Grid Code Modification Proposal Form Email to gridcode@eirgrid.com	

Title of Modification Proposal:

Non-Mandatory Grid Forming Requirements for HVDC Units

MPID (EirGrid Use Only): 349

Date:	10/06/2026
Company Name:	EirGrid
Applicant Name:	EirGrid
Email Address:	Gridcode@eirgrid.com
Grid Code Version:	16
Grid Code Section(s) Impacted by Modification Proposal:	• PC.A6 • CC.7.5 • Definitions

Modification Proposal Justification:

Purpose:

The purpose of this modification is to incorporate grid forming capabilities for Interconnectors in anticipation of the upcoming HVDC 2.0 requirements. The minimum grid forming technical requirements for Interconnectors introduced in this modification are non-mandatory.

Background:

The European Union framework for HVDC systems, established under Commission Regulation (EU) 2016/1447 [1], is currently being updated through the HVDC 2.0 process. Following a request from the European Commission, ACER developed proposed amendments under the Connection Network Codes 2.0 programme. This work led to Recommendation 01/2024 [2], issued in December 2024, which sets out a revised NC HVDC 2.0 and includes provisions on grid forming capability.

ACER's public consultation on the draft amendments for HVDC 2.0 showed support for the inclusion of grid forming provisions, while also emphasising that these should remain flexible rather than mandatory for all HVDC projects. With respect to feedback received, ACER concluded that grid forming requirements should be incorporated in the Network Codes, leaving flexibility for mandatory or voluntary implementation to the relevant System Operators [3]. Within the proposed NC HVDC 2.0 text, Article 14 introduces grid forming capability on a functional, performance-based basis, without prescribing the converter design or its internal control implementation [2]. This regulation is pending approval by the European Commission.

ENTSO-E also recommends that, pending adoption and implementation of amended Connection Network Codes, TSOs update the relevant national technical connection requirements as soon as possible [4]. It also advises that, without such updates, key technologies, including grid forming converters, remain outside the current framework, increasing operational and cross-border risks.

International precedent supports this approach. In Great Britain, Grid Code Modification GC0137 introduced a non-mandatory minimum specification for grid forming capability in 2022 [5]. In Germany, national HVDC

requirements are set out in VDE-AR-N 4131 and supported by guidance on grid forming behaviour and verification [6], [7].

At national level, the All-Island Grid Forming Strategy, published by EirGrid and SONI in February 2026 [8], was developed through an eight-month programme of engagement with industry stakeholders during 2025. It sets out a structured pathway for the integration of grid forming capability on the All-Island Power System. The Strategy identifies the need for Grid Code amendments and proposes a staged approach beginning with non-mandatory provisions and operational trials, followed by mandatory requirements aligned with the entry into force of RfG 2.0 and HVDC 2.0.

Introducing non-mandatory HVDC grid forming provisions at this stage therefore provides early visibility of emerging requirements and supports alignment with both the All-Island Grid Forming Strategy and anticipated European developments. This modification proposal also supports the development of operational experience with HVDC grid forming behaviour, as captured in the "All Island Operational Policy Roadmap" [9].

This Grid Code modification should be understood as an intermediate step supporting the non-mandatory phase identified in the All-Island Grid Forming Strategy. The proposed requirements are non-mandatory. Existing HVDC installations would not be required to retrofit equipment or change their operating modes as a result of this proposal. Where grid forming capability is declared by an interconnector owner, this modification defines the expected behaviour at the Grid Connection Point and provides a basis for assessment and compliance in grid forming mode.

The drivers for this Grid Code modification reflect the evolving operational needs of the All-Island power system. As the level of synchronous generation declines, system inertia and system strength decrease, increasing the likelihood of interactions between converter-based resources and creating new stability challenges. Grid forming controls allow converter-based resources like HVDC, BESS, wind and solar PV to provide stabilising functions traditionally delivered by synchronous machines, supporting secure operation as the system transitions to higher levels of renewable generation [9]. When this capability is provided, it will enhance the strength of the Transmission System and will support stable and secure operation with increased shares of renewable generation.

References

[1] European Commission, "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," *Official Journal of the European Union*, Aug. 2016. [Online]. Available: https://eur-lex.europa.eu/eli/reg/2016/1447/oj/eng

[2] Agency for the Cooperation of Energy Regulators (ACER), "Recommendation No. 01/2024 on reasoned proposals for amendments to Commission Regulation (EU) 2016/1447," Dec. 2024. [Online]. Available: https://www.acer.europa.eu/sites/default/files/documents/Recommendations/ACER_Recommendation_01-2024_on_NC_HVDC.pdf

[3] Agency for the Cooperation of Energy Regulators (ACER), "Annex 3 to Recommendation No. 01/2024," Dec. 2024. [Online]. Available: https://www.acer.europa.eu/acer-recommendation-01-2024-reasoned-proposals-amendments-network-code-requirements-grid-connection-high-voltage-direct-current-systems-and-direct-current-connected-power-park-modules

[4] ENTSO-E, "ENTSO-E position on the need for national connection requirements to ensure EU power system stability," Dec. 22, 2025. [Online]. Available: https://www.entsoe.eu/2025/12/22/entso-e-position-on-the-need-for-national-connection-requirements-to-ensure-eu-power-system-stability/

[5] Office of Gas and Electricity Markets (Ofgem), "Grid Code Modification GC0137: Authority Decision," Jan. 2022. [Online]. Available: https://www.ofgem.gov.uk/decision/grid-code-modification-gc0137-authority-decision

[6] VDE FNN, "VDE-AR-N 4131: Technical Connection Rule for the connection of HVDC systems and generation plants connected via HVDC systems," Mar. 2019. [Online]. Available: https://www.vde.com/en/fnn/topics/technical-connection-rules/tcr-hvdc

[7] VDE FNN, "Grid forming behaviour of HVDC systems and DC-connected Power Park Modules," guideline. [Online]. Available: https://www.vde.com/en/fnn/dokumente-en

[8] EirGrid and SONI, "All-Island Grid Forming Strategy," Feb. 2026. [Online]. Available: https://cms.eirgrid.ie/sites/default/files/publications/Grid-Forming-Strategy-February-2026.pdf

[9] EirGrid and SONI, "Operational Policy Roadmap 2025–2035," Mar. 2025. [Online]. Available: https://cms.eirgrid.ie/sites/default/files/publications/EirGrid-SONI-Operational-Policy-Roadmap-2025-2035.pdf

Red-line Version of Impacted Grid Code Section(s) - show proposed changes to text:

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PC.A6 Interconnector Data Requirements

PC.A6.1. Interconnector Operating Characteristics and Registered Data

(v) Interconnector power electronic converter and control systems

(h) If the Interconnector has declared **Non-mandatory Grid Forming** capability, the following additional data shall be provided to the **TSO**:

- Positive and negative sequence **Grid Forming Effective Impedance (z_{eff})** and X/R ratio of the **Interconnector Converter Station**.
- Equivalent Inertia Constant (H_{eq}).
- Damping ratio.
- Frequency-dependent impedance (R, X and Z) of the **Interconnector Converter Station** in the frequency range from 5 Hz to 2500 Hz for a representative number of operating points and control modes.

CC.7.5.13 NON -MANDATORY GRID FORMING

CC.7.5.13.1 The conditions specified in this section of the **Grid Code** apply to **Interconnector Converter Stations** with declared **Non-mandatory Grid Forming** capability including those operated in **Interconnector STATCOM State**, unless otherwise specified**. Non-mandatory Grid Forming** capability is a non-mandatory requirement which will be provided through agreement with the **TSO**.

CC.7.5.13.2 The conditions specified in this section of the **Grid Code** are in addition to those specified in CC.7.5.1 to CC.7.5.12 for **HVDC Units**, excluding the clauses listed below. The equivalent clause applicable to **Non-mandatory Grid Forming** are included between brackets for clarity:

- CC.7.5.9.5(a) does not apply for **Grid Forming** (CC.7.5.13.13 applies for **Grid Forming**)
- CC.7.5.12.5 does not apply for **Grid Forming** (CC.7.5.13.12.2 for **Grid Forming**)
- CC.7.5.12.6 does not apply for **Grid Forming** (CC.7.5.13.12.3 for **Grid Forming**)

CC.7.5.13.3 The **Interconnector Converter Station**(s) shall have the capability to remotely enable/disable the **Grid Forming Mode** upon **TSO** request. The details of this functionality will be provided by the **TSO**. When the **Grid Forming Mode** is disabled in all **Interconnector Converter Stations**, all clauses from CC.7.5.1 to CC.7.5.12 will apply to the **Interconnector** instead of CC.7.5.13.

CC.7.5.13.4 The conditions specified in this section of the **Grid Code** apply at the **Grid Connection Point** of the **Interconnector Converter Station,** unless otherwise specified.

CC.7.5.13.5 The performance requirements specified in CC.7.5.13.8, CC.7.5.13.9 and CC.7.5.13.10 shall be met within the **Interconnector** current and energy limits for any operating point within the U-Q/Pmax profile defined in CC.7.5.10.d, voltage ranges defined in CC.7.5.1.1 (v), frequency ranges defined in CC.7.5.1.1 (t), and short circuit capacity (in MVA) at each **Grid Connection Point** provided by the **TSO** in accordance with CC.7.5.12.1.

For weak system strength conditions, below the minimum short circuit capacity (in MVA) at the **Grid Connection Point** provided by the **TSO** in accordance with CC.7.5.12.1, including islanded operation, the **Interconnector** performance may deviate from the conditions specified in this section of the Grid Code but the **Interconnector Converter Station** shall be capable of stable operation within the ranges defined in CC.7.5.1.1(t) and CC.7.5.1.1(v).

CC.7.5.13.6 The performance requirements specified in CC.7.5.13.8, CC.7.5.13.9 and CC.7.5.13.10 shall be met for any initial operating point within the U-Q/Pmax profile defined in CC.7.5.10.d, for the following **Transmission System Disturbances** and during **Network** topology changes:

- A voltage phase angle jump of ±10° applied within the **Transmission System**.
- A voltage magnitude jump of ±0.1p.u. applied within the **Transmission System.** provided that the final expected operating point is within the U-Q/Pmax profile.
- A **ROCOF** of 1Hz/s for a duration 1s, provided that the sum of initial operating point and expected **Synthetic Inertia Contribution** remain within the U-Q/Pmax profile.

The response to the above **Disturbances** shall be provided within the **Interconnector Converter Station** or **Interconnector** current and energy limits. Reduced performance is acceptable when the **Interconnector Converter Station** or **Interconnector** limits are reached. For the avoidance of doubt, the **Interconnector** is not required to reserve any headroom.

CC.7.5.13.7 The **Active Power** response resulting from **Grid Forming** behaviour at the remote end **Interconnector Converter Station** caused by a **Disturbance** as observed at their **Grid Connection Point**, shall not cause larger **Active Power** variation on the other **Interconnector Converter Station**(s) than the Active Power response as seen at the remote end **Interconnector Converter Station**.

CC.7.5.13.8 **Voltage Source Behaviour**

CC.7.5.13.8.1. Within the **Interconnector** voltage, current and energy limits, the **Interconnector Converter Station** shall be capable of behaving as a controllable voltage source behind an internal impedance (i.e. a Thevenin source) during both the normal operation and immediately after a grid **Disturbance**. The Thevenin source is characterized by its constant internal voltage amplitude, voltage phase angle, frequency, and internal impedance.

After the first instants of the **Disturbance**, the parameters of the Thevenin voltage source can change to support the secure operation of the **Transmission System**.

CC.7.5.13.8.2. The **Interconnector** shall actively contribute to the generation of the AC voltage waveforms, by providing **Synchronising Active Power** and **Voltage Stiffness**, within the **Interconnector** current and energy limits, immediately after a voltage **Disturbance** (phase angle or/and magnitude) in the **Transmission System**. The **Interconnector Converter Stations** shall emulate a Thevenin source behind an impedance as immediate response to a **Transmission System Disturbance**. The dynamic behaviour is described in CC.7.5.13.8.4 and CC.7.5.13.8.5.

CC.7.5.13.8.3. The **Interconnector Converter Station** positive and negative sequence **Grid Forming Effective Impedance** (without current limitation) shall be within the range of [0.2 to 0.5] in per unit, with a minimum X/R ratio of 10. The selected final value shall be communicated to the **TSO**.

CC.7.5.13.8.4. The **Interconnector** shall have the capability to provide **Synchronising Active Power.** This means that, following a voltage phase angle jump within the **Transmission System**, the **Interconnector** shall react immediately by varying its **Active Power** at the **Grid Connection Point**, within its current and energy limits, in a manner that counteracts the **Disturbance**, with an amplitude that depends on the network and converter impedances. Considering the measurement bandwidth and the dynamics of converter internal quantity limitations, the immediate **Active Power** response shall be observed within 5 ms to 20 ms of the voltage phase angle jump occurrence (measurements shall be done in compliance with IEC 61400-21-1).

For **Interconnectors** with at least two **Interconnector Converter Stations** in **Grid Forming Mode**, or for **Interconnector STATCOM State,** the capability to provide **Synchronising Active Power** for a voltage phase angle jump within the **Transmission System** may be limited by its inherent energy buffer. The **Interconnector Owner** shall agree the expected **Synchronising Active Power** with the **TSO**.

CC.7.5.13.8.5. The **Interconnector** shall have the capability to provide **Voltage Stiffness Contribution**. This means that, following a positive sequence voltage magnitude jump within the **Transmission System**, the **Interconnector** shall react immediately by varying its **Reactive Power** at the **Grid Connection Point**, within its current and energy limits, in a manner that counteracts the **Disturbance**, with an amplitude that depends on the network and converter impedances. Considering the measurement bandwidth and the dynamics of converter internal quantity limitations, the immediate **Reactive Power** response shall be observed within 5 ms to 20ms of the voltage magnitude jump occurrence (measurements shall be done in compliance with IEC 61400-21-1).

CC.7.5.13.8.6. The **Interconnector Converter Stations** shall provide **Self-synchronisation Capability.**

CC.7.5.13.9 **Synthetic Inertia Contribution**

CC.7.5.13.9.1 The **Interconnector** shall have the capability to provide **Synthetic Inertia Contribution** for high and low frequency conditions, within its current and energy limits, with an equivalent inertia constant (H_{eq}) of at least 3MW / MVA. The **Synthetic Inertia Contribution** shall be provided without delay. This means that, during ROCOF up to ±1 Hz/s within the **Transmission System**, the **Interconnector** shall immediately adjust the **Active Power** transfer at the **Grid Connection Point**, within its current and energy limits, proportionally to the ROCOF experienced at the **Grid Connection Point** such as:

$$\Delta P_{pu} = -2H_{eq}\frac{1}{f_0} \times ROCOF$$

For **Interconnectors** with at least two **Interconnector Converter Stations** in **Grid Forming mode**, or for **Interconnector STATCOM State,** the capability to provide **Synthetic Inertia Contribution** may be limited. The **Interconnector Owner** shall agree the expected **Synthetic Inertia Contribution** with the **TSO**.

The **Interconnector Owner** shall agree the value of the equivalent inertia (H_{eq}) with the **TSO,** even if it is below the specified value or effective only for a limited duration.

CC.7.5.13.9.2 The **Synthetic Inertia Contribution** shall be provided with a damped system response and the **Active Power** transfer at the **Grid Connection Point** shall smoothly return to its reference value with a damping ratio ξ of 0.4 or higher.

CC.7.5.13.10 **Expected Behaviour when reaching Current Capability Limits**

CC.7.5.13.10.1. If the **Grid Forming** response of the Interconnector exceeds the **Interconnector Converter Station** capability limit, current limitation can be implemented. The response to changes in voltage phase angle, amplitude and/or frequency shall be equivalent to that of a voltage source (or a synchronous generator), except that the current magnitude may be limited as specified in CC.7.5.13.10.2. Under such conditions, the **Interconnector** shall remain stable and ensure a smooth, bump-less transition without interruption, operating continuously. The **Interconnector Converter Station** current limitation shall not lead to a switch of control mode. As soon as **Transmission System** conditions permit, the **Interconnector Converter Station** shall return to its normal operating capability (without current limitation) with a smooth, bump-less transition.

CC.7.5.13.10.2. During a **Voltage Dip** requiring current limitation, the **Interconnector Converter Station** shall limit its output current by reducing the magnitude of the current phasor only, while preserving its phase angle, such that the total magnitude complies with the **Interconnector Converter Station** current limit.

The unsaturated fault current is defined as the theoretical current delivered by an equivalent constant voltage source behind an impedance (without current limitations) when subjected to a fault on the **Transmission System** that produces the same voltage dip at the **Grid Connection Point**. The unsaturated fault current is calculated as follows:

$$I_{sc-unsat} = \frac{V_{conv} \cdot V_{gcp}}{Z_{Eff}} \qquad \text{(p.u)}$$

Where:

- $I_{sc-unsat}$ is the unsaturated (unlimited) short circuit current contribution from the **Interconnector Converter Station** (p.u.)**.**
- z_{eff} is the **Interconnector Converter Station Grid Forming Effective Impedance** at the **Grid Connection Point** (p.u.)
- v_{conv} is the **Interconnector Converter Station** internal voltage magnitude prior to (and in the first instants of) the voltage dip (p.u.)
- v_{gcp} is the retained voltage magnitude at the **Grid Connection Point** during the **Voltage Dip** (p.u.)

The required **Interconnector Converter Station** output current limitation is illustrated in Figure CC.7.5.13.10. For the avoidance of doubt, the expected response during current limitation is the saturated fault current I_{sc-sat}.

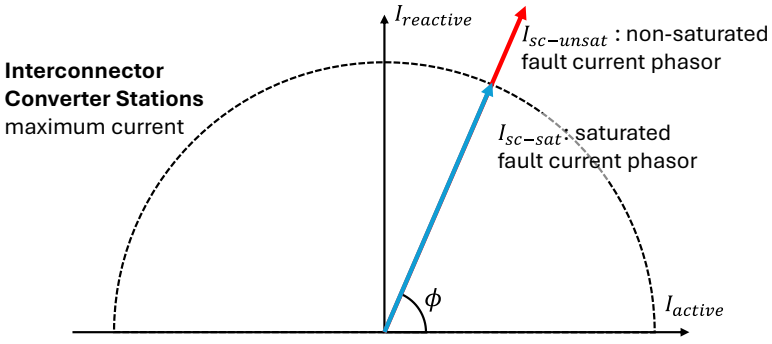


Figure CC.7.5.13.10: Illustration of **Grid Forming** Current limitation

CC.7.5.13.10.3. When the **Transmission System** voltage magnitude and/or voltage phase angle recovers towards the pre-**Disturbance** grid conditions, the **Interconnector Converter Station** shall react

with an instantaneous reduction of current, once the unlimited voltage source behaviour results in a current below the **Interconnector Converter Station** capability limits.

CC.7.5.13.11 **Grid Forming Withstand Capability**

CC.7.5.13.11.1 The **Interconnector** shall have **Withstand Capabilities** for the Transmission System conditions defined in CC.7.5.1.1 and below:

- Phase-angle jump at the **Grid Connection Point** up to ±30°.
- Any sudden **Transmission System** topology change under the range of short circuit power (in MVA) and network characteristics specified by the **TSO** in CC.7.5.1.1(x).

Under these conditions at the **Grid Connection Point**, the **Interconnector Converter Station** shall remain connected to the **Transmission System** and operate in a stable and controllable manner while **Interconnector**'s operational limits (such as voltage, currant and/or energy) may be reached. However, the **Interconnector** shall not introduce oscillations in the **Transmission System** and shall not trip or block, even temporarily.

CC.7.5.13.11.2 It is accepted that the **Grid Forming** performance requirements specified in CC.7.5.13.8, CC.7.5.13.9 and CC.7.5.13.10 may be compromised for **Disturbance** levels at the **Grid Connection Point** between the limits defined in CC.7.5.13.6 (performance limits) and CC.7.5.13.11.1 (withstand limits). The **Interconnector Owner** shall communicate to the **TSO** any reduced performance capability in this operating range.

CC.7.5.13.12 **Fault Ride Through**

CC.7.5.13.12.1. The **Interconnector Converter Stations** shall provide immediate and inherent voltage support, according to the **Interconnector Converter Station Grid Forming Effective Impedance** defined in CC.7.5.13.8.3, during symmetric and asymmetric **Voltage Dips** as defined in CC.7.5.12.1. If this voltage support requires output current limitations, it shall be performed according to the principles defined in CC.7.5.13.10.

CC.7.5.13.12.2. During **Voltage Dips,** no priority shall be given to any current component, whether active or reactive, positive sequence or negative sequence.

CC.7.5.13.12.3. After a **Voltage Dip**, the **Interconnector** shall reach its **Active Power** set-point as quickly as the **Grid Forming Mode** allows, considering dependencies with the selected equivalent inertia constant (H_{eq}), and in any event the **Interconnector** shall provide at least 50% and 90% of its **Active Power** set-point within 500 ms and 1.5 seconds, respectively, of the **Transmission System Voltage** recovering to 90% of nominal **Voltage**. This requirement does not apply to **Interconnector STATCOM State.**

CC.7.5.13.12.4. At **Fault Disturbance** clearance, the **Interconnector Converter Station** shall support the **Transmission System** voltage recovery by providing **Reactive Power** but shall not contribute to voltage overshoot by more than 5% of pre-fault voltage.

CC.7.5.13.13 The speed of response of the **Voltage Regulation System** shall be such that, following a step change in **Voltage** at the **Grid Connection Point** the **Interconnector Converter Station** shall achieve 90 % of its steady-state **Reactive Power** response within 3 seconds. The **Reactive Power** shall settle at the steady-state **Reactive Power** response within 10 seconds, with a steady-state **Reactive Power** tolerance no greater than 5 % of the maximum **Reactive Power**.

Subject to agreement with **TSO**, the **Voltage Regulation Set-point** may be operated with or without a deadband selectable in a range from zero to ±5% of reference 1 p.u. **Transmission System Voltage**, with continuous setting.

Voltage Regulation Set-point shall include the capability to change **Reactive Power** output based on a combination of a modified set-point **Voltage** and an additional instructed **Reactive Power** component. The **TSO** will specify a slope with a range and step on a site-specific basis.

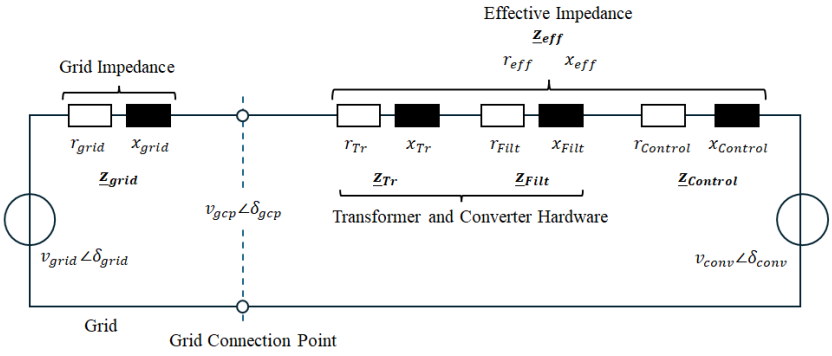
CC.7.5.13.14 The **Interconnector** may have the capability to provide **Voltage Balancing**. It this capability is provided, the **Interconnector Converter Station** shall behave as a pure positive sequence voltage source behind the equivalent impedance as defined in CC.7.5.13.8.3. The negative-sequence current shall vary linearly with the magnitude of the negative-sequence voltage no less than 3% negative-sequence current of the nominal current.

CC.7.5.13.15 The **Interconnector** may provide **Islanding Capability** and **Re-synchronisation Capability**, as agreed with the **TSO**. The conditions and parameters of these capabilities shall be agreed with the **TSO**.

CC.7.5.13.16 The **Interconnector** may provide **Black Start Capability.** If this capability is provided, the **Black Start Station** shall be able to remain in **Grid Forming Mode** with no change of control mode. The **Black Start** requirements defined in OC.4.7 remain applicable.

Note: **Black Start Capability** alone shall not be considered sufficient to demonstrate **Grid Forming** capability at the **Grid Connection Point.** All the criteria defined in CC.7.5.13 shall be met.

Definitions

Grid Forming Effective Impedance (z_{eff})	This is the impedance of a **Plant** with **Grid Forming** capability, observed at the **Grid Connection Point**, at nominal **Frequency**. For clarity, the **Grid Forming Effective Impedance** includes the aggregate of all physical impedances such as transformers, cables and converter(s) impedance, and the virtual impedance from the control at nominal **Frequency**. The **Grid Forming Effective Impedance** (z_{eff}) is illustrated in the following equivalent circuit representation:  The **Grid Forming Effective Impedance** of a **Grid Forming** capable **Plant**, in positive and negative sequences, is defined in per unit as: $$z_{eff} = \frac{Z_{Eff\ SI}}{Z_{base}}$$ $$Z_{eff\ SI} = \sqrt{X_{eff\ SI}^2 + R_{eff\ SI}^2}$$ $$Z_{base} = \frac{V_{base}{}^2}{S_{base}}$$

	$$S_{base} = \sqrt{P_{base}^2 + Q_{base}^2}$$ Where: • z_{eff} is the **Grid Forming** capable **Plant Grid Forming Effective Impedance** in per unit (p.u.). • $Z_{eff\ SI}$ is the **Grid Forming** capable **Plant** effective impedance at the nominal **Transmission System Frequency**, seen from the **Grid Connection Point** in Ohms (Ω). It includes the aggregate of physical equipment impedances such as cables, transformers and filters, and the virtual impedance from the control. • $X_{eff\ SI}$ is the **Grid Forming** capable **Plant** effective reactance at the nominal **Transmission System Frequency**, seen from the **Grid Connection Point** in Ohms (Ω). It includes the aggregate of physical equipment reactances such as cables, transformers and filters, and the virtual reactance from the control. • $R_{eff\ SI}$ is the **Grid Forming** capable **Plant** effective resistance at the nominal **Transmission System Frequency**, seen from the **Grid Connection Point** in Ohms (Ω). It includes the aggregate of physical equipment resistances such as cables, transformers and filters, and the virtual resistance from the control. • V_{base} is nominal phase to phase RMS voltage in kV of the **Grid Forming** capable **Plant Grid Connection Point.** • S_{base} is the base MVA power of the **Grid Forming** capable **Plant**. • P_{base} is the **Grid Forming** capable **Plant Registered Capacity** in MW. • Q_{base} is the maximum absolute value of **Reactive Power** capability, in either consumption (Import/lead) or production (Export/lag), of the **Grid Forming** capable **Plant** in Mvar.
Grid Forming (GFM)	The expected requirement for a **Plant** with **Grid Forming** characteristics is for it to be capable of appearing at the **Grid Connection Point** as a passive source such that, following a **Disturbance**, it results in the injection of current, within its current capability limits, in the sub-transient and transient frame (sub-cycle up to tens of cycles) in a manner that helps oppose the impact of the **Disturbance**.
Grid Forming (GFM) Mode	Control mode of a **Grid Forming** capable **Plant** which corresponds to and fulfils the **Grid Forming** functional requirements as specified in this **Grid Code**.
Interconnector STATCOM State	A specific state of an **Interconnector Converter Station**, which is DC islanded from the other **Interconnector Converter Station(s)**, with or without the DC transmission lines or cable connected to it.
Islanding Capability	It refers to the **Grid Forming Plant** capability to form the AC network **Voltage** at the **Grid Connection Point** and sustain local loads or generation (passive and/or active) connected to an islanded part of network after its disconnection from the main **Transmission System** (such as last feeder trip).
Non-mandatory Grid Forming	It refers to **Grid Forming** capabilities provided by a **Plant** on a voluntary basis.
Re-synchronisation Capability	It refers to the **Grid Forming Plant** capability to smoothly synchronise from an islanded condition, with load and generation, to a live **Transmission System** and remain in **Grid Forming Mode**.
Self-Synchronisation Capability	It refers to the **Grid Forming Plant** capability to generate and control an AC voltage waveform of specified magnitude and **Frequency** independently from other generation sources, and to synchronise autonomously with the rest of the **Transmission System**.

Synchronising Active Power	It refers to the **Grid Forming Plant** capability to maintain constant internal voltage phase angle for a few milliseconds after a voltage phase angle jump **Disturbance** within the **Transmission System.** As a result, the **Grid Forming Plant** provides an immediate **Active Power** response at the **Grid Connection Point** based on its **Grid Forming Effective Impedance** (z_{eff})**.** The **Synchronising Active Power** (ΔP) is calculated according to the following expression under the assumption of $r_{\text{Eff}} << x_{\text{Eff}}$ (i.e. $x_{\text{Eff}} \approx z_{\text{Eff}}$): $$\Delta P = \frac{v_{conv} v_{gcp}}{x_{eff}} \sin(\Delta\delta)$$ Where: • ΔP is the **Synchronising Active Power**, defined as the immediate **Active Power** variation at the **Grid Connection Point** (p.u.). • v_{gcp} is the **Transmission System** voltage magnitude at the **Grid Connection Point** (p.u.) • v_{conv} is the **Grid Forming** device internal voltage magnitude at nominal **Frequency** (p.u.). • x_{eff} is the **Grid Forming Plant** effective reactance at nominal **Frequency** at the **Grid Connection Point** (p.u.) • $\Delta\delta$ is the **Transmission System** voltage phase angle jump at the **Grid Connection Point** (degree) ($\delta_{conv} - \delta_{gcp}$) Note: **Synchronising Active Power** is also commonly referred to as "voltage phase angle jump response" or "instantaneous active power response".
Synthetic Inertia Contribution	It refers to the **Grid Forming Plant** capability to limit transient **Frequency** deviations by immediately adjusting **Active Power** exchange with the **Transmission System** based on the **Rate of Change of Frequency.** The **Synthetic Inertia Contribution (**ΔP) is calculated according to the following expression: $$\Delta P = -2H_{eq} \frac{1}{f_0} \frac{df}{dt}$$ Where: • ΔP is the **Synthetic Inertia Contribution**, defined as the immediate **Active Power** variation at the **Grid Connection Point** (p.u.) • $\frac{df}{dt}$: is the **Rate of Change of Frequency (RoCoF)** (Hz/s) • f_0: is the **Transmission System** nominal **Frequency** (50 Hz) • H_{eq}: is the equivalent inertia constant of the **Grid Forming Plant** (MW.s/MVA) Note: synthetic inertia shall be considered as *the prescribed electrical dynamic performance provided by a **Grid Forming Plant** at its **Grid Connection Point** with the purpose of emulating the equivalent dynamic effect of the inertia provided by a synchronous power-generating module.*
Voltage Balancing	It refers to the **Grid Forming Plant** capability to contribute to balance the three-phase AC network voltage waveforms in magnitude. A **Grid Forming Plant** with **Voltage Balancing** capabilities operates as a passive sink for network voltage unbalances at the **Grid Connection Point**, permitting the immediate and permanent flow of negative sequence current to reduce the network **Voltage Unbalance Factor.**

Voltage Unbalance Factor (VUF)	The **Voltage Unbalance Factor** quantifies the degree of unbalance in a three-phase electrical system, indicating how much the phase voltages deviate from a balanced condition. The VUF is defined as the ratio of the negative sequence voltage (V_2) to the positive sequence voltage (V_1), expressed as a percentage.
Voltage Stiffness Contribution	It refers to the **Grid Forming Plant** capability to support and maintain the **Transmission System Voltage** magnitude. This feature results in an immediate **Reactive Power** response at the **Grid Connection Point** following a voltage magnitude variation within the **Transmission System**. The **Voltage Stiffness Contribution** (ΔQ) is calculated as follows: $$\Delta Q \approx -\frac{v_{conv}\Delta v_{gcp}}{x_{eff}}$$ Where: • ΔQ is the **Voltage Stiffness Contribution**, defined as the immediate **Reactive Power** variation at the **Grid Connection Point** (p.u.). • Δv_{gcp} is the **Transmission System** voltage magnitude variation at the **Grid Connection Point** at nominal **Frequency** (p.u.). • v_{conv} is the **Grid Forming** device internal voltage magnitude at nominal **Frequency** (p.u.). • x_{eff} is the **Grid Forming Plant** effective reactance at nominal **Frequency** at the **Grid Connection Point** (p.u.).
Withstand Capability	It refers to the ability of the **Grid Forming Plant** to sustain dynamic **Disturbances** on the connected **Transmission System** and remain stable and controllable while its operating limits may be reached.

Green-line Version of Impacted Grid Code Section(s) - show proposed changes to text:

PC.A6 Interconnector Data Requirements

PC.A6.1. Interconnector Operating Characteristics and Registered Data

(v) Interconnector power electronic converter and control systems

(h) If the Interconnector has declared **Non-mandatory Grid Forming** capability, the following additional data shall be provided to the **TSO**:

- Positive and negative sequence **Grid Forming Effective Impedance (z_{eff})** and X/R ratio of the **Interconnector Converter Station**.
- Equivalent Inertia Constant (H_{eq}).
- Damping ratio.
- Frequency-dependent impedance (R, X and Z) of the **Interconnector Converter Station** in the frequency range from 5 Hz to 2500 Hz for a representative number of operating points and control modes.

CC.7.5.13 NON -MANDATORY GRID FORMING

CC.7.5.13.1 The conditions specified in this section of the **Grid Code** apply to **Interconnector Converter Stations** with declared **Non-mandatory Grid Forming** capability including those operated in **Interconnector STATCOM State**, unless otherwise specified**. Non-mandatory Grid Forming** capability is a non-mandatory requirement which will be provided through agreement with the **TSO**.

CC.7.5.13.2 The conditions specified in this section of the **Grid Code** are in addition to those specified in CC.7.5.1 to CC.7.5.12 for **HVDC Units**, excluding the clauses listed below. The equivalent clause applicable to **Non-mandatory Grid Forming** are included between brackets for clarity:

- CC.7.5.9.5(a) does not apply for **Grid Forming** (CC.7.5.13.13 applies for **Grid Forming**)
- CC.7.5.12.5 does not apply for **Grid Forming** (CC.7.5.13.12.2 for **Grid Forming**)
- CC.7.5.12.6 does not apply for **Grid Forming** (CC.7.5.13.12.3 for **Grid Forming**)

CC.7.5.13.3 The **Interconnector Converter Station**(s) shall have the capability to remotely enable/disable the **Grid Forming Mode** upon **TSO** request. The details of this functionality will be provided by the **TSO**. When the **Grid Forming Mode** is disabled in all **Interconnector Converter Stations**, all clauses from CC.7.5.1 to CC.7.5.12 will apply to the **Interconnector** instead of CC.7.5.13.

CC.7.5.13.4 The conditions specified in this section of the **Grid Code** apply at the **Grid Connection Point** of the **Interconnector Converter Station,** unless otherwise specified.

CC.7.5.13.5 The performance requirements specified in CC.7.5.13.8, CC.7.5.13.9 and CC.7.5.13.10 shall be met within the **Interconnector** current and energy limits for any operating point within the U-Q/Pmax profile defined in CC.7.5.10.d, voltage ranges defined in CC.7.5.1.1 (v), frequency ranges defined in CC.7.5.1.1 (t), and short circuit capacity (in MVA) at each **Grid Connection Point** provided by the **TSO** in accordance with CC.7.5.12.1.

For weak system strength conditions, below the minimum short circuit capacity (in MVA) at the **Grid Connection Point** provided by the **TSO** in accordance with CC.7.5.12.1, including islanded operation, the **Interconnector** performance may deviate from the conditions specified in this section of the Grid Code but the **Interconnector Converter Station** shall be capable of stable operation within the ranges defined in CC.7.5.1.1(t) and CC.7.5.1.1(v).

CC.7.5.13.6 The performance requirements specified in CC.7.5.13.8, CC.7.5.13.9 and CC.7.5.13.10 shall be met for any initial operating point within the U-Q/Pmax profile defined in CC.7.5.10.d, for the following **Transmission System Disturbances** and during **Network** topology changes:

- A voltage phase angle jump of ±10° applied within the **Transmission System**.
- A voltage magnitude jump of ±0.1p.u. applied within the **Transmission System.** provided that the final expected operating point is within the U-Q/Pmax profile.
- A **ROCOF** of 1Hz/s for a duration 1s, provided that the sum of initial operating point and expected **Synthetic Inertia Contribution** remain within the U-Q/Pmax profile.

The response to the above **Disturbances** shall be provided within the **Interconnector Converter Station** or **Interconnector** current and energy limits. Reduced performance is acceptable when the **Interconnector Converter Station** or **Interconnector** limits are reached. For the avoidance of doubt, the **Interconnector** is not required to reserve any headroom.

CC.7.5.13.7 The **Active Power** response resulting from **Grid Forming** behaviour at the remote end **Interconnector Converter Station** caused by a **Disturbance** as observed at their **Grid Connection Point**, shall not cause larger **Active Power** variation on the other **Interconnector Converter Station**(s) than the Active Power response as seen at the remote end **Interconnector Converter Station**.

CC.7.5.13.8 **Voltage Source Behaviour**

CC.7.5.13.8.1. Within the **Interconnector** voltage, current and energy limits, the **Interconnector Converter Station** shall be capable of behaving as a controllable voltage source behind an internal impedance (i.e. a Thevenin source) during both the normal operation and immediately after a grid **Disturbance**. The Thevenin source is characterized by its constant internal voltage amplitude, voltage phase angle, frequency, and internal impedance.

After the first instants of the **Disturbance**, the parameters of the Thevenin voltage source can change to support the secure operation of the **Transmission System**.

CC.7.5.13.8.2. The **Interconnector** shall actively contribute to the generation of the AC voltage waveforms, by providing **Synchronising Active Power** and **Voltage Stiffness**, within the **Interconnector** current and energy limits, immediately after a voltage **Disturbance** (phase angle or/and magnitude) in the **Transmission System**. The **Interconnector Converter Stations** shall emulate a Thevenin source behind an impedance as immediate response to a **Transmission System Disturbance**. The dynamic behaviour is described in CC.7.5.13.8.4 and CC.7.5.13.8.5.

CC.7.5.13.8.3. The **Interconnector Converter Station** positive and negative sequence **Grid Forming Effective Impedance** (without current limitation) shall be within the range of [0.2 to 0.5] in per unit, with a minimum X/R ratio of 10. The selected final value shall be communicated to the **TSO**.

CC.7.5.13.8.4. The **Interconnector** shall have the capability to provide **Synchronising Active Power.** This means that, following a voltage phase angle jump within the **Transmission System**, the **Interconnector** shall react immediately by varying its **Active Power** at the **Grid Connection Point**, within its current and energy limits, in a manner that counteracts the **Disturbance**, with an amplitude that depends on the network and converter impedances. Considering the measurement bandwidth and the dynamics of converter internal quantity limitations, the immediate **Active Power** response shall be observed within 5 ms to 20 ms of the voltage phase angle jump occurrence (measurements shall be done in compliance with IEC 61400-21-1).

For **Interconnectors** with at least two **Interconnector Converter Stations** in **Grid Forming Mode**, or for **Interconnector STATCOM State,** the capability to provide **Synchronising Active Power** for a voltage phase angle jump within the **Transmission System** may be limited by its

inherent energy buffer. The **Interconnector Owner** shall agree the expected **Synchronising Active Power** with the **TSO**.

CC.7.5.13.8.5. The **Interconnector** shall have the capability to provide **Voltage Stiffness Contribution**. This means that, following a positive sequence voltage magnitude jump within the **Transmission System**, the **Interconnector** shall react immediately by varying its **Reactive Power** at the **Grid Connection Point**, within its current and energy limits, in a manner that counteracts the **Disturbance**, with an amplitude that depends on the network and converter impedances. Considering the measurement bandwidth and the dynamics of converter internal quantity limitations, the immediate **Reactive Power** response shall be observed within 5 ms to 20ms of the voltage magnitude jump occurrence (measurements shall be done in compliance with IEC 61400-21-1).

CC.7.5.13.8.6. The **Interconnector Converter Stations** shall provide **Self-synchronisation Capability.**

CC.7.5.13.9 **Synthetic Inertia Contribution**

CC.7.5.13.9.1 The **Interconnector** shall have the capability to provide **Synthetic Inertia Contribution** for high and low frequency conditions, within its current and energy limits, with an equivalent inertia constant (H_{eq}) of at least 3MW / MVA. The **Synthetic Inertia Contribution** shall be provided without delay. This means that, during ROCOF up to ±1 Hz/s within the **Transmission System**, the **Interconnector** shall immediately adjust the **Active Power** transfer at the **Grid Connection Point**, within its current and energy limits, proportionally to the ROCOF experienced at the **Grid Connection Point** such as:

$$\Delta P_{pu} = -2H_{eq}\frac{1}{f_0} \times ROCOF$$

For **Interconnectors** with at least two **Interconnector Converter Stations** in **Grid Forming mode**, or for **Interconnector STATCOM State,** the capability to provide **Synthetic Inertia Contribution** may be limited. The **Interconnector Owner** shall agree the expected **Synthetic Inertia Contribution** with the **TSO**.

The **Interconnector Owner** shall agree the value of the equivalent inertia (H_{eq}) with the **TSO,** even if it is below the specified value or effective only for a limited duration.

CC.7.5.13.9.2 The **Synthetic Inertia Contribution** shall be provided with a damped system response and the **Active Power** transfer at the **Grid Connection Point** shall smoothly return to its reference value with a damping ratio ξ of 0.4 or higher.

CC.7.5.13.10 **Expected Behaviour when reaching Current Capability Limits**

CC.7.5.13.10.1. If the **Grid Forming** response of the Interconnector exceeds the **Interconnector Converter Station** capability limit, current limitation can be implemented. The response to changes in voltage phase angle, amplitude and/or frequency shall be equivalent to that of a voltage source (or a synchronous generator), except that the current magnitude may be limited as specified in CC.7.5.13.10.2. Under such conditions, the **Interconnector** shall remain stable and ensure a smooth, bump-less transition without interruption, operating continuously. The **Interconnector Converter Station** current limitation shall not lead to a switch of control mode. As soon as **Transmission System** conditions permit, the **Interconnector Converter Station** shall return to its normal operating capability (without current limitation) with a smooth, bump-less transition.

CC.7.5.13.10.2. During a **Voltage Dip** requiring current limitation, the **Interconnector Converter Station** shall limit its output current by reducing the magnitude of the current phasor only, while preserving its phase angle, such that the total magnitude complies with the **Interconnector Converter Station** current limit.

The unsaturated fault current is defined as the theoretical current delivered by an equivalent constant voltage source behind an impedance (without current limitations) when subjected to a fault on the **Transmission System** that produces the same voltage dip at the **Grid Connection Point**. The unsaturated fault current is calculated as follows:

$$I_{sc-unsat} = \frac{V_{conv} \cdot V_{gcp}}{z_{Eff}} \qquad \text{(p.u)}$$

Where:

- $I_{sc-unsat}$ is the unsaturated (unlimited) short circuit current contribution from the **Interconnector Converter Station** (p.u.)**.**
- z_{eff} is the **Interconnector Converter Station Grid Forming Effective Impedance** at the **Grid Connection Point** (p.u.)
- v_{conv} is the **Interconnector Converter Station** internal voltage magnitude prior to (and in the first instants of) the voltage dip (p.u.)
- v_{gcp} is the retained voltage magnitude at the **Grid Connection Point** during the **Voltage Dip** (p.u.)

The required **Interconnector Converter Station** output current limitation is illustrated in Figure CC.7.5.13.10. For the avoidance of doubt, the expected response during current limitation is the saturated fault current $I_{sc\text{-}sat}$.

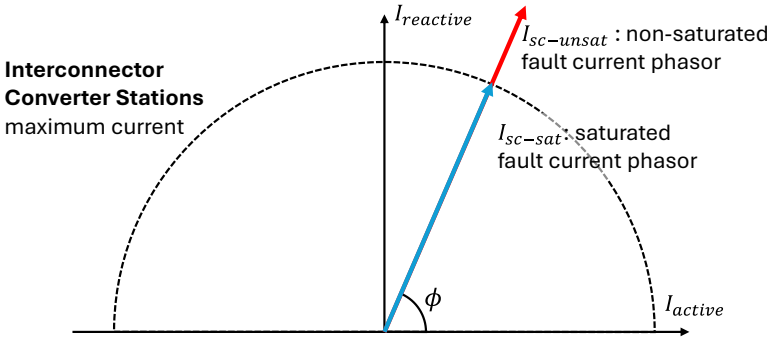


Figure CC.7.5.13.10: Illustration of **Grid Forming** Current limitation

CC.7.5.13.10.3. When the **Transmission System** voltage magnitude and/or voltage phase angle recovers towards the pre-**Disturbance** grid conditions, the **Interconnector Converter Station** shall react with an instantaneous reduction of current, once the unlimited voltage source behaviour results in a current below the **Interconnector Converter Station** capability limits.

CC.7.5.13.11 **Grid Forming Withstand Capability**

CC.7.5.13.11.1 The **Interconnector** shall have **Withstand Capabilities** for the Transmission System conditions defined in CC.7.5.1.1 and below:

- Phase-angle jump at the **Grid Connection Point** up to ±30°.
- Any sudden **Transmission System** topology change under the range of short circuit power (in MVA) and network characteristics specified by the **TSO** in CC.7.5.1.1(x).

Under these conditions at the **Grid Connection Point**, the **Interconnector Converter Station** shall remain connected to the **Transmission System** and operate in a stable and controllable manner while **Interconnector**'s operational limits (such as voltage, currant and/or energy) may be reached. However, the **Interconnector** shall not introduce oscillations in the **Transmission System** and shall not trip or block, even temporarily.

CC.7.5.13.11.2 It is accepted that the **Grid Forming** performance requirements specified in CC.7.5.13.8, CC.7.5.13.9 and CC.7.5.13.10 may be compromised for **Disturbance** levels at the **Grid Connection Point** between the limits defined in CC.7.5.13.6 (performance limits) and CC.7.5.13.11.1 (withstand limits). The **Interconnector Owner** shall communicate to the **TSO** any reduced performance capability in this operating range.

CC.7.5.13.12 **Fault Ride Through**

CC.7.5.13.12.1. The **Interconnector Converter Stations** shall provide immediate and inherent voltage support, according to the **Interconnector Converter Station Grid Forming Effective Impedance** defined in CC.7.5.13.8.3, during symmetric and asymmetric **Voltage Dips** as defined in CC.7.5.12.1. If this voltage support requires output current limitations, it shall be performed according to the principles defined in CC.7.5.13.10.

CC.7.5.13.12.2. During **Voltage Dips,** no priority shall be given to any current component, whether active or reactive, positive sequence or negative sequence.

CC.7.5.13.12.3. After a **Voltage Dip**, the **Interconnector** shall reach its **Active Power** set-point as quickly as the **Grid Forming Mode** allows, considering dependencies with the selected equivalent inertia constant (H_{eq}), and in any event the **Interconnector** shall provide at least 50% and 90% of its **Active Power** set-point within 500 ms and 1.5 seconds, respectively, of the **Transmission System Voltage** recovering to 90% of nominal **Voltage**. This requirement does not apply to **Interconnector STATCOM State.**

CC.7.5.13.12.4. At **Fault Disturbance** clearance, the **Interconnector Converter Station** shall support the **Transmission System** voltage recovery by providing **Reactive Power** but shall not contribute to voltage overshoot by more than 5% of pre-fault voltage.

CC.7.5.13.13 The speed of response of the **Voltage Regulation System** shall be such that, following a step change in **Voltage** at the **Grid Connection Point** the **Interconnector Converter Station** shall achieve 90 % of its steady-state **Reactive Power** response within 3 seconds. The **Reactive Power** shall settle at the steady-state **Reactive Power** response within 10 seconds, with a steady-state **Reactive Power** tolerance no greater than 5 % of the maximum **Reactive Power**.

Subject to agreement with **TSO**, the **Voltage Regulation Set-point** may be operated with or without a deadband selectable in a range from zero to ±5% of reference 1 p.u. **Transmission System Voltage**, with continuous setting.

Voltage Regulation Set-point shall include the capability to change **Reactive Power** output based on a combination of a modified set-point **Voltage** and an additional instructed **Reactive Power** component. The **TSO** will specify a slope with a range and step on a site-specific basis.

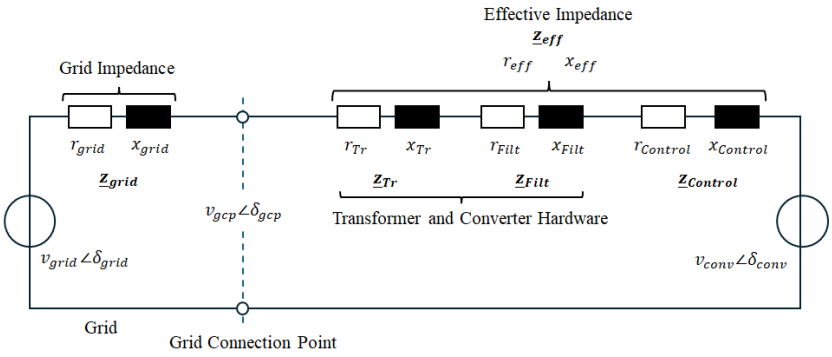
CC.7.5.13.14 The **Interconnector** may have the capability to provide **Voltage Balancing**. It this capability is provided, the **Interconnector Converter Station** shall behave as a pure positive sequence voltage source behind the equivalent impedance as defined in CC.7.5.13.8.3. The negative-sequence current shall vary linearly with the magnitude of the negative-sequence voltage no less than 3% negative-sequence current of the nominal current.

CC.7.5.13.15 The **Interconnector** may provide **Islanding Capability** and **Re-synchronisation Capability**, as agreed with the **TSO**. The conditions and parameters of these capabilities shall be agreed with the **TSO**.

CC.7.5.13.16 The **Interconnector** may provide **Black Start Capability.** If this capability is provided, the **Black Start Station** shall be able to remain in **Grid Forming Mode** with no change of control mode. The **Black Start** requirements defined in OC.4.7 remain applicable.

Note: **Black Start Capability** alone shall not be considered sufficient to demonstrate **Grid Forming** capability at the **Grid Connection Point.** All the criteria defined in CC.7.5.13 shall be met.

Definitions

Grid Forming Effective Impedance (z_{eff})	This is the impedance of a **Plant** with **Grid Forming** capability, observed at the **Grid Connection Point**, at nominal **Frequency**. For clarity, the **Grid Forming Effective Impedance** includes the aggregate of all physical impedances such as transformers, cables and converter(s) impedance, and the virtual impedance from the control at nominal **Frequency**. The **Grid Forming Effective Impedance** (z_{eff}) is illustrated in the following equivalent circuit representation:  The **Grid Forming Effective Impedance** of a **Grid Forming** capable **Plant**, in positive and negative sequences, is defined in per unit as: $$z_{eff} = \frac{Z_{Eff\ SI}}{Z_{base}}$$ $$Z_{eff\ SI} = \sqrt{X_{eff\ SI}^2 + R_{eff\ SI}^2}$$ $$Z_{base} = \frac{{V_{base}}^2}{S_{base}}$$ $$S_{base} = \sqrt{P_{base}^2 + Q_{base}^2}$$ Where: • z_{eff} is the **Grid Forming** capable **Plant Grid Forming Effective Impedance** in per unit (p.u.). • $Z_{eff\ SI}$ is the **Grid Forming** capable **Plant** effective impedance at the nominal **Transmission System Frequency**, seen from the **Grid Connection Point** in Ohms (Ω). It includes the aggregate of physical equipment impedances such as cables, transformers and filters, and the virtual impedance from the control. • $X_{eff\ SI}$ is the **Grid Forming** capable **Plant** effective reactance at the nominal **Transmission System Frequency**, seen from the **Grid Connection Point** in Ohms (Ω). It includes the aggregate of physical equipment reactances such as cables, transformers and filters, and the virtual reactance from the control. • $R_{eff\ SI}$ is the **Grid Forming** capable **Plant** effective resistance at the nominal **Transmission System Frequency**, seen from the **Grid Connection Point** in Ohms (Ω). It includes the aggregate of physical

	equipment resistances such as cables, transformers and filters, and the virtual resistance from the control. • V_{base} is nominal phase to phase RMS voltage in kV of the **Grid Forming** capable **Plant Grid Connection Point.** • S_{base} is the base MVA power of the **Grid Forming** capable **Plant**. • P_{base} is the **Grid Forming** capable **Plant Registered Capacity** in MW. • Q_{base} is the maximum absolute value of **Reactive Power** capability, in either consumption (Import/lead) or production (Export/lag), of the **Grid Forming** capable **Plant** in Mvar.
Grid Forming (GFM)	The expected requirement for a **Plant** with **Grid Forming** characteristics is for it to be capable of appearing at the **Grid Connection Point** as a passive source such that, following a **Disturbance**, it results in the injection of current, within its current capability limits, in the sub-transient and transient frame (sub-cycle up to tens of cycles) in a manner that helps oppose the impact of the **Disturbance**.
Grid Forming (GFM) Mode	Control mode of a **Grid Forming** capable **Plant** which corresponds to and fulfils the **Grid Forming** functional requirements as specified in this **Grid Code**.
Interconnector STATCOM State	A specific state of an **Interconnector Converter Station**, which is DC islanded from the other **Interconnector Converter Station(s)**, with or without the DC transmission lines or cable connected to it.
Islanding Capability	It refers to the **Grid Forming Plant** capability to form the AC network **Voltage** at the **Grid Connection Point** and sustain local loads or generation (passive and/or active) connected to an islanded part of network after its disconnection from the main **Transmission System** (such as last feeder trip).
Non-mandatory Grid Forming	It refers to **Grid Forming** capabilities provided by a **Plant** on a voluntary basis.
Re-synchronisation Capability	It refers to the **Grid Forming Plant** capability to smoothly synchronise from an islanded condition, with load and generation, to a live **Transmission System** and remain in **Grid Forming Mode**.
Self-Synchronisation Capability	It refers to the **Grid Forming Plant** capability to generate and control an AC voltage waveform of specified magnitude and **Frequency** independently from other generation sources, and to synchronise autonomously with the rest of the **Transmission System**.
Synchronising Active Power	It refers to the **Grid Forming Plant** capability to maintain constant internal voltage phase angle for a few milliseconds after a voltage phase angle jump **Disturbance** within the **Transmission System.** As a result, the **Grid Forming Plant** provides an immediate **Active Power** response at the **Grid Connection Point** based on its **Grid Forming Effective Impedance** (z_{eff})**.** The **Synchronising Active Power** (ΔP) is calculated according to the following expression under the assumption of $r_{\text{Eff}} << x_{\text{Eff}}$ (i.e. $x_{\text{Eff}} \approx z_{\text{Eff}}$): $$\Delta P = \frac{v_{conv} v_{gcp}}{x_{eff}} \sin(\Delta\delta)$$ Where: • ΔP is the **Synchronising Active Power**, defined as the immediate **Active Power** variation at the **Grid Connection Point** (p.u.). • v_{gcp} is the **Transmission System** voltage magnitude at the **Grid Connection Point** (p.u.) • v_{conv} is the **Grid Forming** device internal voltage magnitude at nominal **Frequency** (p.u.).

	• x_{eff} is the **Grid Forming Plant** effective reactance at nominal **Frequency** at the **Grid Connection Point** (p.u.) • $\Delta\delta$ is the **Transmission System** voltage phase angle jump at the **Grid Connection Point** (degree) ($\delta_{conv} - \delta_{gcp}$) Note: **Synchronising Active Power** is also commonly referred to as "voltage phase angle jump response" or "instantaneous active power response".
Synthetic Inertia Contribution	It refers to the **Grid Forming Plant** capability to limit transient **Frequency** deviations by immediately adjusting **Active Power** exchange with the **Transmission System** based on the **Rate of Change of Frequency.** The **Synthetic Inertia Contribution (**ΔP) is calculated according to the following expression: $$\Delta P = -2H_{eq}\frac{1}{f_0}\frac{df}{dt}$$ Where: • ΔP is the **Synthetic Inertia Contribution**, defined as the immediate **Active Power** variation at the **Grid Connection Point** (p.u.) • $\frac{df}{dt}$: is the **Rate of Change of Frequency (RoCoF)** (Hz/s) • f_0: is the **Transmission System** nominal **Frequency** (50 Hz) • H_{eq}: is the equivalent inertia constant of the **Grid Forming Plant** (MW.s/MVA) Note: synthetic inertia shall be considered as *the prescribed electrical dynamic performance provided by a **Grid Forming Plant** at its **Grid Connection Point** with the purpose of emulating the equivalent dynamic effect of the inertia provided by a synchronous power-generating module.*
Voltage Balancing	It refers to the **Grid Forming Plant** capability to contribute to balance the three-phase AC network voltage waveforms in magnitude. A **Grid Forming Plant** with **Voltage Balancing** capabilities operates as a passive sink for network voltage unbalances at the **Grid Connection Point**, permitting the immediate and permanent flow of negative sequence current to reduce the network **Voltage Unbalance Factor.**
Voltage Unbalance Factor (VUF)	The **Voltage Unbalance Factor** quantifies the degree of unbalance in a three-phase electrical system, indicating how much the phase voltages deviate from a balanced condition. The VUF is defined as the ratio of the negative sequence voltage (V_2) to the positive sequence voltage (V_1), expressed as a percentage.
Voltage Stiffness Contribution	It refers to the **Grid Forming Plant** capability to support and maintain the **Transmission System Voltage** magnitude. This feature results in an immediate **Reactive Power** response at the **Grid Connection Point** following a voltage magnitude variation within the **Transmission System**. The **Voltage Stiffness Contribution** (ΔQ) is calculated as follows: $$\Delta Q \approx -\frac{v_{conv}\Delta v_{gcp}}{x_{eff}}$$ Where: • ΔQ is the **Voltage Stiffness Contribution**, defined as the immediate **Reactive Power** variation at the **Grid Connection Point** (p.u.).

	• Δv_{gcp} is the **Transmission System** voltage magnitude variation at the **Grid Connection Point** at nominal **Frequency** (p.u.). • v_{conv} is the **Grid Forming** device internal voltage magnitude at nominal **Frequency** (p.u.). • x_{eff} is the **Grid Forming Plant** effective reactance at nominal **Frequency** at the **Grid Connection Point** (p.u.).
Withstand Capability	It refers to the ability of the **Grid Forming Plant** to sustain dynamic **Disturbances** on the connected **Transmission System** and remain stable and controllable while its operating limits may be reached.