

Modification proposal:	Grid Code (GC) GC0137: Minimum Specification Required for Provision of GB Grid Forming (GBGF) Capability (formerly Virtual Synchronous Machine (VSM) Capability) (GC0137)		
Decision:	The Authority ¹ directs ² that the proposed modification to the Grid Code be made		
Target audience:	National Grid Electricity System Operator (NGESO or ESO), the Grid Code Review Panel, Grid Code users and other interested parties		
Date of publication:	31 January 2022	Implementation date:	14 February 2022

Background

Synchronous generators have historically dominated electricity generation, with synchronous plant characteristics influencing the stability of the electricity system. Since the 1990's, a move to renewable energy has resulted in the displacement of synchronous plant with non-synchronous plant, primarily utilising power electronic converters.

The inherent design characteristics of synchronous generators means that they provide instant responses to changes or disturbances on the electricity system as a natural feature of their physical operation. These characteristics are of paramount importance to the stability of the electricity system, particularly under fault conditions. For example, the declining levels of system inertia available as a result of the declining level of synchronous generation has driven ESO works to address the system impacts. This includes the Network Options Assessment Stability Pathfinder³, the Accelerated Loss of Mains Change Programme⁴, and the introduction of additional Balancing Services such as the faster acting frequency response product, Dynamic Containment⁵. Despite such

¹ References to the "Authority", "Ofgem", "we" and "our" are used interchangeably in this document. The Authority refers to GEMA, the Gas and Electricity Markets Authority. The Office of Gas and Electricity Markets (Ofgem) supports GEMA in its day to day work. This decision is made by or on behalf of GEMA.

² This document is notice of the reasons for this decision as required by section 49A of the Electricity Act 1989.

³ <https://www.nationalgrideso.com/future-energy/projects/pathfinders/stability>

⁴ <https://www.nationalgrideso.com/industry-information/accelerated-loss-mains-change-programme-alomcp>

⁵ <https://www.nationalgrideso.com/balancing-services/frequency-response-services/dynamic-containment>

works, at times (e.g. during periods of high renewable output coupled with low demand), the ESO is forced to take action to curtail renewable output and bring on synchronous generation, typically using fossil fuel sources, in order to maintain system stability. This conflicts with the ESO's Net-Zero ambition to achieve zero carbon operation of the Transmission System⁶.

Grid Forming Capability can be described as a plant's ability to exhibit similar characteristics to that of a conventional synchronous generator, therefore contributing to the stability of the electricity system. The ESO considers such capability to be key, alongside other system stability services, to enable zero carbon operation of the electricity system. GC0137 builds on previous research on the concept of Grid Forming Capability (also known as Virtual Synchronous Machine (VSM)), VSM / Grid Forming demonstrations, and developments of the ESO Virtual Synchronous Machine Expert Group established in 2018.⁷

The modification proposal

GC0137 was proposed by NGENSO on 10 December 2019. It aims to address the system stability issues arising as a result of declining levels of synchronous generation on the electricity system. It does so by introducing a non-mandatory Grid Code minimum specification for enhancing the capability of asynchronous plant so that they exhibit similar characteristics to that of conventional synchronous plant under fault conditions.

The ESO expect this specification to form the basis of a future short term operational stability market where the capability can be procured. GC0137 defines the types of power (including reactive power) and fault current responses required under Grid Forming Capability, however it does not prescribe a minimum magnitude of response required. We note that a future market in which Grid Forming Capability will be procured is yet to be developed. However, through discussion with the ESO, we understand that all plant with Grid Forming Capability (e.g. synchronous plant, power electronic converter plant, storage plant, smart loads etc.) will be able to participate in the market. It is anticipated that they will price their service according to the magnitude of their capability against each of the types of responses required under Grid Forming Capability.

⁶ More information on the ESO's Net-Zero system operation ambition can be found on their website; <https://www.nationalgrideso.com/news/zero-carbon-operation-great-britains-electricity-system-2025>

⁷ The level of research and development of Grid Forming or Virtual Synchronous Machine capability is demonstrated in references 18 and 19 of the GC0137 Final Modification Proposal.

GC0137 proposes to introduce:

- Definitions for Grid Forming Capability, and the types of power and current injection or response characteristics that plant with such capability must be capable of providing, in the Grid Code Glossary & Definitions.
- Minimum technical requirements, including monitoring, for the provision of Grid Forming Capability, in the Grid Code European Connection Conditions.
- Compliance requirements, including simulation studies and compliance testing, for the provision of Grid Forming Capability, in the Grid Code European Compliance Process.
- Data requirements for the provision of Grid Forming Capability in the Grid Code Planning Code and Data Registration Code.

Six workgroup meetings took place between April 2020 and June 2021, during which NGENSO committed to establishing an Expert Working Group tasked with producing a 'GB Grid Forming Best Practice Guide'. GC0137 proposes to define a high level specification for Grid Forming Capability, with additional guidance and further detail prescribed via the Best Practice Guide.

A Code Administrator Consultation was issued on 3 September 2021, closing on 4 October 2021. Seven responses were received, all in support of GC0137, with the majority supporting the implementation approach. We note that some responses highlighted a number of areas in the technical specifications that required further development. We have discussed these issues with NGENSO who confirmed that they have responded to each concerned party and, for each technical concern, either adopted changes, or referred to the GB Grid Forming Best Practice Guide where the issues are to be discussed further. They also invited that respondents to join the Expert Working Group producing the GB Grid Forming Best Practice Guide.

Grid Code Review Panel recommendation

The Grid Code Review Panel carried out their recommendation vote on 27 October 2021. They recommend by majority (7 out of 8) that GC0137 better facilitates the Grid Code objectives when compared with the existing terms of the Grid Code.

One Grid Code Review Panel Member voted against GC0137, giving two reasons in their voting statement. The reasons and our views against these are listed in the section below.

Our decision

We have considered the issues raised by the modification proposal and in the Final Modification Report dated 11 November 2021. We have considered and taken into account the responses to the industry consultation on the modification proposal which are included in the Final Modification Report⁸. We have concluded that:

- implementation of the modification proposal will better facilitate the achievement of the objectives of the Grid Code;⁹ and
- approving the modification is consistent with our principal objective and statutory duties.¹⁰

We note that one Grid Code Review Panel Member voted against GC0137, giving two reasons in their voting statement. These are listed below along with our views against each point:

1. That it is unclear whether or not Synchronous Compensators (a type of plant contracted via the ESO Stability Pathfinder) are included in GC0137 (i.e. whether or not synchronous compensators can be considered to have Grid Forming Capability).

We note that synchronous compensators are referenced in the Grid Code definition for 'Dynamic Reactive Compensation Equipment', which is in turn included in the proposed definition for 'Grid Forming Capability'. The requirements for providing Grid Forming Capability are technology agnostic, and therefore any type of plant, including synchronous compensators, may provide the capability.

2. That the changes proposed under GC0137 are not required for NGENSO to procure Grid Forming Capability.

We consider that for NGENSO to contract a service such as Grid Forming Capability, from asynchronous plant in particular, the requirements are likely to

⁸ Grid Code proposals, final reports and representations can be viewed on NGENSO's website at: <https://www.nationalgrideso.com/industry-information/codes/grid-code/modifications>

⁹ As set out in Standard Condition C14(1)(b) of the Electricity Transmission Licence, available at: <https://epr.ofgem.gov.uk/>

¹⁰ The Authority's statutory duties are wider than matters which the Grid Code Panel Review must take into consideration and are detailed mainly in the Electricity Act 1989 as amended.

need to be grounded within the Grid Code due to the novelty and technical complexity involved.

Whilst we acknowledge that the changes proposed by GC0137 are not required for NGENSO to contract a Grid Forming Capability service, we consider the introduction of the concept of Grid Forming Capability, and recognising and defining the types of responses inherent in the design of typical synchronous generators better promotes system security within the Grid Code. As stated below, we consider GC0137 to better facilitate the achievement of Grid Code objectives (i)¹¹, (ii)¹² and (iii)¹³.

Reasons for our decision

We consider this modification proposal will better facilitate Grid Code objectives (i), (ii), and (iii), and has a neutral impact on the other applicable objectives.

(i) to permit the development, maintenance and operation of an efficient, co-ordinated and economical system for the transmission of electricity

At present during periods of high renewable generation and low system demand, NGENSO can be required to take action to curtail renewable output and bring on synchronous generation in order to maintain system stability. The synchronous generation brought on provides the same amount of power as the curtailed renewable output, along with the provision of stability services, leading to inefficient market outcomes.

Further, synchronous generators are typically fuelled by fossil fuel sources and are increasingly being replaced by asynchronous renewable generators. Sourcing stability from alternative plant is therefore crucial to the maintenance and operation of an efficient system, particularly as the industry transitions towards net zero carbon operation. GC0137 facilitates this by introducing a non-mandatory minimum specification for plant (of all types, including renewables) to exhibit similar characteristics to traditional synchronous plant, and therefore contribute to system stability.

11 Grid Code Objective (i); to permit the development, maintenance and operation of an efficient, co-ordinated and economical system for the transmission of electricity

12 Grid Code Objective (ii); to facilitate 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)

13 Grid Code Objective (iii); 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

Whilst we acknowledge that GC0137 will have no immediate impact on system stability, we consider GC0137 to be a vital step in transitioning to carbon neutral system operation. We therefore consider GC0137 to better facilitate this Grid Code objective.

(ii) to facilitate 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)

NGESO state that the non-mandatory minimum specification proposed under GC0137 will underpin a future short term operational stability market. Historically, synchronous generators, typically using fossil fuel sources, have dominated the provision of electricity system stability services. In recent years, the trend towards net zero has led to NGESO programmes of works to bring on alternative sources for system stability, eg. the Stability Pathfinder¹⁴. Despite this, at times, NGESO is forced to take action to curtail renewable output and bring on synchronous generation in order to maintain system stability. We consider that GC0137 will facilitate competition by underpinning a short term operational stability market allowing asynchronous generators with Grid Forming Capability to participate in the provision of a service historically provided by synchronous generators only.

We further consider that the requirements proposed under GC0137 are technology agnostic, so that any type of plant capable of providing Grid Forming Capability is permitted to do so. This further facilitates competition by diversifying the range of plant permitted to participate in a future short term operational stability market. We note that there has been significant industry involvement in the development of GC0137, and that a number of renewable generator manufacturers have responded to the Workgroup and Code Administrator Consultations. We consider that the engagement and responses demonstrate the appetite for manufacturers to provide such capability, as well as satisfaction with the prescribed requirements.

We note that one Grid Code Review Panel Member considered GC0137 does not better facilitate this Grid Code objective, stating that some Code Administrator Consultation responses highlighted technical issues which may not be able to be resolved within the GB Grid Forming Best Practice Guide. As noted above, we have discussed these responses with

¹⁴ <https://www.nationalgrideso.com/future-energy/projects/pathfinders/stability>

NGESO, and consider that the issues can be resolved within the GB Grid Forming Best Practice Guide. We note that those respondents have been invited to join the Expert Working Group tasked with producing the guidance document.

We therefore consider that GC0137 better facilitates this Grid Code objective.

(iii) 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

The inherent design characteristics of a typical synchronous generator in providing instant responses to changes or disturbances on the electricity system as a natural feature of their physical operation are well known. These characteristics play a vital role in ensuring the stability of the electricity system, particularly under fault conditions, but currently are not explicitly recognised in the Grid Code. Further, with the trend in the fall in the level of synchronous generation forecast to continue, alternative sources of stability are required. We consider that GC0137 better promotes the security of the electricity system for two reasons:

1. It modifies the Grid Code to recognise Grid Forming Capability and defines the minimum requirements for such capability.
2. It introduces the minimum requirements for Grid Forming Capability for all plant, and so will likely expand the types and number of plant providing system stability.

We therefore consider that GC0137 better facilitates this Grid Code objective.

Decision notice

In accordance with Standard Condition C14 of the Transmission Licence, the Authority hereby directs that Grid Code modification proposal GC0137: *Minimum Specification Required for Provision of GB Grid Forming (GBGF) Capability (formerly Virtual Synchronous Machine (VSM) Capability)* be made.

Martin Queen

Principal Engineer, Analysis and Assurance

Signed on behalf of the Authority and authorised for that purpose