Code Administrator Consultation Response Proforma

GC0137: Minimum Specification Required for Provision of GB Grid Forming (GBGF) Capability (formerly Virtual Synchronous Machine/VSM Capability)

Industry parties are invited to respond to this consultation expressing their views and supplying the rationale for those views, particularly in respect of any specific questions detailed below.

Please send your responses to grid.code@nationalgrideso.com by **5pm** on **04 October 2021**. Please note that any responses received after the deadline or sent to a different email address may not receive due consideration.

If you have any queries on the content of this consultation, please contact Kavita Patel Kavita.patel@nationalgrideso.com or grid.code@nationalgrideso.com

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I wish my response to be:
(Please mark the relevant box) ☒Non-Confidential ☐Confidential

Note: A confidential response will be disclosed to the Authority in full but, unless agreed otherwise, will not be shared with the Panel or the industry and may therefore not influence the debate to the same extent as a non-confidential response.

For reference the Applicable Grid Code Objectives are:

a) *To permit the development, maintenance and operation of an efficient, coordinated and economical system for the transmission of electricity*
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);*
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;*
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*
e) *To promote efficiency in the implementation and administration of the Grid Code arrangements*

Please express your views in the right-hand side of the table below, including your rationale.

Standard Code Administrator Consultation questions		
1	Do you believe that the GC0137 Original Proposal better facilitates the Applicable Objectives?	Yes, the document is helpful and well describes main objectives of the working group.
2	Do you support the proposed implementation approach?	Partly Yes. The description is overall well developed. However, some questions can be further clarified.
3	Do you have any other comments?	Yes, please see below.

Specific Comments by page ordering.

Page 6.

Table I. Reference text that describe each one of the solutions can be included. For example VSM0 [xx] with xx being the reference number(s).

Page 7.

The text "*[…] Unfortunately, these characteristics are not an inherent feature of current power electronic converter based designs, which use PLL as one of their primary controls that is used to stop the output power of current power electronics converter responding to changes in the phase-angle of the AC grid*." is questionable.

It is understood that the problem comes from the lack of a quality frequency estimation in the faulty scenario. This need not necessarily be an inherent limitation of power converter itself, but a presumably outcome from a sub-optimal adaptation from the grid-following case.

Currently this kind of topics, such as the so-called synchronization instability of special relevance in weak grids, are being on the scope of research. A scientific paper PCIM2020 [R1] for reference is recommended to check in this regard.

What could a more accurate description can reflect?

a.- Accurate Synchronization/estimation of the grid-frequency/angle are needed to implement grid-forming solutions and this can be challenging in practical scenarios (e.g., weak grids) and of more complexity that classical grid-following based PLL approaches.

b. - In our view a limitation of existing power converter technology is the fact that extra energy buffers (e.g., the excess of energy of a dc-bus to be used with frequency control purposes) are much smaller that the kinetic energy stored in the rotor of a synchronous generator.

[R1] F. D. Freijedo, D. Lopez, and R. Huempfner, “Enhancement of grid synchronization stability by means of disturbance estimation,” in Proc.of PCIM, May 2021.

Page 12.

“Proper’s” seems a typo.

Page 15.

The “*phase jump power*” is described and according to the text, associated to a benefit.

It is unclear the benefit of a power response to a random phase-angle event. Some reference of clarification would be welcome.

Page 16.

“Perquisite” seems a typo.

Page 17.

The examples at the end of the page seem a bit unformal. But somehow may help some readers. (no action required)

Page 18.

The comments about PLL operation seem disputable.

Usually, each inverter has its own PLL that tracks the phase-angle/frequency of its point of connection, not a plant output (what is a plant here is unclear). The PLL poor performance can be seen as trying to track a variable or state of the system that is not stiff enough [R1]. The “forbidden operation” of the PLL that points to change ISV seems unclearly defined. Some reference work here could be helpful. However, it is unclear if a strong boundary for internal control operation of the inverter is needed to describe the Grid-Forming functionalities and expectations. These functionalities should be clearly identified from an exogenous observation of the inverter performances, e.g., in the presence of a frequency event, and should avoid software implementation related limits.

Page 19.

The text “The requirements should not mandate minimum overload ratings.” Seems in contradiction with specification of figure 7.0a.

Page 21.

Wide definitions such as “Active Control Based Power” may loss generality if numerical values, such as bandwidth limit of 5Hz, are included. Even acknowledging that this sort of band-limiting is based on sound conjecture (resonances in 10-15 Hz region), the definition box seems not an ideal place. The table I (see page 28) seems a more suitable.

Page 24.-

The text “[…] and would not comprise virtual impedances.” Sound too restrictive, likely unfeasible and unclear. We may argue that some advance control algorithms are based on the technique of shaping the equivalent impedance/admittance of the inverter in a different region of the spectrum [R2]. This is in fact, included in normative related to stability [R3]. In practice, virtual impedance may comprise as a more general and solid control approach based on state-feedback control (a well stablished control design approach present in most of the textbooks). In that sense it is recommended to be more accurate with this kind of assertion that point to a particular case. In my understanding, this text seems to refer to the fact that a so-called virtual inertia (likely implemented by a low bandwidth outer-loop) cannot be claimed as a substitute of an inductive filter; the virtual controller cannot substitute the real short-circuit limit of the passive-bulky component. Indeed, I fully support that some basic control techniques (maybe really implementing the admittance in a small-signal sense) may not substitute the physics.

[R2] E. Rodriguez-Diaz, F. D. Freijedo, J. M. Guerrero, J.-A. Marrero-Sosa, and D. Dujic, “Input-admittance passivity compliance for grid-connected converters with an LCL filter,” IEEE Trans. Ind. Electron., vol. 66, no. 2, pp. 1089–1097, Feb. 2019.

[R3] EN50388 Ed.2. Railway Applications – Power Supply and Rolling Stock – Technical Criteria for the Coordination Between Power Supply (substation) and Rolling Stock to Achieve Interoperability, Cenelec Std., 2012.

Page 24.b.

The last statement seems too strong. It could be agreed that that response would not be expected by a classical grid-following approach.

Page 25.

About the 5Hz bandwidth to avoid AC system resonance problems. Please detail the nature of this band-limits applies for active power grid forming controls detailed in this code. Furthermore, some description for the kind of resonance; e.g., negative resistive behaviour in the 10Hz region of the spectrum or other phenomena could be added. Sometimes an active control is needed to stabilize the inverter behaviour (for example when using LCL filters) in higher frequency regions of the spectrum (e.g., around 1 kHz). An open loop operation of the inverter beyond 5Hz seems not feasible, in the sense that stable operation of inverters rely on a high bandwidth current control that, in most of cases, helps to damp pure electrical resonances in the system [R2, R3].

Page 25b.

Damping Factor within range 0.2-5 is too widely defined. A 0.2 damping factor could be associated to a really oscillating response; 5 otherwise may look very conservative. Possibly, the context or more details can be added. Some reference paper could be added for further investigation by the reader.

Page 27.

A further reference, where schemes 8 and 9 are explicitly described can be included. The text is not totally clear if any vendor has to adapt its own model descriptions to those exact models, or, if otherwise, there is a reasonable degree of flexibility to develop strategies and hence, accurate models.

A big concern that may arise in the case that those schemes are strict requests of the normative may arise in the case that any company files an IP (patent) that covers in part some of the implicit features of such implementations, this would represent a big limitation for other participants.

Maybe, it would be reasonable to ask for a model that verifies the compliance of the grid-forming services, but provide more open descriptions of such modelling.

Page 41.

“Nicolls” chart seems a typo