European Network of
Transmission System Operators
for Electricity

General Guidance on Compliance Verification – use of Simulation Models

ENTSO-E GUIDANCE DOCUMENT FOR NATIONAL IMPLEMENTATION FOR NETWORK CODES ON GRID CONNECTION

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1 DESCRIPTION

1.1 Code(s) & Article(s)

The following articles in the connection codes specify requirements and responsibilities concerning how to apply simulation models in the compliance verification process.

COMMISSION REGULATION (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators.

Title IV Compliance: Chapters 2-7 – Compliance testing & simulations

- Chapter 2 – Compliance Testing for Synchronous Power Generating Modules
    - Article 44 – Compliance tests for type B synchronous power-generating modules
    - Article 45 – Compliance tests for type C synchronous power-generating modules
    - Article 46 – Compliance tests for type D synchronous power-generating modules
- Chapter 3 – Compliance Testing for Power Park Modules
    - Article 47 – Compliance tests for type B power park modules
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- Chapter 4 – Compliance Testing for Offshore Power Park Modules
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- Chapter 5 - Compliance simulations for synchronous power-generating modules
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- Chapter 6 - Compliance simulations for power park modules

- Article 54 - Compliance simulations for type B power park modules
- Article 55 – Compliance simulations for type C power park modules
- Article 56 – Compliance simulations for type D power park modules

- Chapter 7 – Compliance simulations for offshore power park modules
  - Article 57 – Compliance simulations applicable to offshore power park modules

COMMISSION REGULATION (EU) 2016/1388 of 17 August 2016 establishing a Network Code on Demand Connection.

- Chapter 2 – Compliance Testing
  - Article 36 – Common provisions for compliance testing
  - Article 37 – Compliance testing for disconnection and reconnection of transmission-connected distribution facilities
  - Article 38 – Compliance testing for information exchange of transmission-connected distribution facilities
  - Article 39 – Compliance testing for disconnection and reconnection of transmission-connected demand facilities
  - Article 40 – Compliance testing for information exchange of transmission-connected demand facilities
  - Article 41 – Compliance testing for demand response active power control, reactive power control and transmission constraint management
- Chapter 3 – Compliance simulation
  - Article 42 – Common provisions on compliance simulations
  - Article 43 – Compliance simulations for transmission-connected distribution facilities
  - Article 44 – Compliance simulations for transmission-connected demand facilities
  - Article 45 – Compliance simulations for demand units with demand response very fast active power control
  - Article 40 – Compliance testing for information exchange of transmission-connected demand facilities

- Article 41 – Compliance testing for demand response active power control, reactive power control and transmission constraint management

COMMISSION REGULATION (EU) 2016/1447 of 26 August 2016 establishing a network code on requirements for grid connection of high voltage direct current systems and direct current-connected power park modules

Title VI Compliance: Chapters 2-3 – Compliance testing & simulations

- Chapter 2 – Compliance Testing
    - Article 69 – Compliance testing for HVDC systems
    - Article 70 – Compliance testing for DC-connected PPMs and remote end HVDC convertor units
- Chapter 3 – Compliance simulations
    - Article 73 – Compliance simulations for HVDC systems
    - Article 74 – Compliance simulations for DC-connected PPMs and remote end HVDC convertor units

1.2 Introduction

The overall purpose of this Implementation Guidance Document (IGD) is to guide the Relevant System Operator (RSO) (DSO, TSO, CDSO) and the Relevant TSO on compliance verification at the facility Connection Point (CP), which is the focus of CNCs, to clearly distinguish it from compliance verification at unit / component / equipment terminals.

To make sure that the connected facilities remain compliant with CNC requirements during its life cycle, the RSO and where applicable the relevant TSO has the right to request the owner of power-generating facilities, demand facilities and HVDC facilities to carry out compliance verification tests and develop, maintain, and validate representative simulation models according to a compliance verification process. In particular:

- Demonstrated compliance via onsite testing and a valid simulation model for the facility during the compliance verification process.
- Carry out compliance tests and relevant simulation studies in accordance with a compliance monitoring programme, after any failure, modification or replacement of any equipment

or component that may have an impact on compliance with applicable requirements as described by RSOs and in line with CNCs, throughout the life cycle of the facility.

As per the EU Connection Network Codes (CNCs), newly connected or significantly modernised system users must be compliant with the relevant CNC technical requirements, and compliance must be verified at the time of the request for an operational notification and monitored throughout the life cycle.

For any new or significantly modernised equipment, initial compliance verification must be obtained using onsite tests and simulations during the operational notification process.

The following major phases of the compliance verification process might include but are not limited to the following actions:

1. Authorized certifiers to issue the relevant Equipment Certificate (EqC). Facility owner can use EqC for the purpose of partly or completely demonstrating the compliance of components, units or modules with the required functionalities and capabilities based on the specifications in the relevant CNC and the corresponding national implementation and based on compliance tests and/or simulations.

2. Facility owners to perform Compliance Verification Test (CVT) as onsite tests according to test specifications defined by the relevant CNC, the corresponding national implementation of CNCs and agreed between the facility owner and the RSO. The CVT is an activity that takes place during the operational notification issuing process with the purpose of demonstrating compliance with CNC specified minimum required functionalities and capabilities, based on the relevant onsite tests according to the minimum compliance verification requirements stated in the CNCs - NC RfG, NC DCC and NC HVDC. The RSO may participate in the execution of the CVTs and record the test results obtained in onsite tests. The compliance verification process is finalised with the RSO acceptance of the provided documentation including the relevant EqCs if applicable and a statement of compliance with the purpose of issuing an operational notification for the facility and signing of a final grid connection agreement. This covers the test activities up to the FON (Final Operation Notification).

3. Facility owners to provide a validated Compliance Verification Simulation model (CVS) with the purpose of demonstrating compliance with the required functionalities and capabilities using for this purpose an adequate electrical simulation model according to the relevant CNC requirements (NC RfG Article 15(6)(c), NC DCC Article 21, NC HVDC Article 54). Electrical simulations models used to verify compliance are required where onsite testing is not applicable or reasonable due to the possible impact on the facility or the grid. If the

Member State decide so the simulation model will need to be qualified by an authorized certifier in line with relevant CNC requirements.

4. RSOs and if applicable the relevant TSO to perform a Compliance Monitoring (CM) process. Triggered CM process the facility owner shall ensure that all connected facilities remain compliant with the required functionality and parameter ranges according to the relevant CNC requirements after issuing the operational notification and throughout the life cycle until the facility is decommissioned and disconnected, or until the operational notification is revoked or expires. More detailed guidance on the CM is presented in the specific IGD on "Compliance Verification – Compliance Monitoring after operational notification".

These stated requirements are in line with the ACER Framework Guidelines on Connection Codes, Article 2.4 "the basis of the Compliance testing, compliance monitoring and enforcement" and correspond to national processes through which RSOs seek assurance that equipment connected to their grid systems is technically sound and meets company standards in terms of technical capability, behaviour, or provision of services.

1.3 Scope of document

The scope of the present document is to guide the RSOs and if applicable the relevant TSO on the application of simulation models in the process of demonstrating compliance partly or completely and to make guidance on the mandatory and supplementary onsite tests required to demonstrate full compliance with the grid connection requirements for granting a grid connection and the operational notification according to the signed connection agreement.

The scope of the document does not include the specifications for issuing certificates on simulation models as this is up to the relevant standardization bodies and the authorized certifiers and authorized laboratories to agree on a harmonized set of conditions and specifications for issuing certificates on simulation models applicable for demonstrating compliance according to the relevant CNC.

1.4 Acronyms applied

In table below is listed the acronyms applied in this document.

CDSO: Closed Distribution System Operator

CP: Connection Point

CVT: Compliance Verification Test (onsite test)

CVS: Compliance Verification Simulation (electrical simulation model)

DF: Demand Facility

DRUD: Demand Response Unit Document

DU: Demand Unit

EqC: Equipment Certificate

EON: Energisation operational notification

FACTS: Flexible Alternating Current Transmission System (a family of power electronics-based devices able to enhance AC system controllability and stability)

FON: Final operational notification

HVDC: High Voltage Direct Current

IEEE: Institute of Electrical and Electronics Engineers

IGD: Implementation Guidance Document

ION: Interim operational notification

LON: Limited operational notification

NC RfG: Network Code for all Generators

NC DC: Network Code for Demand Connection

NC HVDC: Network Code for HVDC systems

NPGU: Non-synchronous Power Generating Unit

NPPGU: Non-synchronous Power Park Generating Unit

PGF: Power Generating Facility

PPC: Power Park Controller

PGFO: Power Generating Facility Owner

PGM: Power Generating Module

PGMD: Power Generating Module Document

PGU: Power Generating Unit

PPGU: Power Park Generating Unit (a part of a PPM and can be either SPPGU of NPPGU)

PPM: Power Park Module (unit or an ensemble of units which can be understood as an aggregation of one or more PPGUs)

RSO: Relevant System Operator (TSO, DSO or CDSO)

SPGM: Synchronous Power Generating Module (an indivisible set of installations which can be understood as aggregation of one or more SPGUs)

SPGU: Synchronous Power Generating Unit

SPPGU: Synchronous Power Park Generating Unit (e.g., Permanent Magnet Synchronous Generator – a commercially available wind turbine generator system)

SSTI: Sub Synchronous Torsional Interactions

1.5 Definitions

Definitions stated here is in addition to the definitions given in the related network codes RfG, DCC and HVDC. The additional terms are the following.

1. Simulation model – a simulation model is a mathematical representation of an equipment and/or a component, that includes the electrical characteristics at the terminals of the entire PGM including any mechanical influence on electrical characteristics and any subsystem impact on the active and reactive power response of the facility.

1.6 NC frame

With the purpose of demonstrating compliance with the required functionalities and capabilities an adequate electrical simulation model according to the relevant CNC requirements is required. The specific requirements are specified in the following network codes and articles:

- NC RfG Article 15(6)(c)
- NC DCC Article 21
- NC HVDC Article 54

1.7 Roles and responsibility

The facility owner is responsible for providing a valid simulation model representing the facility to be connected. The simulation model is a part of the required documentation for fulfilling the connection requirements.

The RSO in corporation with the relevant TSO is responsible for specifying the minimum set of requirements for providing the facility simulation model.

1.8 Documents required to demonstrate compliance – focusing simulation models

The documentation required according to the compliance verification process must include a description of the detailed simulation model and related model configuration parameters so any with the required skills and simulation model environment are able to reproduce the results provide as requested by the RSO and relevant TSO.

1.9 Compliance simulation model requirements

1.9.1 SPGM requirements

1.9.1.1 RMS modelling requirements in large network studies

This section provides RMS model requirements for SPGMs to be used in network dynamic simulations. The table attached to this report in section 1.12 is based on the European Network Codes and Guidelines and shows all the required simulations for SPGMs together with proposals for the details of the necessary procedures. In that frame, without prejudice to the Member State's rights to introduce additional requirements, it is recommended for the national implementation of the NC RfG Article 15 that the RMS simulation models of SPGMs should include the following points:

(a) Dynamic RMS model of AVR (Automatic Voltage Regulation): The model shall simulate the AVR response including the static or rotating excitation system. In line with IEEE 421.5, it shall be fit for dynamic simulations of steps, short circuits and oscillations up to 3 Hz and grid frequency deviations within +/- 5 % from the rated frequency. The model shall also contain internal limiters (e.g. V/Hz, over-/under-excitation, stator current etc.). A reduced order model in accordance with IEEE Std. 421.5 is preferred;

(b) dynamic RMS model of PSS (Power System Stabilizer): The model shall simulate the PSS and be fit for dynamic simulations of steps, short circuits and oscillations up to 3 Hz and grid frequency deviations within +/- 5 % from the rated frequency. The model shall also contain internal limiters and automatic (de-) activating equipment (e.g. only if active power > x p.u. will the PSS be activated. with a time delay and/or hysteresis). A reduced order model in accordance with IEEE Std. 421.5 is preferred;

(c) dynamic RMS model of turbine-governor and other prime movers: The model shall simulate the turbine-governor including the actuators and valves with their specific curves. It shall be fit for small-signal stability simulations as well as for rotor angle transient stability simulations and include the initial response of the turbine-governor in the seconds following a grid disturbance or islanding (e.g. the concept of fast-valving) and be fit for grid frequency deviations within +/- 5 % from the rated frequency. The model shall also contain internal limiters, dead bands and where applicable automatic switch-over between power control and speed control. A model in accordance with IEEE or CIGRE is preferred;

(d) two-axis model of alternator: The two-axis model of the alternator shall be based on the standard Park's model. This model has been used for several decades and has been demonstrated to be fit for stability and dynamic grid simulations. For enhanced performance in capturing both the transient and steady-state field current response of synchronous generators some recent generator model development have been recommended by the Western Electricity Coordinating Council (WECC).

The above listed simulation model requirements and information must not violate manufactures intellectual property.

1.9.1.2 The EMT modelling requirements for near-synchronous and sub-synchronous torsional interaction studies

For the purpose of electromagnetic transient (EMT) simulations (especially for sub-synchronous and near synchronous torsional interactions), without prejudice to the Member State's rights to introduce additional requirements, the SPGM models (type C and D) should contain the following:

(a) Be valid in the agreed frequency range;

(b) be valid for the specified operating range and all operation modes of the SPGM;

(c) be fit for EMT simulations of active/reactive power and voltage steps, short circuits and grid frequency deviations within +/- 5 % from the rated frequency;

(d) should represent the AVR control module in the given frequency range including the static or rotating excitation system. For example the recommendations given in the IEEE Std. 421.5.13, the models are reduced order models, valid for oscillation frequencies up to 3 Hz and these models would not normally be adequate for use in studies of sub-synchronous resonance or other shaft torsional interaction behaviour. Based on this, the adequacy of an IEEE model for AVR should be evaluated before use in studies of sub synchronous resonance or other shaft torsional interaction behaviour;

(e) should represent the PSS control module in the given frequency range and be fit for EMT simulations of steps, short circuits and grid frequency deviations within +/- 5 % from the rated frequency. For example the recommendations given in the IEEE Std. 421.5, these models are reduced order models, valid for oscillation frequencies up to 3 Hz. Based on this, the adequacy of an IEEE Std. 421.5[1] model for PSS should be evaluated before use in studies of sub-synchronous resonance or other shaft torsional interaction behaviour;

(f) should represent the mass-spring model of turbine and alternator shaft. The mass-spring model of the turbine, alternator and where applicable the exciter shall correctly simulate all eigen-frequencies and associated eigen-modes up to the agreed frequency. The accuracy of the three lowest eigen-frequencies should be better than +/- 0.5 Hz. The accuracy of the fourth eigen-frequency and higher should be better than +/- 1.0 Hz;

(g) where available, the mechanical damping of the shaft should be part of the model. If not available, the mechanical damping will be assumed a conservative value close to zero to be delivered by the owner of the SPGM;

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[1] *"IEEE Recommended Practice for Excitation System Models for Power System Stability Studies,", IEEE May 2016.*

(h) include a dynamic model of turbine-governor;

(i) in the case that encrypted EMT models of AVR or PSS are accepted by the relevant TSO or where applicable RSO, the relevant TSO or where applicable RSO together with the SPGM owner should specify the model encryption (the model structure and the signal interfaces to be observable in the SSTI studies);

(j) the above listed simulation model requirements and information must not violate manufactures intellectual property;

Up to date AVR and PSS models for higher frequency ranges are not yet always available in commercial tools or provided for EMT torsional interaction studies. The use of models, not adequate for the frequency range of torsional interactions, may lead to false conclusions and needs further investigations and studies on the impact of the application of these RMS based defacto standard AVR and PSS models on the SSTI risk assessment and mitigation measures, and other torsional interactions. Especially in comparison to extended frequency range models as described in ISSM report, section 5.4.

1.9.2 PPM requirements

1.9.2.1 RMS modelling requirements

For the purpose of electromechanical dynamic simulations (RMS simulation studies) the relevant system operator or the relevant TSO shall have the right to specify the model requirements. For the national implementation of the NC RfG Article 15 without prejudice to the Member State's rights to introduce additional requirements, the RMS simulation models of PPMs shall include the following points:

(a) Be valid for the specified operating range and all control modes of the power-generating facility;

(b) include a proper representation of the converter modules and its control systems (including the synchronization module) that influence the dynamic behaviour of the power-generating module in the specified time frame up to and including 3 Hz;

(c) be open source/standard generic model for cross border network stability studies;

(d) in the case that encrypted detailed RMS models are accepted by the relevant TSO, the relevant TSO shall specify the requirements of the model encryption according to national regulations (for example use of source code, the model structure and the signal interfaces to be observable in the network studies);

(e) include the relevant protection function models.

The above listed simulation model requirements and information must not violate manufactures intellectual property.

1.9.2.2 EMT modelling requirements

For the purpose of time domain electromagnetic transient (EMT) simulations the relevant system operator or the relevant TSO shall have the right to specify the model requirements. In that frame, it is recommended that for the national implementation of the NC RfG Article 15, without prejudice to the Member State's rights to introduce additional requirements, the EMT simulation models of PPMs shall include the following points:

(a) Be valid in the frequency range 0.1 Hz – 2500 Hz for relevant interaction studies; The validity of the PPM model shall be ensured for the given frequency range at the connection point;

(b) be valid for specified operating range and control modes of the PPM in both the positive and in the negative phase sequence;

(c) reproduce the detailed response of the power-generating module and its control blocks during balanced and unbalanced AC network faults in the valid frequency range;

(d) include the power plant level control and the power plant relevant functionalities if applicable;

(e) include the frequency dependence of the lines and/or cables in the power-generating facility;

(f) represent the power park module (PPM) transformers models including saturation, resistors, filter, breaker and AC arrester in the valid frequency range;

(g) include all the relevant protection function models for the relevant interaction studies;

(h) be capable to be used for the numerical calculation of the frequency dependent impedance of the PPM at the connection point (impedance amplitude and impedance phase angle) in the frequency range that the model is valid);

(i) in the case that encrypted detailed EMT models are accepted by the relevant system operator or the relevant TSO, the relevant system operator or the relevant TSO shall have the right to specify the model encryption based on national regulations (for example the model structure and the signal interfaces to be observable in the network studies);

(j) the above listed simulation model requirements and information must not violate manufacture’s intellectual property.

1.9.2.3 Frequency dependent impedance modelling requirements

For the purpose of frequency domain simulation for the risk assessment of the resonance stability of the power plant module, the relevant system operator or the relevant TSO shall have the right to request from the power-generating facility owner the frequency dependent impedance model of the power-generating facility at the point of interconnection to the grid. In that case, without prejudice to the Member State's rights to introduce additional requirements, the following requirements shall apply:

(a) The impedance model of the power-generating facility shall be requested at least in the range 5.0 Hz – 2500 Hz; As an additional requirement, the relevant system operator can extend the required applicability of the model to up to 9000 Hz;

(b) the relevant system operator or the relevant TSO shall have the right to request the calculation of the impedance model of the power-generating facility either numerically (using the EMT model) or analytically (using transfer function);

(c) the relevant system operator or the relevant TSO shall have the right to request the impedance profile of the power-generating facility at the connection point through the whole operating range and control modes of operation;

(d) the impedance model of the power-generating facility shall be provided for both the positive and for the negative phase sequence;

(e) the power-generating facility owner shall take into account the influence of the power generating module control and measurement system as other parts of the power generating module which influences the output impedance in the specified frequency range;

(f) the power-generating facility owner shall specify and justify simplifications made in the calculation of the impedance model.

For the purpose of the steady-state harmonic component examinations of the PPMs, the TSO shall have the right to request from the HVDC system owner the harmonic component emissions in the positive and in the negative sequence considering a set of frequency dependent impedances of the grid connection point.

In case Battery Energy Storage Systems (BESS) are included in a facility and having an impact on response of the system frequency and voltage at the POC the simulation model must include the complete characteristics of all subsystems (and/or different equipments) assembled at the connection point.

The capability characteristics in generation mode and demand mode must be included in the facility simulation model and assembled at the connection point of the combined facility.

1.9.3 HVDC requirements

1.9.3.1 RMS modelling requirements

For the purpose of electromechanical (RMS) simulation models which are used in network studies, the relevant TSO shall have the right to specify the modelling requirements. For the national implementation of the NC HVDC (and specifically of the Article 54) without prejudice to the Member State's rights to introduce additional requirements, the RMS simulation models of the HVDC system shall:

(a) be valid for the specified operating range and all control modes of the HVDC system;

(b) include representation of HVDC converter unit, HVDC lines/cables and control systems that influence the dynamic behaviour of the HVDC transmission system in the specified time frame;

(c) include the relevant protection function models as agreed between the relevant TSO and the HVDC system owner;

(d) be open-source generic model for RMS simulations delivered for cross-border network stability studies. Open-source generic RMS models require simplified converter control representation due to intellectual property rights. This could impact the model performance and model accuracy.

(e) In the case that encrypted detailed RMS models are accepted by the relevant TSO, the relevant TSO together with the HVDC system owner shall specify the requirements of the model encryption (for example use of source code, the model structure and the signal interfaces to be observable in the network studies) according to national regulations. The agreement should be made on project specific basis according to national regulations;

(f) The above listed simulation model requirements and information must not violate manufacture's intellectual property.

1.9.3.2 EMT modelling requirements

For the purpose of electromagnetic transient simulations (EMT), the relevant TSO shall have the right to specify the simulation model requirements.

For the national implementation of the NC HVDC (and specifically the Article 54) without prejudice to the Member State's rights to introduce additional requirements, the EMT simulation models of the HVDC system shall:

(a) be valid at least in the frequency range 0.1Hz to 2500 Hz for relevant studies;

(b) be valid for the specified operating range and all operation modes of the HVDC system in both the positive and in the negative phase sequence;

(c) be able to reproduce the detailed transient response of the HVDC system and its control blocks (including synchronisation) during balanced and unbalanced AC network faults in the valid frequency range;

(d) include an accurate representation of the semiconductor valves (switching patterns if required), the frequency dependency of the HVDC system lines and sufficient representation of communication systems instruments;

(e) represent transformers models (including saturation), resistors, filter, breaker, AC and DC arrester in the valid frequency range;

(f) include all the control and protection models as agreed between the relevant TSO and the HVDC system owner (under/overvoltage, overcurrent, chopper and frequency sensitive control functions);

(g) be capable to be used for the numerical calculation of the frequency dependent impedance of the HVDC converter station (magnitude and phase angle of the Z(f)) in the frequency range that the model is valid;

(h) In the case that encrypted EMT models are accepted by the relevant TSO, the relevant TSO together with the HVDC system owner shall specify the level of the model encryption (for example the model structure and the signal interfaces to be observable in the network studies); The agreement should be made on project specific basis according to national regulations; In case public documents or standards are available, it should be utilised;

(i) The above listed simulation model requirements and information must not violate manufacture's intellectual property.

1.9.3.3 Frequency dependent impedance model requirements

For the purpose of the risk assessment of the resonance stability of the HVDC converter station, the TSO shall have the right to request from the HVDC system owner the frequency dependent impedance model of the HVDC converter station at the AC side. In that case, without prejudice to the Member State's rights to introduce additional requirements, the following requirements shall apply:

(a) The impedance model of the HVDC converter station shall be requested in the frequency range 5Hz till 2500 Hz; The TSO has the right to extend the required applicability of the model up to 9000 Hz;

(b) The relevant TSO together with the HVDC owner shall agree if the calculation of the impedance model of the HVDC converter station will be either numerically (using the EMT model) or analytically (using transfer function) or both; In the case of numerical calculation, the TSO shall specify the frequency steps where the impedance is provided. The number of different frequency step shall be reasonably limited to provide acceptable results and at the same time limit the simulation effort and data storage to an acceptable amount. In both cases, the impedance model should have a sufficient accuracy in a defined range around its operating point;

(c) The relevant TSO shall have the right to request the impedance model of the HVDC station through the specified operating range and all control modes of operation;

(d) The impedance model of the HVDC converter station shall be provided for both the positive and for the negative phase sequence;

(e) The HVDC system owner shall take into account the influence of the whole HVDC unit control and measurement system as well as other parts of the HVDC unit which influences the output impedance in the specified frequency range; If coupling between different frequencies exists in a given frequency range, this should be sufficiently represented;

(f) The HVDC system owner shall specify and justify simplifications made in the calculation of the impedance model.

1.10 Operational Notification Procedure – focusing simulation model

Initial compliance of all new installations shall be demonstrated during the operational notification procedure according to the provisions of each CNC as part of the process of connecting to the system. Each of the CNCs includes similar provisions as summarised below.

NC RfG 2016/631 – Power Generating Facilities

Title III Chapter 1 - Operational Notification Procedure for New Power Generating Modules

This chapter sets out the requirements for new generators to demonstrate their compliance with title II (articles 13-28), stating the detailed technical specifications for generators, as part of their connection process. The operational notification process sets out the steps through which demonstration of compliance with these requirements can be done, including steady state and dynamic performance as required by chapters 2-7 of title IV.

The operational notification procedure is specified for each type A-D of power-generating modules and are, broadly defined, as follows.

Type A PGM:

Submission of an installation document as required by the RSO to a minimum standard as detailed in article 30. For type A, EqC can cover the entire PGU or component.

In principle, EqCs should be the base documents used in the compliance process during the notification procedure. The scope of the use of EqCs is specified by the authorized certifier. The RSO must specify according to NC RfG, Article 41(3)(g): Conditions and procedures for the use of relevant equipment certificates issued by an authorized certifier and make it public available.

EqCs typically certify the compliance of specific equipment, but not of the entire power generating module. However, EqCs may provide essential information such as type-test results, proved manufacturer information (e.g., parameter ranges and functional characteristics) and a validated equipment model and, hence, contribute to the subsequent assessment at PGM level at the connection point.

There is no specific requirement in title IV to demonstrate performance, since Articles 40 and 41 specify that the owner of the power-generating facility may rely upon EqCs.

For type A, the installation document shall include the EqCs and other relevant information.

Types B, C, D PGM: – use of equipment certificates (EqCs)

For Type B, C and D PGMs site-specific compliance shall be evidenced in addition to the type tests performed once, for example, during its unit certification process.

However, as per type A, EqCs typically certify the compliance of specific equipment but not of the entire power generating module. However, EqCs may provide essential information such as type-test results, proved manufacturer information (e.g., parameter ranges and functional characteristics) and a validated equipment model and, hence, contribute to the subsequent assessment at PGM level at the connection point.

As part of the evidence used to prove compliance with the relevant grid codes in a corresponding assessment as detailed below, the use of EqCs issued by an authorized certifier is allowed.

Type B-C PGM:

A Power Generating Module Document (PGMD) is to be provided to the RSO for each power-generating module by the power-generating facility owner (or authorized certifiers, based on national implementation of the RfG) including a statement of compliance. The PGMD is to include information as specified by the RSO within the scope set out in article 32 and must include, as required, compliance test reports as required in chapters 2-4 of title IV, including the use of actual, measured values during tests and studies demonstrating steady state and dynamic performance as required in chapters 5-7 of title IV. Simulations can be based on validated equipment models provided by the EqCs. On acceptance of a complete and satisfactory PGMD, the RSO will issue a final operational notification to the facility owner.

The PGMD could include EqCs for the various parts of a unit, a module or the facility.

Type D PGM:

For type D generators, the Operational Notification issuing process is more complex, considering their size and potential impact on the system. Due to the extent of the services and technical capabilities that this type of generator should be able to provide or demonstrate, these must undergo more detailed testing procedures.

The operational notification procedure for type D generators comprises:

Energisation operational notification (EON)

An EON entitles the facility owner to energise the equipment using the grid connection, but not to generate power, and is subject to the agreement with the RSO on protection and control settings.

Interim operational notification (ION)

An ION entitles the facility owner to operate the power-generating module and to generate power for a limited period, which is specified by the RSO but will not extend beyond 24 months (an extension of this period may be granted if a request for derogation is made to the RSO before the expiry of that period in accordance with the derogation procedure specified in article 60). Issue of an ION is subject to completion of the data and study review as specified/requested by the RSO and must include simulation models and studies demonstrating steady state and dynamic performance as required by chapters 5-7 of title IV, and details of intended compliance tests to be undertaken to fulfil requirements in chapters 2-4 of title IV. Tests may, to some extent, be substituted by the provision of EqCs. Simulations can be based on validated equipment models provided by the EqCs.

Final operational notification (FON)

A FON confirms the completion of the operational notification process and allows the power-generating facility owner to operate a power-generating module using the grid connection.

As part of the FON, the RSO and the facility owner should reach an agreement on how compliance will be monitored over the life cycle of the generator, considering possible changes in generator software, hardware, and changes in the connection point characteristics, like short-circuit power and frequency impedance characteristics. This will be further detailed in the IGD on Compliance Monitoring.

Limited Operational Notification (LON)

A type D generator holding an FON must inform the RSO with whom a connection agreement has been made if the equipment is affected by a temporary loss of capability, is subject to significant modification affecting performance, or is affected by equipment failure affecting performance, whenever this is expected to last for more than 3 months.

Issue of a LON by the RSO should be subject to identification of the means and timescales by which the non-compliance will be resolved and can last for a maximum of 12 months without requiring further derogation. An extension of the period of validity of the LON may be granted upon a request for a derogation made by the RSO before the expiry of that period, in accordance with the derogation described in Title V.

NC DCC 2016/1388 – Demand Facilities

Title II Connection of Transmission Connected Demand Facilities, Transmission Connected Distribution Facilities and Distribution Systems

Chapter 3 – Operational Notification Procedure

The requirements in 2016/1388 are like those in 2016/631. This chapter states that each transmission-connected demand facility owner or DSO to which one or more of the requirements in Title II (articles 12-21) apply shall confirm to the RSOs its ability to satisfy these by following an operational notification procedure.

Unlike in EU regulation 2016/631, there is no distinction in terms of scale or connection voltage to the process which comprises:

Energisation Operational Notification (EON)

This allows energisation of the facility subject to satisfying the RSO of preparations, including agreement of protection and control settings.

Interim Operational Notification (ION)

As with 2016/631, an ION entitles the facility owner to operate connected to the system for a limited period – which is to be specified by the RSO but will not extend beyond 24 months. An extension of this period may be granted if a request for derogation is made to the relevant TSO before the expiry of that period in accordance with the derogation procedure specified in article 50.

Issue of an ION is subject to completion of the data and study review as specified and must include simulation models as specified in article 21 and studies demonstrating steady state and dynamic performance as required in articles 43 and 46(7).

An itemised statement of compliance supported by any EqC cited in this is also required.

Final operational notification (FON)

An FON confirms the completion of the operational notification process and allows the facility to operate without a time limitation.

NC HVDC 2016/1447 – HVDC Facilities

Title V Operational Notification Procedure for Connection

The HVDC requirements are very similar to those in EU regulation 2016/631, but are subdivided into two sections as follows:

Chapter 1 – Connection of New HVDC Systems

Chapter 2 – Connection of New DC-connected Power Park Modules

Each HVDC system owner is required to demonstrate to the TSO that it complies with the relevant requirements set out in Titles II-IV articles 11-37 and 46-54 for general HVDC systems, and additionally title III for DC connected PPMs (articles 38-45 but also articles 13-22 of 2016/631) at the connection point through the operational notification procedure.

Similarly, to 2016/1388, but again unlike EU regulation 2016/631, there is no distinction in terms of scale or connection voltage to the process which comprises:

Energisation Operational Notification (EON)

This allows connection and energisation of the facility subject to satisfying the TSO of preparations, including agreement of protection and control settings at the connection point.

Interim Operational Notification (ION)

As with 2016/631, an ION entitles the facility owner to operate connected to the system for a limited period – which is to be specified by the TSO but will not extend beyond 24 months (an extension of this period may be granted if a request for derogation is made to the RSO before the expiry of that period in accordance with the derogation procedure specified in Title VII).

Issue of an ION is subject to completion of the data and study review as specified and must include simulation models as specified in article 54 and studies demonstrating steady state and dynamic performance as required in titles II-IV. An itemised statement of compliance supported by any EqCs cited in this is also required plus details of any intended compliance tests according to article 70 and article 71 (DC-connected PPMs).

Final operational notification (FON)

A FON confirms the completion of the operational notification process and allows the facility to operate without a time limitation.

To be granted an FON, the facility owner must already hold an ION. Completion of the FON is subject to completion of any outstanding requirements set out in the ION and must include submission, by the facility owner, of an itemised statement of compliance and an update of the technical data, studies and models provided as part of the ION but now also validated and using actual values found through tests.

Limited Operational Notification (LON)

A DC-connected PPM with an FON must inform the RSO with whom a connection agreement has been made if the equipment is affected by a temporary loss of capability, is subject to significant modification affecting performance, or is affected by equipment failure affecting performance, whenever this is expected to last for more than 3 months.

Issue of a LON by the RSO should be subject to identification of the means and timescales by which the non-compliance will be resolved and can last for a maximum of 12 months without requiring further derogation.

1.11 Derogations to the CNCs

Derogations to 2016/631, 2016/1388, 2016/1447:

In case of a derogation request, the connection procedure for the Operational Notification could be put on hold or an ION according to NC RfG, Article 35(5) could be issued depending on the severity of the derogation request. Details to be provided in the derogation process depending on the relevant regulatory authority.

1.12 Use of simulation models in the compliance assessment process

The following three tables provide a non-binding guideline on the requirements for which the compliance could be verified via application of equipment certificates, supplementary onsite compliance tests and/or supplementary compliance simulations based on a verified electrical simulation model.

To demonstrate the compliance of the required capability the power-generating facility owner may use equipment certificates to demonstrate the compliance issued by an authorized certifier to demonstrate compliance with the NC requirement. In that case, the equipment certificates shall be provided to the RSO as a part of the installation document or the PGMD.

The tables below indicate the fundamental basis for issuing an EqC based on either testing and/or simulation.

It is at the discretion of the RSO to decide whether a EqC is deemed sufficient or additional test/simulation is required. The detailed list of compliance tests and simulations to be foreseen in EqCs may be specified at a national level.

The capability requirements listed in the table below are the minimum requirements for being granted a grid connection. Capability requirements marked with * are optional.

National implementation could require additional capabilities if the grid system needs more specific services as specified in the NC RfG, but this is a national consideration.

The NC RfG requirements specifying the minimum compliance verification requirements are as follows:

EU Regulation 2016/631 (NC RfG)

Title IV Compliance: Chapters 2-7 – Compliance testing & simulations

Chapter 2 – Compliance Testing for Synchronous Power Generating Modules

Article 44 – Compliance tests for type B synchronous power-generating modules

Article 45 – Compliance tests for type C synchronous power-generating modules

Article 46 – Compliance tests for type D synchronous power-generating modules

Chapter 3 – Compliance Testing for Power Park Modules

Article 47 – Compliance tests for type B power park modules

Article 48 – Compliance tests for type C power park modules

Article 49 – Compliance tests for type D power park modules

Chapter 4 – Compliance Testing for Offshore Power Park Modules

(Note that this is only for AC-connections. DC-connected offshore PPMs are governed by 2016/1447). Selected criteria only from articles 44 and 48.

The following Table 1 provides an overview of NC RfG compliance verification requirements and related capability requirements.

The following table is a recommendation for the different way of demonstrating the compliance in the connection point using EqC and/or additional verification.

The first four columns depict for each NC requirement and the related NC article stating the compliance requirement.

The last three columns depict the compliance assessment methodology with onsite testing CVT and/or CVS supplementing the relevant EqCs.

For PGM type A and B application of EqC is recommended, but it’s up to the RSO to decided which compliance assessment method the PGM owner must follow.

EU regulation 2016/631 NC RfG compliance tests and simulations

NC RfG requirements – capability and compliance verification				Compliance assessment based on EqC and CVT / CVS		
NC RfG Articles Title II – Requirements	**Description of capability requirement**	**PGM Type**	**NC RfG Articles Title IV - Compliance**	**EqC (minimum requirement)**		**CVT / CVS PPM&SPGM**
				PPM	**SPGM**	
13(2)	Limited Frequency Sensitive Mode – Overfrequency (LFSM-O)	≥A	44, 47, 51(1)(2), 54(2)	T for A; T&S for ≥B	T for A; T&S for ≥B	M (≥C)
15(2)(a)(b)	Active power controllability	≥C	48(2)	T	-	M
15(2)(e)	Frequency restoration control*	≥C	45(4), 48(5)	Co(T)	Co(T)	Co
15(2)(d)	Frequency Sensitive Mode (FSM)	≥C	45(3), 48(4), 51(3), 55(3)	T&S	T&S	M
15(2)(c)	Limited Frequency Sensitive Mode-Underfrequency (LFSM-U)	≥C	45(2), 48(3), 51(2). 55(2)	T&S	T&S	M
21(2)	Synthetic inertia during very fast frequency variations*	≥C	55(5)	Co(S)	-	-
17(3), 20(3)	Recovery of active power after a fault	≥B	51(4), 54(5)	S	S	-
14(3)	Fault ride-through capability < 110 kV	B	51(3)	S	S	-
		C	54(4)	S	S	-
16(3)	Fault ride-through capability ≥ 110 kV	D	53(3), 56(3)	S	S	-
15(5)(a)	Black start capability*	≥C	45(5)	-	Co(T)	Co
15(5)(b)	Capability to take part in island operation*	≥C	51(4)	-	S	Co
15(5)(c)	Quick re-synchronisation capability	≥C	45(6)	-	T	-
18(2)(b)	Reactive power capability at maximum capacity	≥C	45(7), 51(5)	-	T&S	M
18(2)(c)	Reactive power capability below maximum capacity	≥C	45(7), 51(5)	-	T&S	M
19(2), 21(3)(f)	Power oscillation damping control*	D	55(7)	Co(S)	Co(S)	Co
20(2)(b), (c)	Fast fault current injection*	≥B	54(3)	Co(S)	-	-
21(3)(b)	Reactive power capability at maximum capacity	≥C	48(6), 55(6)	T&S	-	M
21(3)(c)	Reactive power capability below maximum capacity	≥B	48(6), 55(6)	T&S	-	M
21(3)(d)	Reactive power control modes	≥B	48(7), 48(8), 48(9)	T	-	M

Note 1: Compliance verification requirements for AC-connected offshore PPMs are like those for onshore PPMs.

Note 2: In the column "PGM Type", the text:

≥A means that it applies to PGM Types A, B, C and D;

≥C means that it applies to PGM Types C and D.

Note 3: the colour marking is made to focus the compliance verification actions involving simulation models

Table legend	
-	Not applicable
*	Non-mandatory capability

Co	Conditional – if the functionality exists or is required by the RSO, it must be verified by verification tests or by simulations
CVS	Compliance verification supplementary to the EqC: CVS: Compliance Verification based on electrical Simulation model
CVT	Compliance verification supplementary to the EqC: CVT: Compliance Verification based on onsite Testing
EqC	Equipment Certificate – based on T / S
M	Mandatory capability to be verified by T and/or S
NR	National Requirements for compliance verification – recommended to be established in Member State regulation
O	Optional – EqC may be used instead of some of the tests
S	EqC certificate is based on Simulations
T	EqC certificate is based on Tests
T&S	EqC certificate is based on both simulations and tests

Table 1. The NC RfG Compliance verification requirements overview

EU regulation 2016/1388 NC DCC compliance tests and simulations

The NC DCC requirements specifying the minimum compliance verification requirements are as follows:

Title IV Compliance: Chapters 2-3 – Compliance testing & simulations

Chapter 2 – Compliance Testing

Article 36 – Common provisions for compliance testing

Article 37 – Compliance testing for disconnection and reconnection of transmission-connected distribution facilities

Article 38 – Compliance testing for information exchange of transmission-connected distribution facilities

Article 39 – Compliance testing for disconnection and reconnection of transmission-connected demand facilities

Article 40 – Compliance testing for information exchange of transmission-connected demand facilities

Article 41 – Compliance testing for demand response active power control, reactive power control and transmission constraint management

The following Table 2 provides an overview of the NC DCC compliance verification requirements and related capability requirements.

The following table is a recommendation for the different way of demonstrating the compliance in the connection point using EqC and/or additional verification.

The first four columns depict for each NC requirement and the related NC article stating the compliance requirement.

The last three columns depict the compliance assessment methodology with onsite testing CVT and/or CVS supplementing the relevant EqCs.

The harmonized guideline for issuing an EqC is stating the conditions and methodology to be applied.

EU regulation 2016/1388 NC DCC compliance tests and simulations:

NC DCC requirements – capability and compliance verification for a transmission-connected demand facility, transmission-connected distribution facility, or closed distribution system			Compliance assessment based on EqC and CVT/CVS	
NC DCC articles Title II – Requirements	**Description of capability requirement**	**Article NC DCC (Title IV - Compliance)**	EqC (minimum requirement) Equipment / components	CVT/CVS
12	General frequency requirements	36 (1)	T	M
13	General voltage requirements	36 (1)	T	M
19	Disconnection and reconnection of transmission-connected distribution facilities	37(1)	T	M (T)
18(3)	Information exchange of transmission-connected distribution facilities	38(1)	T	M (T)
19	Disconnection and reconnection of transmission-connected demand facilities	39(1)	T	M (T)
18(3)	Information exchange of transmission-connected demand facilities	40(1)	T	M (T)
15	Reactive power capability simulation	43.1(c)	-	M (S)
15(3)	Active control of reactive power	43.2	-	M (S)
15(1), 15(2)	Reactive power capability	44(1)(c), 41(2)(c)	-	M (S)
28(2)(a), 12(1), (2)	Operating across the frequency ranges	NR	-	-
28(2)(k)	Not disconnect from the system due to RoCoF	NR	-	-
28(2)(b)(c)	Operating across the voltage ranges specified in Article 13, standards, Article 6, and Article 9(1)	NR	-	-
28(2)(d)(f)(g)(h), 28(l)	Demand modification	41 (1)	T	M (T)
28 (3)	Disconnection or reconnection of static compensation facilities	41 (2)	T	M (T)
29(2)(a)	Operating across the frequency ranges specified in Article 12(1) and the extended range specified in Article 12(2)	NR	-	Co

29(2)(b)	Operating across the voltage ranges specified in Article 13, standards, Article 6, and Article 9(1)	NR	-	-
30	Demand units with demand response very fast active power control	45 (1), (2)	-	M (S)

Note 1: the colour marking is made to focus the compliance verification actions involving simulation models

Table legend	
-	Not applicable
*	Non-mandatory capability
Co	Conditional – if the functionality exists or is required by the RSO, it must be verified by verification tests or by simulations
CVS	Compliance verification supplementary to the EqC: CVS: Compliance Verification based on electrical Simulation model
CVT	Compliance verification supplementary to the EqC: CVT: Compliance Verification based on onsite Testing
EqC	Equipment certificate – based on T / S
M	Mandatory capability to be verified by T and/or S
NR	National Requirements for compliance verification – recommended to be established in Member State regulation
S	EqC certificate is based on Simulations
T	EqC certificate is based on Tests
T&S	EqC certificate is based on both tests and simulations

Table 1. The NC DCC Compliance verification requirements overview

The NC HVDC requirements specifying the minimum compliance verification requirements are as follows:

EU Regulation 2016/1447 (NC HVDC)

Title VI Compliance: Chapters 2-3 – Compliance testing & simulations

Chapter 2 – Compliance Testing

Article 69 – Compliance testing for HVDC systems

Article 70 – Compliance testing for DC-connected PPMs and remote end HVDC convertor units

The following Table 3 provides an overview of the NC HVDC compliance verification requirements and related capability requirements.

The following table is a recommendation for the different way of demonstrating the compliance in the connection point using EqC and/or additional verification.

The first four columns depict for each NC requirement and the related NC article stating the compliance requirement.

The last three columns depict the compliance assessment methodology with onsite testing CVT and/or CVS supplementing the relevant EqCs.

EU regulation 2016/1447 NC HVDC compliance tests and simulations:

NC HVDC - Requirements – capability and compliance verification			Compliance assessment based on EqC and CVT/CVS	
NC HVDC articles Title II & III requirements	Description of capability requirement	NC HVDC Articles Title VI - Compliance	EqC (minimum requirement) DC connected - PPM	CVT/CVS HVDC
69	Roles and responsibilities	69	-	-
57, 70(3)(f), 70.3(g)	Conditions and procedures for use of relevant equipment certificates	70(3)	-	-
13(1)(a), 13(1)(d), 41, 48(3) NC RfG	Active power controllability	71(9), 72(10)	T	M
20, 48	Reactive power capability	71(4), 72(2), 72(3)	T	M
21(3) NC RfG	Power factor control	71(5), 72(6)	T	M
22(3), 22(4), 22(5), 40, 48	Voltage control mode	71(5), 72(4)	T	M
Article 48(4) NC RfG	FSM response	71(6), 72(11)	T	M
Article 47.3 NC RfG	LFSM-O response	71(7), 72(8)	T	M
Article 48.3 NC RfG	LFSM-U response	71(8), 72(9)	T	M
Article 45.5 NC RfG	Frequency restoration control	72(12)	T&S	M
13.2	Ramp rates	71(10)	T&S	M
37	Black start capability*	71(11)	-	Co(T)
39 Article 13, 15 NC RfG	Frequency stability – response requirements	72(12)	-	M
44	Power Quality	NR	-	NR

Note 1: the colour marking is made to focus the compliance verification actions involving simulation models

Table legend	
-	Not applicable
*	Non-mandatory capability
Co	Conditional – if the functionality exists or is required by the RSO, it must be verified by verification tests or by simulations
CVS	Compliance verification supplementary to the EqC: CVS: Compliance Verification based on electrical Simulation model
CVT	Compliance verification supplementary to the EqC: CVT: Compliance Verification based on onsite Testing
EqC	Equipment certificate – based on T / S
I/C	Individually or collectively as part of demand aggregation - Role of demand aggregator?
M	Mandatory capability to be verified by T and/or S

NR	National Requirements for compliance verification – recommended to be established in Member State regulation
O	Optional – EqC may be used instead of some of the tests
S	EqC certificate is based on Simulations
T	EqC certificate is based on Tests
T&S	EqC certificate is based on both simulations and tests

Table 2. The NC HVDC compliance verification requirements overview

1.13 Role of Third Parties – focusing simulation models

International standards with specifics on simulation model validation, such as, IEC 61400-27-2 2020 (wind farms), consider the following stakeholders as potential users of the model validation procedures:

- TSOs and DSOs need procedures to validate the accuracy of the models which they use in power system stability studies;
- PGFOs are typically responsible to provide validation of their models to TSO and/or DSO prior to plant commissioning;
- manufacturers will typically provide validation of the equipment models to the owner.
- developers of modern software for power system simulation tools may use the standard to implement validation procedures as part of the software library;
- certification bodies in case of independent model validation;
- education and research communities, who can also benefit from standard model validation procedures.

1.14 Involvement of Third Parties – focusing simulation models

According to IGD “, GENERAL GUIDANCE ON COMPLIANCE verification – Compliance testing and use of Equipment Certificates”, **Third parties** could be any additional stakeholder to the owner of a PGM and must be understood as authorized certifiers and/or authorized laboratories.

The role of authorized certifiers and authorized laboratories is to assure independency, harmonized methodology, criteria, and degree of evaluation of equipment or components versus CNC requirements (mandatory and non-mandatory) as was specified in EC regulation and national regulation for EU countries.

With regard to the simulation models to be used in the compliance verification process, the following steps are usual when a third party is involved:

1) Simulation model development: The manufacturer of equipment or the PGM owner shall run a set of laboratory or field test campaign in order to fine tune the manufacturer specific or generic model, minimizing the deviation between the simulation and test results magnitudes to ensure compliance with the tolerances or maximum deviations allowed in the acceptance criteria of their customers.

2) Simulation model validation: The authorized laboratory, which is usually contracted by the manufacturer or PGM owner, to prepare a validation model report to comply with.

3) Simulation model certification: The model validation report shall be supplied to a certification body, that shall assess if the report complies with the validation criteria that is specified in an evaluation programme, and then, the authorized certifier shall issue a model certificate. Third parties are also used to verify compliance of Plant facility based on EqCs when these are available and using correspondent validated model. In case EqCs are not available, for example in case of big power generating unit, third parties can be involved in the verification test at site, providing final assessment eventually based on simulation, based on validated simulation model. Sometimes tests for model validation are part of the site activities. Verification of compliance: The accredited laboratory shall use the simulation model to run the compliance simulations established in the evaluation programme and prepare a simulation report. The simulation report shall be provided to authorized certifier, to be issued the certificate of compliance.

2 FURTHER INFORMATION

- General Guidance On Compliance Verification – Compliance Testing and use of Equipment Certificates, Published – Nov 2021
- https://www.aemo.com.au/news/-/media/Files/Electricity/NEM/Security_and_Reliability/System-Security-Market-Frameworks-Review/2018/Power_Systems_Model_Guidelines_PUBLISHED.pdf

3 INTERDEPENDENCIES

3.1 Between CNCs

This IGD covers the compliance verification activities related to applying simulation models in the compliance verification process required in the three Connection Network CNCs –2016/631 NC RfG; 2016/1388 NC DCC; 2016/1447 NC HVDC.

3.2 To other NCs

System Operation Guideline (SO GL) / Network Code on Emergency and Restoration (NC ER)

- Black Start services and monitoring under the scope of NC ER and SO GL.
- Coordinated synchronisation

3.3 System characteristics

All compliance verification activities must relate to the connection point for the facility under compliance verification.

4 COORDINATION

4.1 TSO-MS-NRA

If compliance is not established, the right to connect to the system or to import/export power through the connection point can be withheld or removed from the facility owner by the RSO; alternatively, a derogation could be requested from the NRA.

4.2 RSO – Grid User

Compliance Monitoring is joint task for the TSO/RSO and the facility owner and is required as part of the connection procedure and must be maintained during the life cycle of the facility.

The compliance monitoring subject will be addressed in detail in the IGD on compliance verification – compliance monitoring.

5 REFERENCES

[1] General Guidance on Compliance Verification – Compliance Testing and use of Equipment Certificates, Published – Nov 2021 https://www.entsoe.eu/Documents/Network%20codes%20documents/NC%20RfG/210730_IGD_Guidance_on_Compliance_Verification.pdf

[2] GC ESC Expert Group Interaction Studies and Simulation Models (EG ISSM), REPORT DRAFT 01.10.2021 https://eepublicdownloads.azureedge.net/clean-documents/Network%20codes%20documents/GC%20ESC/ISSM/EG_ISSM_Final_Report.pdf

[3] Cigre B4.67 Technical Brochure: AC side harmonics and appropriate harmonic limits for VSC HVDC

[4] Cigre TB 563 "Modelling and Simulation Studies to be performed during the lifecycle of HVDC Systems" in Section 3.3.2 AC

[5] IEEE Task Force on Turbine-Governor Modeling, "Dynamic Models for Turbine-Governors in Power System Studies," IEEE, Technical Report PES TR1, Jan. 2013.

[6] CIGRE Task Force C4.02.25, "Modeling of Gas Turbines and Steam Turbines in Combined Cycle Power Plants," CIGRE Technical Brochure 238, Dec. 2003.

[7] P. Pourbeik, B. Agrawal, S. Patterson, R. Rhinier, "Modeling of synchronous generators in power system studies," CIGRE Science & Engineering, No. 6, October 2016.

[8] IEEE Std. 421.5 "IEEE Recommended Practice for Excitation System Models for Power System Stability Studies,", IEEE May 2016.