Code Administrator Consultation Response Proforma

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

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 **02 May 2024**. 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 Elana Byrne Elana.Byrne@nationalgrideso.com or grid.code@nationalgrideso.com .

Respondent details	Please enter your details	
Respondent name:	Dr Pablo Briff	
Company name:	SSEN Transmission	
Email address:	pablo.briff@sse.com	
Phone number:	Click or tap here to enter text.	
Which best describes your organisation?	☐Consumer body ☐Demand ☐Distribution Network Operator ☐Generator ☐Industry body ☐Interconnector	☐Storage ☐Supplier ☐System Operator ☒Transmission Owner ☐Virtual Lead Party ☐Other

I wish my response to be: (Please mark the relevant box)	☒ **Non-Confidential** *(this <u>will be shared</u> with industry and the Panel for further consideration)*
	☐ **Confidential** (this *will be disclosed to the Authority in full but, unless specified, <u>will not be shared</u> with the Panel or the industry for further consideration)*

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	Please provide your assessment for the proposed solution(s) against the Applicable Objectives?	Mark the Objectives which you believe the proposed solution(s) better facilitates:	
		Original	☒a) ☒b) ☐c) ☐d) ☐e)
		Click or tap here to enter text.	
2	Do you have a preferred proposed solution?	☐Original ☐Baseline ☐No preference	
		Please see comments below.	
3	Do you support the proposed implementation approach?	☐Yes ☒No	
		SSEN Transmission (SSEN-T) acknowledges the benefits virtual impedances can bring to the electrical grid, since they provide flexibility in varying the equivalent impedance presented by the inverter to the grid, a feature that would be extremely difficult to implement only with physical impedances. However, SSEN-T does not support the proposed implementation in its current form. In SSEN-T's view, there are several topics which require closer attention, as detailed below. a. <u>Characterisation of virtual impedances</u>: while a physical impedance can be characterized well from its manufacturer's datasheet parameters, and further supported by experimental results, a controller impedance characterization can be more difficult to	

		exercise as the controllers tend to vary their behaviour as a function of the operating point. b. Discrete-time behaviour: as opposed to a physical impedance which runs in continuous-time and is independent of the controller's state, a virtual impedance implemented by a controller will be represented as one of many controller functions, running at a finite timestep, which may not necessarily be seen by the controller as a continuous-time component. This different in nature may impact the system performance, which can in turn be a function of the controller's state. c. Fault-ride through characteristic: while passive components in a power converter serve the purpose of supporting the controllability of power converters, one of the main objectives of passive components sizing is to limit the fault current during a DC-side fault. For example, the size of limb reactors and DC reactors in a high voltage DC (HVDC) converter is mainly driven by the converter's fault response requirement. With HVDC half-bridge converters being unable to block a DC fault due to the inherent uncontrolled diode-bridge rectification experienced during a DC fault scenario, the objective of a passive reactance is to limit the rise of the fault current as a function of time (di/dt) to give sufficient time for the protection systems to actuate before the fault current has risen beyond acceptable limits within the converter equipment. The time response of the fault ride-through (FRT) behaviour implemented by using virtual impedances would largely depend on the controller implementation, i.e., control algorithm design, controller time steps, as well as controller measurement and actuation delays. Therefore, it must be ensured that di/dt within the Great Britain Grid Forming Inverter (GBGF-I) during a fault event, mainly limited by a virtual impedance, remains below a maximum acceptable value. d. Safety integrity level: in the absence of a physical separation between the main controller and the virtual impedance controller, the virtual impedance synthesis may need to be ensured to be safety integrity level (SIL) certified to a level equivalent to SIL 3 or greater. e. Requirement on protection systems: with the proposed reduction of physical impedance, particularly with the reduction of inductance, in the GBGF-I, the time response of the protection systems may need to be reduced, i.e., requiring the protection algorithms to detect and trip faster than compared to using conventional physical impedances. This is because, in the event of

		virtual impedance mal-function, the GBGF-I will have less physical impedance to limit the di/dt during a fault scenario, and hence the protection systems must be prepared to act faster than they currently do. f. CAPEX reduction justification: while the proposal form mentions on the economic benefits - understood by SSEN-T as Capital Expenditure (CAPEX) reduction - that virtual impedances could bring, the report does not sufficiently clarify the added system risk that a virtual impedance can introduce, which could ultimately translate into increased redundancy levels and increased CAPEX investment. A cost-benefit analysis (CBA) would be required to support the CAPEX reduction statement. g. OPEX reduction justification: with virtual impedance likely requiring a faster controller timestep, the switching frequency of the semiconductors in the GBGF-I may increase, thus linearly increasing its power conduction losses and therefore its Operating Expenses (OPEX), and/or requiring larger number of converter submodules comprised of semiconductor devices and DC capacitors, which would ultimately lead to larger cooling system requirements (increased CAPEX). Furthermore, when implementing virtual impedances with voltage sourced converters (VSCs), there may be an additional voltage magnitude requirement arising from the additional control functions. This increment in voltage demand would translate into increased CAPEX and therefore OPEX due to the increased power conduction losses introduced by a larger number of series-connected semiconductor devices. Overall, a CBA would be required to support the OPEX reduction statement. h. IPR: the method of synthesizing an impedance is likely to be considered as proprietary and protected by the intellectual property rights (IPR) of the relevant control algorithms, therefore limiting the amount of information that can be shared and specified, ultimately increasing the costs involved for stakeholders to guarantee the necessary system-level transient response. SSEN-T would welcome further discussion of the points raised above.
4	Do you have any other comments?	No