

Grid Code Modification Proposal Form

GC0163: GB Grid Forming (GBGF) - Removal of Virtual Impedance restriction

Overview: The purpose of this modification is to clarify the Grid Code with regard to the treatment of Virtual Impedance as defined within a Grid Forming Plant.

Modification process & timetable



Status summary: The Proposer has raised a modification and is seeking a decision from the Panel on the governance route to be taken.

This modification is expected to have a: Low impact

Generators, Manufacturers, Interconnectors

Modification drivers: New Technologies, System Security, Net Zero

Proposer's recommendation of governance route

Self-Governance modification to proceed to Code Administrator Consultation

Who can I talk to about the change?

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What is the issue?

National Grid ESO implemented Grid Code [Modification GC0137 “Minimum Specification Required for Provision of GB Grid Forming \(GBGF\) Capability \(formerly Virtual Synchronous Machine/VSM Capability\)”](#) in February 2022 following Ofgem’s approval. As a follow-up, the ESO’s GB Grid Forming Best Practice Group further co-developed National Grid ESO’s [GB Grid Forming Best Practice Guide](#) with a wide range of external stakeholders in the UK and wider afield. Its key aims being:

- (a) Provide the necessary guidance on the existing Legal Text following Grid Code Modification GC0137*.

Note*: For the avoidance of doubt, this GB Grid Forming Best Practice Guide should be used in conjunction with GC0137 rather than as a standalone document.
- (b) Identify any potential Grid Code modifications required to facilitate future GB Grid Forming applications.
- (c) Appropriately capture good practice and suggestions from a wide range of members of the GBGF Best Practice Group for future improvements of the GB Grid Code.

In line with (b), one of the widely debated topics of concern highlighted by group members was on the restriction of a Virtual Impedance for a GBGF Inverter (GBGF-I).

Rather than restricting the type of impedance used, it was proposed that the Grid Code should focus on the outputs of the converter meeting operational requirements, rather than the method of producing the output.

As the power system variables that are required to be complied with are already captured within the Grid Code requirements, the Virtual Impedance restriction can be removed without loss of system security.

Why change?

Allowing GBGF-I’s impedance to include a combination of physical and Virtual Impedance will enable a manufacturer to design and manufacture a system which has a greater capability than with physical impedance alone. This will provide a more stable network and prevent unnecessary exclusion of some converters from the market.

ESO have also reviewed the European Network of Transmission System Operators’ (ENTSO-E) Proposed Requirements for Generators (RfG) 2.0 during the ENTSO-E consultation stage and this potential change would bring harmonisation to the definition of Grid Forming Impedance.

As discussed and commonly agreed within the ESO’s GB Grid Forming Best Practice Group, which included a comprehensive representation from the UK and further afield*, the following points were noted:

- The equivalent Internal Voltage Source should be defined as a Grey Box rather than a White Box, where its functionality & performance as well as inputs/outputs should be clearly defined. The proposal of a Grey Box has been widely supported by stakeholders during GB Grid Forming Best Practice Group discussions and individual stakeholder engagements for consultation purposes.
- The Internal Voltage Source should be defined as the Grey Box so the clause, definition and figures as relevant to Virtual Impedance should be removed.

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*Note For details of those stakeholders, please see the Section of “Acknowledgements” (Pages 5-6) of [GB Grid Forming Best Practice Guide](#) in the Reference as listed in this form.

What is the proposer’s solution?

It is proposed to make minor changes to the European Connection Conditions (ECC) and the Glossary & Definitions within the Grid Code to require only an internal impedance rather than specifying the type.

Draft legal text

Full legal text can be found in Annex 1.

ECC.6.3.19.3 As noted in ECC.6.3.19.2, **Grid Forming Capability** is not a mandatory requirement, however where a **User** (be they a **GB Code User** or **EU Code User**) or **Non-CUSC Party** wishes to offer a **Grid Forming Capability**, then they will be required to ensure their **Grid Forming Plant** meets the following requirements.

- (i) The **Grid Forming Plant** must fully comply with the applicable requirements of the Grid Code including but not limited to the **Planning Code (PC)**, **Connection Conditions (CC’s)** or **European Connection Conditions (ECC’s)** (as applicable), **Compliance Processes (CP’s)** or **European Compliance Processes (ECP’s)** (as applicable), **Operating Codes (OC’s)**, **Balancing Codes (BC’s)** and **Data Registration Code (DRC)**.
- (ii) Each GBGF-I shall comprise an **Internal Voltage Source** ~~behind an impedance and reactance. For the avoidance of doubt, the reactance between the Internal Voltage Source and Grid Entry Point or User System Entry Point (if Embedded) within the Grid Forming Plant can only be made by a combination of several physical discrete reactances. This could include the reactance of the Synchronous Generating Unit or Power Park Unit or HVDC System or Electricity Storage Unit or Dynamic Reactive Compensation Equipment and the electrical Plant and Apparatus connecting the Synchronous Generating Unit or Power Park Unit or HVDC System or Electricity Storage Unit (such as a transformer) to the Grid Entry Point or User System Entry Point (if Embedded).~~

<p>Internal Voltage Source or IVS</p>	<p>For a GBGF-S, a real magnetic field, that rotates synchronously with the System Frequency under normal operating conditions, which as a consequence induces an internal voltage (which is often referred to as the Electro Motive Force (EMF)) in the stationary generator winding that has a real impedance.</p> <p>In a GBGF-I, switched power electronic devices are used to produce a voltage waveform, with harmonics, that has a fundamental rotational component called the Internal Voltage Source (IVS) that rotates synchronously with the System Frequency under normal operating conditions.</p> <p>For a GBGF-I there must be an <u>internal impedance</u> with only real physical values, between the Internal Voltage Source and the Grid Entry Point or User System Entry Point.</p> <p>For the avoidance of doubt, a virtual impedance, is not permitted in GBGF-I.</p>
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What is the impact of this change?

Proposer's assessment against Grid Code Objectives

Relevant Objective	Identified impact
(a) To permit the development, maintenance and operation of an efficient, coordinated and economical system for the transmission of electricity	Neutral
(b) Facilitating effective competition in the generation and supply of electricity (and without limiting the foregoing, to facilitate the national electricity transmission system being made available to persons authorised to supply or generate electricity on terms which neither prevent nor restrict competition in the supply or generation of electricity);	Positive Allowing GB Grid Forming Inverters (GBGF-Is) that use Virtual Impedance will increase the size of the market and allow a more competitive market. It should also reduce the cost of installations.
(c) Subject to sub-paragraphs (i) and (ii), to promote the security and efficiency of the electricity generation, transmission and distribution systems in the national electricity transmission system operator area taken as a whole;	Positive The use of Virtual Impedance in a control methodology may allow GBGF-Is to contribute to Electricity System Stability and Security if appropriately designed and configured resulting in a cheaper solution which has wider benefits to society
(d) To efficiently discharge the obligations imposed upon the licensee by this license and to comply with the Electricity Regulation and any relevant legally binding decisions of the European Commission and/or the Agency; and	Neutral
(e) To promote efficiency in the implementation and administration of the Grid Code arrangements	Neutral

Proposer's assessment of the impact of the modification on the stakeholder / consumer benefit categories

Stakeholder / consumer benefit categories	Identified impact

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Improved safety and reliability of the system	Neutral
Lower bills than would otherwise be the case	Positive The use of a Virtual Impedance rather than a Real Impedance should reduce costs.
Benefits for society as a whole	Positive Reduced costs.
Reduced environmental damage	Neutral
Improved quality of service	Neutral

When will this change take place?**Implementation date**

This modification will be implemented 5 working days after the appeals window closes on 26/02/24, providing no objections have been raised.

Date decision required by

25 January 2024

Implementation approach

No internal systems or process changes will be required. Changes will be reflected in the ESO GB Grid Forming Compliance Guidance Note for relevant developers and manufacturers.

Proposer's justification for governance route

Governance route: Self-Governance modification to proceed to Code Administrator Consultation

The proposed solution removes discrimination between different GBGF-I manufacturers/developers and as such will not have a material effect on any parties identified within the criteria for self-governance. The Proposed change has been widely discussed with stakeholders at the Grid Code Development Forum, and the GB Grid Forming Best Practice Guide development group with no objections raised.

Interactions

- | | | | |
|--|--|---|--------------------------------|
| <input type="checkbox"/> CUSC | <input type="checkbox"/> BSC | <input type="checkbox"/> STC | <input type="checkbox"/> SQSS |
| <input type="checkbox"/> European
Network Codes | <input type="checkbox"/> EBR Article 18
T&Cs ¹ | <input type="checkbox"/> Other
modifications | <input type="checkbox"/> Other |

Acronyms, key terms and reference material

Acronym / key term	Meaning
BSC	Balancing and Settlement Code
CUSC	Connection and Use of System Code
EBR	Electricity Balancing Regulation
ENTSO-E	European Network of Transmission System Operators
GBGF	Great Britain Grid Forming
GBGF-I	Great Britain Grid Forming Inverter
GC	Grid Code
STC	System Operator Transmission Owner Code
SQSS	Security and Quality of Supply Standards
T&Cs	Terms and Conditions

Reference material

- [ESO's GC0137 "Minimum Specification Required for Provision of GB Grid Forming \(GBGF\) Capability \(formerly Virtual Synchronous Machine/VSM Capability\)" as implemented in February 2022.](#)
- [ESO's GB Grid Forming Best Practice Guide as issued in April, 2023.](#)
- European Union Agency for the Cooperation of Energy Regulators (ACER) draft amendments to the Network Code on Requirements for Generators

Annexes

Annex	Information
Annex 1	Legal Text

¹ If your modification amends any of the clauses mapped out in Annex GR.B of the Governance Rules section of the Grid Code, it will change the Terms & Conditions relating to Balancing Service Providers. The modification will need to follow the process set out in Article 18 of the Electricity Balancing Regulation (EBR – EU Regulation 2017/2195). All Grid Code modifications must be consulted on for 1 month in the Code Administrator Consultation phase, unless they are Urgent modifications which have no impact on EBR Article 18 T&Cs. N.B. This will also satisfy the requirements of the NCER process.