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:	*Athanasios Krontiris & Grant McKay – ABB HVDC*
Company Name:	*ABB, Power Grids Division, HVDC*
Please express your views regarding the Workgroup Consultation, including rationale. **(Please include any issues, suggestions or queries)**	We are pleased to provide comments below on the questions which relate specifically to the performance or future development of HVDC converter systems. We would welcome the opportunity for further discussions with National Grid in this regard should you require any clarification or further information.

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 facilitates the Grid Code Objectives?	
2	Do you support the proposed implementation approach?	
3	Do you have any other comments?	
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?	Requirements in EU network codes are either exhaustive (values or value ranges set within the codes) or non-exhaustive (open for the relevant system operators to further specify). In the former case, more stringent requirements in national implementation than in the original EU network codes is not allowed, since this would undermine the general aim of EU-wide network codes, namely product and system harmonization. In addition to the distinction above, requirements in EU network codes are either mandatory (must be implemented on national level) or non-mandatory (can, but don't have to be implemented on national level). It is not clear if additional requirements further than the non-mandatory requirements stated in the EU network codes can be added in the national implementation. Such further requirements, which may be specific to a particular system such as the UK power system, appear in our opinion to be compatible with EU regulations, as long as they are technically justified and do not constitute unnecessary barriers to an integrated electricity market.
2	Are you comfortable with using the EU definition of Maximum Capacity instead of the GB definition of "Registered Capacity"?	Either term may be used. We recommend a clear definition in the UK grid code, potentially with a note if another term as the one in the original EU network code is used.
	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?	In our view the proposal as well as the underlying studies do not clearly identify the specific system needs; in particular, it is unclear, whether challenges in future operation are related to voltage control or frequency control. Requirements need to fall into one of these categories to be assessed correctly. We believe that fast fault current injection can already be fulfilled with today's technology (current control with PLL). We cannot therefore concur with the statement in section 4.4. (page 35) that "in summary conventional PLL converters are slow to inject reactive current and this in turn will affect the retained voltage at the connection point". Requirements for fault current injection need to cover both control implementation (e.g. performance with

		regards to timing) and rating (maximum fault current needed). The proposal stipulates values for ratings (1.5 pu for option 1, 1.25 pu for option 2), however it is unclear how these requirements are derived from system needs. With respect to (fast) frequency control, a need for provision of synchronising torque and inertia can be expected in the future as the share of non-synchronous generation increases. This need, and any related requirements, should be treated separately from fault current injection, although proposed technical solutions may address both aspects at the same time. A requirement for synchronising torque in the future seems reasonable, but –as studies by National Grid indicate– can be allocated to some generating plants only, or can be regulated by means of ancillary service markets. In our view, a market-based approach is more likely to ensure cost-optimization, since: i) The requirements for option 1 (VSM) will introduce additional costs, and ii) The exact system needs are not known yet Furthermore, a market-based approach could allow utilisation of already existing potential (e.g. in existing HVDC interconnections) potentially at a lower cost. Further comments on the proposed options: · For option 1 (VSM), several additional features/benefits are indicated on pages 35-36, including contribution to system inertia and rate of change of system frequency (RoCoF), compatibility with synchronous machines, and easy integration into existing grids, thus enabling greater market share for converter derived generator technologies. We would like to highlight that these features are not only specific to VSM, and similar behaviour can be reached by today's current control (option 2 or 3). In particular, for a low share of non-synchronous generation, operating in current control may even be more robust than VSM control. · For options 2 and 3, it is not clear from figures 4.4 under which condition blocking is permitted (for instance, is this related to potential over-voltage after fault clearance? Or is blocking due to thermal protection for longer fault clearing times also allowed?

		Furthermore, what does temporary blocking imply for the requirement for active power recovery after the fault §ECC.6.3.15.8.vi ?). In addition, the requirements for fault current injection (pu value) for fault clearing times longer than 140 ms are not given. Finally, there is no relation between remaining voltage at the PCC and required fault current injection; a requirement would need to be added defining this relation.
4	Do you have any alternative fast fault current injection solutions noting that the requirement applies to the Converter not the wider Power System?	With respect to fault current injection, we believe that current control should be sufficient; please refer to the answer in question 3 above. With respect to the provision of synchronizing torque, several solutions have been proposed for operating converters in a grid-forming matter. Concepts include among others: · Power synchronization control, refer to: "Power-Synchronization Control of Grid-Connected Voltage-Source Converters," L. Zhang, L. Harnefors, and H.-P. Nee, IEEE Transactions on Power Systems, vol. 25, pp. 809-820, 2010. · Swing-Equation-Based-Inertial-Response control, refer to: "Virtual synchronous machine", H.-P. Beck and R. Hesse, in 9th International Conference on Electrical Power Quality and Utilisation, 2007, pp. 1-6. · Inertia-Less Virtual Synchronous Machine (VSM0H) control, refer to: “Use of an Inertia-less Virtual Synchronous Machine within Future Power Networks with High Penetrations of Converters”, M. Yu, A.J. Roscoe, C.D. Booth, A. Dysko, R. Ierna, J. Zhu and H. Urdal, Power System Computation Conference (PSCC) 2016 As mentioned in the proposal, work is ongoing within entso-e. A requirement for the provision of synchronizing torque is not stated in the EU network codes, and therefore would not necessarily need to be included in the UK implementation of the codes at this stage. Instead, we recommend a later introduction of such requirements based on the findings from the entso-e study and other studies specific to the UK power system.
5	In considering the three Fast Fault Current Injection options 1,	Option 3 is state-of-the-art. Option 2 does not introduce any additional R&D

	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?	requirements for the control of converters. Therefore, it can be considered as commercially available. However, it may have some cost implications. Raising the fault current contribution to 1.25 pu means that the converter must be overrated. For HVDC converters, the requirement for higher fault current may result in the short-term to a minor increase in investment cost. In the mid-term (3-5 years), this increase in cost may be further reduced by R&D activities and new products. For the assessment of option 1, one needs to differentiate: The requirement for increased fault current stated in the proposal (1.5 pu) will have some cost implications. For HVDC converters, it will result in the short-term to an increase in investment cost. Similar to the discussion for option 2 above, the requirement for higher fault current itself is no new feature and the technology to meet such a requirement is commercially available. On the other hand, the requirement for inertia contribution cannot be covered by the state-of-the-art technology. R&D activities are required to make the proposed VSM control concept commercially available. Additional costs are related to the converter itself and the storage required for the provision of inertia. The former depends on the expanded operating range: an increase by +33% according to Annex 6 will result in higher investment cost. The latter depends mainly on the requirement for inertia support. In the supporting documents in Annex 6 a value in the range of 2-7 MWs/MVA is stated, however there is no figure in the proposal. In particular, for HVDC systems energy storage on the DC side of the converter is unlikely to be technically and/or economically feasible due to the very high voltage; instead, a separate converter with lower voltage and storage facilities on the DC side would be required which has significant implication on investment costs as well as operating losses. It is, however, possible in HVDC systems to compensate for the energy needed for inertia support in the remote terminal, as long as the VSM requirements are not valid for both terminals.
6	Do you have any evidence to support your views?	We are not aware of VSM control being implemented in any commercially available HVDC system offering. Furthermore, HVDC suppliers have not communicated to the market (press releases or publications) plans to incorporate VSM control into HVDC converters in the near future.

7	Do you have any views on the specific costs related to the additional requirements?	Please refer to our answer to question 5 above.
8	Is the current proposed wording for the remote end HVDC and DC Connected Power park modules sufficient to facilitate future new technology?	
	Banding questions	
9	What are the specific costs related to the additional requirements?	
10	Do you have any views on the banding thresholds for the original and those suggest for the possible alternative?	
11	Can you provide any feedback/comments on the associated legal text?	
	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?	The fault ride through curve for HVDC converters in Figure 7.3 is in accordance with the EU network code. However, the fault ride through is not related to fault current injection. Setting Ublock equal to zero practically disqualifies line-commutated converters. During drafting of the EU network code for HVDC, great care was taken to avoid such general disqualifications and we suggest that this may be reconsidered. We would like to further highlight that the instance of fault clearance needs a clear definition. The requirements for FRT and subsequent active power recovery up to 90% within 500 ms from fault clearance must be related to the instance the voltage returns in the 0.9-1.1 pu band. Otherwise significant overrating of the converter is necessary. Note that the term “fault clearance” is also used in Figures 4.4 and in section 4.4, however with another interpretation.
13	Do you have any specific views about the proposal to modify the stage 2 under voltage protection for distributed generation interface protection?	
	Other questions	
14	Does the Legal drafting contained in annex 2 and 3	

	deliver the intent of the solution outlined in section 3?	
15	Do you have any information based on the proposed solution in respect of implementation costs?	