Grid Code Workgroup Consultation Response Proforma

GC0100 EU Connection Codes GB Implementation – Mod 1

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 by **5pm** on **2 October 2017** to grid.code@nationalgrid.com. Please note that any responses received after the deadline or sent to a different email address may not receive due consideration by the Workgroup.

Any queries on the content of the consultation should be addressed to Chrissie Brown at Christine.brown1@nationalgrid.com

Respondent:	*Christian Merchan, christian.merchan@ge.com*
Company Name:	*GE Power*
Please express your views regarding the Workgroup Consultation, including rationale. **(Please include any issues, suggestions or queries)**	*For reference, the Grid Code objectives are:* i. To permit the development, maintenance and operation of an efficient, coordinated and economical system for the transmission of electricity 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) 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 iv. 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 v. To promote efficiency in the implementation and administration of the Grid Code arrangements

Standard Workgroup Consultation questions

Q	Question	Response
1	Do you believe that GC0100 Original proposal, or any potential alternatives for change that you wish to suggest, better	Yes. Please refer to comments below.

	facilitates the Grid Code Objectives?	
2	Do you support the proposed implementation approach?	Please refer to comments below.
3	Do you have any other comments?	N/A
4	Do you wish to raise a WG Consultation Alternative Request for the Workgroup to consider?	*If yes, please complete a WG Consultation Alternative Request form, available on National Grid's website, http://www2.nationalgrid.com/uk/industry-information/electricity-codes/grid-code/modifications/forms-and-guidance/ and return to the Grid Code inbox at grid.code@nationalgrid.com*

Specific GC0100 questions

Q	Question	Response
1	Removing More Stringent Requirements' concerns have been expressed by some Workgroup members that applying more stringent requirement on newly connecting parties (that fall within this scope of the EU Network Codes for generation, demand and HVDC systems) maybe incompatible with EU law. Do you have any views on this topic that could assist the Workgroup when they are considering the topic in due course?	No comment
2	Are you comfortable with using the EU definition of Maximum Capacity instead of the GB definition of "Registered Capacity"?	No comment
	Fast Fault Current Injection questions	
3	What are your views on options 1, 2 and 3 as set out in paragraph 4.4 for Fast Fault Current Injection and which option (if any) would you prefer?	The capacity limiting factor in a power electronic converter, in particular for the large type of converter adopted in HVDC, is the current carrying capability of the available power electronic devices. The operating DC voltage with respect to ground is also

		an important determining factor as this influences the cost of the transmission circuit. These two factors then combine to provide the economic power transmission capacity of the transmission link. In general, the larger the indivisible “block” of power transmission (i.e., the larger the MegaWatt rating of the converter) the lower the cost of the converter per MegaWatt). This was true for the older technology of Line-Commutated Converter and remains so for Voltage Source converters. Reference is made to CIGRE Brochure 186, “Economic Assessment of HVDC Links”, Table 4.1. There is a fundamental difference between the operation of a synchronous machine and a power electronic based source under dynamic conditions. The machine, due to its construction will have a significant current carrying capability under dynamic (fault) conditions. However, a power electronic based source has a limited current capability due to the nature of power electronic devices. In addition, it must be highlighted that these power electronic devices have negligible thermal overload capability, that is, they are not able to operate beyond their rated current. Consequently, the fastest control associated with a converter is that which determines the instantaneous current flowing through the power electronics, and hence, being delivered to the AC system. Any demand of the converter to deliver current to the AC system (either real or reactive) must be regulated by the converter controller in order to protect the power electronics from catastrophic failure resulting in the loss of the plant. The concept of a VSM relies on the premise that the converter controller attempts to maintain an AC voltage irrespective of the consequential current, fundamentally, the current regulation described in the previous paragraph is omitted in the controller, inherently making the current response of the converter faster in the event of a dip in the AC voltage. Which, as highlighted above, risks the catastrophic loss of the converter. A solution, to permit the adoption of a VSM controller, would be to rate the converter such that the physical inductance within the converter limits the maximum current to a value within the capability of the power electronics. However, today, typically, the

		total linear inductance within the converter will be equivalent to approximately 0.3pu, making the inherent fault current 3.33pu. Hence, an unintentional consequence of the adoption of VSM would be to reduce the capacity of all future HVDC links by approximately one-third; significantly impacting on the return-on-investment of the infrastructure. It should be noted that, whilst it would be possible to increase the linear reactance of the converter, to some extent, this has a direct impact on both the maximum transmission capability of the converter and the losses associated with the AC-DC energy conversion, so, again, having a significan impact on the return-on-investment of the infrastructure. The operation of the converter as a VSM for remote faults, that is, those not demanding a current above the current rating of the converter is possible but the step of current regulation (to ensure that the current rating is not breached) must be maintained and this will impact on the speed of current injection. A pro-active approach, on the part of National Grid would be to engage the suppliers of HVDC equipment to establish what is practicable in terms of achieving a Fast Fault Current Injection response and to better define the current response envelope, noting that even a synchronous machines response is limited by its inherent reactance. Considering **Option 2** it is understood that there is no requirement for active positive phase sequence current flow and hence all of the current carrying capability of the converter is available for reactive power. Under these circumstances it may be possible to achieve 1.25pu reactive current but this would affect the voltage rating of the converter, requiring a steady-state margin in the converter design to cope with this contingency. This margin would translate into a higher steady-state converter current, resulting in reduced maximum capacity and higher converter losses, (possibly more than a 50% increase). It would also increase the size of the converter. Clarification is sort with respect to the difference between Figure 4.4(a) and Figure 4.4(b), in particular, what is the associated AC voltage? The

		above comments are based on the definition of fault recovery being that the AC voltage has achieved a positive phase sequence rms voltage of 0.9pu or high. It would be beneficial to indicate the corresponding AC voltage characteristic. Also, Figure 4.4(a) should clarify the time of 'Fault Clearance'". **Option 3** limits the maximum reactive current to 1.0pu. This would operate within the capability of today's VSC converter design without increasing capital cost or losses and would also be consistent with the solution being sourced by the global market.
4	Do you have any alternative fast fault current injection solutions noting that the requirement applies to the Converter not the wider Power System?	Response times required for **Option 2** and **Option 3** would appear to be consistent with today's technology. If this question specifically relates to **Option 1**, the VSM control of a converter then, as referenced in '3' above, it is suggested that National Grid engage with the supply chain for HVDC converters to establish what is practical. It must be borne in mind, however, that any UK special requirements that are over and above the global HVDC market need may result in an artificial restriction of the supply chain and hence a consequential increase in the capital cost.
5	In considering the three Fast Fault Current Injection options 1, 2 and 3 in paragraph 4.4 do you have any comments in relation to technology readiness, cost implications, and can they be implemented date within the context of product development timescales?	Please refer to comments under '3'. **Option 2** and **Option 3** would, based on the assumptions stated, be practicable in the time frames stated. However, **Option 1** is a major divergence from the HVDC technology applied to-date and something that the supply chain may not directly address. This would result HVDC converters connected to the UK grid being limited in power transmission capability significantly impacting on the return-on-investment and hence the economic justification for the HVDC link.
6	Do you have any evidence to support your views?	Please refer to above comments.
7	Do you have any views on the specific costs related to the additional requirements?	**Option 3**, considering the stated assumptions, are not expected to impact on cost. **Option** 2, will impact on both capital cost and losses. Option **1** would have a significant impact on the cost per MegaWatt, roughly increasing the cost by three times (x3).
8	Is the current proposed wording for the remote end HVDC and DC Connected Power park modules sufficient to facilitate future new technology?	As identified above further clarification is needed.

	Banding questions	
9	What are the specific costs related to the additional requirements?	No comment
10	Do you have any views on the banding thresholds for the original and those suggest for the possible alternative?	No comment
11	Can you provide any feedback/comments on the associated legal text?	No comment
	Fault Ride Through	
12	Do you support the fault ride through voltage against time curves If not please state why you disagree, what alternative you would recommend and your justification for any alternative?	No comment
13	Do you have any specific views about the proposal to modify the stage 2 under voltage protection for distributed generation interface protection?	No comment
	Other questions	
14	Does the Legal drafting contained in annex 2 and 3 deliver the intent of the solution outlined in section 3?	No comment
15	Do you have any information based on the proposed solution in respect of implementation costs?	No comment