operator. The submission of the qualified opinion, approved by the grid operator, is a prerequisite for the issuance of the system certificate.		

In general:

No.	Assessment criteria	Acceptance criterion
1	The conformity of the power generating system with the requirements set out in Section 4.2.4 [1] at system level is confirmed by a qualified opinion in accordance with the criteria set out in Section 5.6.3.3 [1]: • The qualified opinion is available. • A valid confirmation from the grid operator regarding compliance with the requirements is available.	True

G.3.3 COMPONENT CERTIFICATE

G.3.3.1 Procedure for reactive power provision

G.3.3.1.1 VDE-AR-N 4110 (TCR MV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.2.4 (TCR)	11.3.2 (TCR)	TG 3	Equipment certificate(s)
4.2.1.4 [1]	5.6.2.6 [1]		Test report, Manufacturer's documentation
Remarks	If the requirements for the control behaviour of the static voltage maintenance of the entire system are to be demonstrated in accordance with Procedure C) or D) as per Section 5.6.2.6 [1], additional tests and manufacturer's documentation are required as part of the component certification of the PGS controller. In accordance with Procedure C) (verification of the control behaviour of the grid-forming unit with the associated PGS controller as part of component certification), it must be ensured that the required setting values of the PGS controller are specified in the component certificate under the conditions of the parameters relevant to the PGS (e.g. SCR value of the network, impedances of the PGS), thereby ensuring the conformity of the control behaviour of the static voltage maintenance for the PGS. In accordance with Procedure D) (evaluation of the control behaviour of static voltage maintenance based on the component and unit certificates and corresponding manufacturer documentation), the capability of the PGS controller must be demonstrated for the verification of static voltage maintenance. In this context, it is necessary for the manufacturer to document for the component (PGS controller) – for example, on the basis of a validated simulation model (e.g. in tabular form) – under which conditions and with which parameterisation for the power generating system, the required control behaviour can be implemented. In doing so, the impedance of the power generating system, communication times between the PGS controller and units, the SCR value at its NCP, and a variation in the delay of the reactive current behaviour of the grid-forming unit must be taken into account.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	Remote and/or manual switching between control methods is possible.	True
2	When switching between control methods, the new setpoint must be reached no faster than the transfer	$\Delta t_{Q \rightarrow Qsetpoint} \geq (5\tau)$

	response required by [1] and no slower than within 4 minutes. In this case, the control behaviour lies within the tolerances derived from a PT1 behaviour in accordance with B.IX [1], taking into account the permissible transition time $t_{ü}$.	& $\Delta t_{Q \rightarrow Qsetpoint} \leq 4$ min
3	The transition time is adjustable for all control methods in accordance with the specifications in Table 2 [1]. In this case, the control behaviour for steady-state and transient response lies within the tolerances derived from a PT1 response in accordance with B.IX [1], taking into account the set transition time $t_{ü}$.	True
3.1	Prerequisite for the application of procedure C) within the framework of system certification: It must be demonstrated for the combination of the PGS controller and the grid-forming unit under which conditions (e.g. SCR values of the grid, impedances of the PGS) and with which parameterisation the requirements for the control behaviour (in particular the specified transition time) of static voltage maintenance within the permissible tolerance curves in accordance with B.IX [1] can be met.	True, manufacturer's documentation is available
3.2	Prerequisite for the application of procedure D) within the framework of system certification: It must be demonstrated (e.g. by means of tabular documentation) under which conditions and with which parameterisation for the PGS the required control behaviour (in particular the specified transition time) of static voltage maintenance within the permissible tolerance curves in accordance with B.IX [1] can be met. *Note: In this context, it is necessary for the manufacturer to document (e.g. in tabular form) for the component (PGS controller), for example on the basis of a validated simulation model, under which conditions and with which parameterisation the required control behaviour can be achieved for the power generating system. In doing so, the impedance of the power generating system, communication times between the PGS controller and units, the SCR value at its NCP, and a variation in the delay of the reactive current behaviour of the grid-forming unit must be taken into account.*	True, manufacturer's documentation is available
4	If the telecontrol connection fails for a period of more than 1 minute, operation may continue either with the last valid value or with a cos φ of approximately 1. For cos φ or Q setpoints, operation must be possible not only with the last valid setpoint but also with a stored default value (adjustable according to the grid operator's specifications).	Information has been provided
5	In the event of a telecontrol link failure, switching to a different method is possible.	Information has been provided

	It must be specified which of the following methods are implementable. The success criterion is that at least method No. 1 is implementable. • Continued operation using the last received value • U_{Q0}/U_c = ...; Q = ... kvar; cos φ= ... (depending on the selected method) • Switchover to $Q(U)$, $Q(P)$, Q, cos φ	
6	The tolerance of ±2 % P_{inst} (or ±4 % P_{inst} for systems with $S_{A,max}$ < 300 kVA) after the reactive power value has settled is maintained. Exceedances of limit values caused by dynamic voltage changes in the grid must be assessed by the certification body.	True
Reactive power-voltage characteristic curve ($Q(U)$)		
7	Interface for the reference voltage U_{Q0}/ U_c is available. The reference voltage can be set in steps of 0.5 U_c.	Information has been provided
8	Voltage dead band adjustable in steps of no more than 0.5% U_c.	±0 % ... ±5 % U_c
9	$Q(U)$ characteristic curve / slope m definable via a value pair.	Information has been provided
10	The slope m can be adjusted within the specified range.	5 ≤ m ≤ 16.5
Reactive power-active power characteristic curve ($Q(P)$)		
11	$Q(P)$ characteristic curve definable via at least 10 data points / value pairs ($Q_{EA, setpoint}$ / $P_{b\ inst}$).	True
Reactive power with voltage limiting function		
12	An interface for specifying the reactive power value Qref / $P_{b\ inst}$ is available.	Information has been provided
13	The reactive power value Qref / $P_{b\ inst}$ can be set in increments of 1% Q / $P_{b\ inst}$.	Information has been provided
14	The $Q_{U\ max}$ procedure can be defined using value pairs.	Information has been provided
15	There is an automatic limitation of the slope of the characteristic curve to values m ≤ 24.	No evaluation, simple display
Shift factor cos φ		
16	After adjusting the cos φ setpoint, the resulting setpoint must be reached within the specified time period.	≤ 4 min settling time
17	The maximum permissible error tolerance is not exceeded – 2% or 4% P_{inst} (for systems with $S_{A,max}$ < 300 kVA) *Note: Limit value exceedances caused by dynamic voltage changes in the grid must be assessed by the certification body.*	True

18	The specification is made with a minimum step size of 0.005.	True

G.3.3.1.2 VDE-AR-N 4120 (TCR HV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.2.4 (TCR)	11.3.2 (TCR)	TG 3	Equipment certificate(s)
4.2.1.4 [1]	5.6.2.6 [1]		Test report, Manufacturer's documentation
Remarks	If the requirements for the control behaviour of the static voltage maintenance of the entire system are to be demonstrated in accordance with Procedure C) or D) as per Section 5.6.2.6 [1], additional tests and manufacturer's documentation are required as part of the component certification of the PGS controller. In accordance with Procedure C) (verification of the control behaviour of the grid-forming unit with the associated PGS controller as part of component certification), it must be ensured that the required setting values of the PGS controller are specified in the component certificate under the conditions of the parameters relevant to the PGS (e.g. SCR value of the network, impedances of the PGS), thereby ensuring the conformity of the control behaviour of the static voltage maintenance for the PGS. In accordance with Procedure D) (evaluation of the control behaviour of static voltage maintenance based on the component and unit certificates and corresponding manufacturer documentation), the capability of the PGS controller must be demonstrated for the verification of static voltage maintenance. In this context, it is necessary for the manufacturer to document for the component (PGS controller) – for example, on the basis of a validated simulation model (e.g. in tabular form) – under which conditions and with which parameterisation for the power generating system the required control behaviour can be implemented. In doing so, the impedance of the power generating system, communication times between the PGS controller and units, the SCR value at its NCP, and a variation in the delay of the reactive current behaviour of the grid-forming unit must be taken into account.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	Remote and/or manual switching between control methods is possible.	True
2	When switching between control methods, the new set-point must be reached no faster than the response time specified in [1] and no slower than within 4 minutes. In this case, the control behaviour lies within the tolerances derived from a PT1 behaviour in accordance with B.IX [1], taking into account the permissible transition time $t_{ü}$.	$\Delta t_{Q \rightarrow Qsetpoint} \geq (5\tau)$ & $\Delta t_{Q \rightarrow Qsetpoint} \leq$ 4 min
3	The transition time is adjustable for all control methods in accordance with the specifications in Table 2 [1]. In this case, the control behaviour for the reference and disturbance responses lies within the tolerances derived from a PT1 response in accordance with B.IX [1], taking into account the set transition time $t_{ü}$.	True
3.1	Prerequisite for the application of method C) within the framework of system certification: It must be demonstrated for the combination of the PGS controller and grid-forming unit under which conditions (e.g. SCR values of the grid, impedances of the PGS) and with which parameterisation the requirements for the control behaviour (in particular the specified transition time) of static voltage maintenance can be met within the permissible tolerance curves in accordance with B.IX [1].	True, manufacturer's documentation is available
3.2	Prerequisite for the application of procedure D) within the framework of system certification: It must be demonstrated (e.g. by means of tabular documentation) under which conditions and with which parameterisation for the PGS the required control behaviour (in particular the specified transition time) of the static voltage maintenance can be achieved within the permissible tolerance curves in accordance with B.IX [1] . *Note: In this context, it is necessary for the manufacturer to document (e.g. in tabular form) for the component (PGS controller), for example on the basis of a validated simulation model, under which conditions and with which parameterisation the required control behaviour can be achieved for the power generating system. In doing so, the impedance of the power generating system, communication times between the PGS controller and units, the SCR value at its NCP, and a variation in the delay of the reactive current behaviour of the grid-forming unit must be taken into account.*	True, manufacturer's documentation is available
4	In the event of a telecontrol link failure lasting longer than 1 minute, operation may continue either using the last valid value or with a cos φ of approximately 1. For	Information has been provided

	cos φ or Q setpoints, operation must be possible not only with the last valid setpoint but also with a stored default value (adjustable according to the grid operator's specifications).	
5	In the event of a failure of the telecontrol connection, it is possible to switch to a different method. It must be specified which of the following methods are implementable. The success criterion is that at least method no. 1 is implementable. • Continued operation using the last received value • U_{Q0}/U_C = ...; Q = ... kvar; cos φ= ... (depending on the selected method) • Switchover to $Q(U)$, $Q(P)$, Q, cos φ	Information has been provided
6	The tolerance of ±2 % P_{inst} (or ±4 % P_{inst} for power levels < 10 % $P_{AV\,E}$) after the reactive power value has settled is maintained. Exceedances of limit values caused by dynamic voltage changes in the grid must be assessed by the certification body.	True
Reactive power-voltage characteristic curve ($Q(U)$)		
7	Interface for the reference voltage U_{Qo}/U_n is available. The reference voltage can be set in increments of 0.5 U_n.	Information has been provided
8	Voltage dead band adjustable in steps of no more than 0.5% U_n.	±0 % ... ±5 % U_n
9	$Q(U)$ characteristic curve / slope m definable via a value pair.	Information has been provided
10	The slope m for variant 1 (Figure 5) is adjustable within the value range.	7 ≤ m ≤ 24
11	The slope m for variants 2 and 3 (Figure 5) is adjustable within the value range.	6 ≤ m ≤ 20
Reactive power with voltage limiting function		
12	An interface for specifying the reactive power value Q_{ref} / $P_{b\,inst}$ is available.	Information has been provided
13	The reactive power reference value Q_{ref} / $P_{b\,inst}$ can be set in steps of 1 % Q / $P_{b\,inst}$.	Information has been provided
14	$Q_{U\,max}$ can be defined via value pairs.	Information has been provided
15	There is an automatic limitation of the slope of the characteristic curve to values m ≤ 24.	No evaluation, display only
Offset factor cos φ		

16	The maximum permissible error tolerance is not exceeded. *Note: Limit value exceedances caused by dynamic voltage changes in the grid must be assessed by the certification body.*	±2 % P_{inst}
17	The specification is made with a minimum increment of 0.005.	True

G.3.3.1.3 VDE-AR-N 4130 (TCR EHV)

Requirement	Evidence	Applicable documents	Prerequisites
10.2.2.4 (TCR)	11.3.2 (TCR)	TG 3	Equipment certificate(s)
4.2.1.4 [1]	5.6.2.6 [1]		Test report, Manufacturer's documentation
Remarks	If the requirements for the control behaviour of the static voltage maintenance of the entire system are to be demonstrated in accordance with Procedure C) or D) as per Section 5.6.2.6 [1] , additional tests and manufacturer's documentation are required as part of the component certification of the PGS controller. In accordance with Procedure C) (verification of the control behaviour of the grid-forming unit with the associated PGS controller as part of component certification), it must be ensured that the required setting values of the PGS controller are specified in the component certificate under the conditions of the parameters relevant to the PGS (e.g. SCR value of the network, impedances of the PGS), thereby ensuring the conformity of the control behaviour of the static voltage maintenance for the PGS. In accordance with Procedure D) (evaluation of the control behaviour of static voltage maintenance based on the component and unit certificates and corresponding manufacturer documentation), the capability of the PGS controller must be demonstrated for the verification of static voltage maintenance. In this context, it is necessary for the manufacturer to document for the component (PGS controller) – for example, on the basis of a validated simulation model (e.g. in tabular form) – under which conditions and with which parameterisation for the power generating system the required control behaviour can be implemented. In doing so, the impedance of the power generating system, communication times between the PGS controller and units, the SCR value at its NCP, and a variation in the delay of the reactive current behaviour of the grid-forming unit must be taken into account.		

In general:

No.	Evaluation criteria	Acceptance criterion
1	Remote and/or manual switching between control methods is possible.	True
2	In the event of communication faults (input/output errors) or failure of the auxiliary power supply, operation must continue with a cos φ of approximately 1, unless the entire system can compensate for the failure of the affected PGU.	Information has been provided
3	The transition time is adjustable for all control methods in accordance with the specifications in Table 2 [1]. In this case, the control behaviour for the reference and fault response lies within the tolerances derived from a PT1 behaviour in accordance with B.IX [1], taking into account the set transition time $t_{ü}$.	True
3.1	Prerequisite for the application of procedure C) within the framework of system certification: It must be demonstrated for the combination of the PGS controller and grid-forming unit under which conditions (e.g. SCR values of the grid, impedances of the PGS) and with which parameterisation the requirements for the control behaviour (in particular the specified transition time) of static voltage maintenance can be met within the permissible tolerance curves in accordance with B.IX [1].	True, manufacturer's documentation is available
3.2	Prerequisite for the application of procedure D) within the framework of system certification: It must be demonstrated (e.g. by means of tabular documentation) under which conditions and with which parameterisation for the PGS the required control behaviour (in particular the specified transition time) of the static voltage maintenance can be achieved within the permissible tolerance curves in accordance with B.IX [1]. *Note: In this context, it is necessary for the manufacturer to document (e.g. in tabular form) for the component (PGS controller), for example on the basis of a validated simulation model, under which conditions and with which parameterisation the required control behaviour can be achieved for the power generating system. In doing so, the impedance of the power generating system, communication times between the PGS controller and units, the SCR value at its NCP, and a variation in the delay of the reactive current behaviour of the grid-forming unit must be taken into account.*	True, manufacturer's documentation is available
Reactive power-voltage characteristic curve ($Q(U)$)		

4	Interface for the reference voltage 1 kV available. Reference voltage can be set in steps of 0.5% U_{ref}.	Information has been provided
5	Voltage dead band adjustable in steps of no more than 0.5% U_{ref}.	±0% … ±5% U_{ref}
6	$Q(U)$ characteristic curve / slope m definable via a value pair.	Information has been provided
7	The slope *m* of the characteristic curve for variant 1 (Fig. 6*) is adjustable within the value range. **Note: Reference error in VDE-AR-N 4130*	$7 \leq m \leq 24$
8	The slope *m* of the characteristic curve for variants 2 and 3 (Figure 6*) is adjustable within the specified range. **Note: Reference error in VDE-AR-N 4130*	$6 \leq m \leq 20$
9	If the telecontrol connection fails for a period of more than 1 minute, either • operation continues using the last valid value or • with a cos φ of approximately 1, or • operation may continue by switching to another method selected by the network operator.	Information has been provided
10	Maximum tolerance ±5% of the maximum reactive power output.	True
Reactive power with voltage limiting function		
11	An interface for specifying the reactive power value Q_{ref} / $P_{b\ inst}$ is available.	Information has been provided
12	The reference reactive power value Q_{ref} / $P_{b\ inst}$ can be set in increments of 1% *of* Q / $P_{b\ inst}$.	Information has been provided
13	If the telecontrol connection is lost for a period of more than 1 minute, either • the last valid value is used, or • a substitute value, or • operation may continue by switching to another procedure selected by the network operator.	Information has been provided
14	Method $Q_{U\ max}$ definable via value pairs (4 value pairs).	Information has been provided
15	There is an automatic limitation of the slope of the characteristic curve to values $m \leq 24$.	The information is only identified, not evaluated
16	Following an adjustment of the reactive power value Q_{ref}/ $P_{b\ inst}$, the resulting setpoint must be reached within ≤ 4 min.	True

	Note: Due to the lack of specification in VDE-AR-N 4130, the tolerance for the Q(U) method must be used as a fallback, i.e. maximum tolerance ±5% of the maximum reactive power output	
17	The settling time must not exceed the rise time plus 1 minute.	$T_{\mathrm{ein}} \leq T_{\mathrm{an}} + 1\ min$
18	Maximum measurement error of the voltage input for the voltage at the NCP < 1 %.	True
Displacement factor cos φ		
19	The maximum permissible error tolerance is not exceeded. *Note: Limit value exceedances caused by dynamic voltage changes in the grid must be assessed by the certification body.*	±2 % P_{inst}
20	The specification is made with a minimum increment of 0.005.	True
21	If the telecontrol connection is lost for a period of more than 1 minute, either • a fixed setpoint is used or • the last received value, or • operation may continue by switching to another method selected by the network operator.	Information has been provided

Bibliography

[1] „Technische Anforderungen an Netzbildende Eigenschaften inklusive der Bereitstellung von Momentanreserve, Anforderungen und Nachweise für Netzbildende Einheiten,“ *VDE FNN Hinweis,* Bd. Version 2.1, Januar 2026.

[2] „Technische Richtlinie für Erzeugungseinheiten, -anlagen und Speicher sowie für deren Komponenten Teil 8: Zertifizierung der elektrischen Eigenschaften von Erzeugungseinheiten und -anlagen, Speicher sowie für deren Komponenten am Stromnetz,“ Bd. Rev. 10, 15.07.2025.

[3] DIN, DIN EN ISO/IEC 17065:2012 Konformitätsbewertung - Anforderungen an Stellen, die Produkte, Prozesse und Dienstleistungen zertifizieren (ISO/IEC 17065:2012), 2012.

[4] DIN, DIN EN ISO/IEC 17025:2017 Allgemeine Anforderungen an die Kompetenz von Prüf- und Kalibrierlaboratorien (ISO/IEC 17025:2017), 2017.

[5] „Technische Richtlinie für Erzeugungseinheiten und -anlagen, Teil 3: Bestimmung der elektrischen Eigenschaften von Erzeugungseinheiten und -anlagen, Speicher sowie für deren Komponenten am Mittel-, Hoch- und Höchstspannungsnetz,“ Bd. Rev. 26, 05.04.2022.

[6] „FGW TR 3 Rev. 26 Beiblatt 2,“ Bd. 26.2, 16.12.2025.

[7] „VDE AR-N 4110 Technische Regeln für den Anschluss von Kundenanlagen an das Mittelspannungsnetz und deren Betrieb (TAR-MS),“ *VDE FNN,* November 2023.

[8] „VDE AR-N 4120 Technische Regeln für den Anschluss von Kundenanlagen an das Hochspannungsnetz und deren Betrieb (TAR-HS),“ *VDE FNN,* November 2018.

[9] „VDE AR-N 4130 Technische Regeln für den Anschluss von Kundenanlagen an das Höchstspannungsnetz und deren Betrieb (TAR-HöS),“ *VDE FNN,* November 2018.

[10] „Technische Richtlinie für Erzeugungseinheiten und -anlagen, Teil 4: Technische Richtlinie für Erzeugungseinheiten und -anlagen, Teil 3: Bestimmung der elektrischen Eigenschaften von Erzeugungseinheiten und -anlagen, Speicher sowie für deren Komponenten,“ Bd. Rev. 10, 05.04.2022.

[11] J. Brombach, J. Koch, H. Wattar und D. Schulz, Optimierung von Bordnetzen hoher Lastdichte durch den Einsatz intelligenter Schutzeinrichtungen 60., Bremen: Deutscher Luft- und Raumfahrtkongress (DLK), 2012.

[12] „Technische Anforderungen an Netzbildende Eigenschaften inklusive der Bereitstellung von Momentanreserve, Anforderungen und Nachweise für Netzbildende Einheiten,“ *VDE FNN Hinweis,* Bd. Version XXX, XXX 2025.