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Modification proposal:	**Grid Code GC0062: Fault Ride Through**		
Decision:	The Authority[1] has decided to approve[2] this modification		
Target audience:	National Grid Electricity Transmission PLC (NGET), the Grid Code Review Panel, Grid Code users and other interested parties		
Date of publication:	15 June 2016	Implementation date:	29 June 2016

Background

Fault Ride Through (FRT) is the ability of generating units and Power Park Modules (PPMs) to ride through Supergrid Transmission System (TS) faults and disturbances whilst connected to a healthy system circuit. This is a fundamental requirement to maintain system security and to avoid cascade tripping of generation, which could cause wider system issues such as frequency collapse and potential system shut down.

The FRT requirements are defined in Connection Condition (CC) CC.6.3.15 of the Grid Code and comprise two parts: CC.6.3.15.1, which relates to generator and PPM requirements to withstand Supergrid voltage dips on the onshore transmission system; and CC.6.3.15.2, which relates to offshore generator and PPM requirements to withstand voltage dips on the Low Voltage (LV) side of the offshore platform. These are further split into two parts: (a) which defines the FRT requirements for balanced and unbalanced transmission system faults which last up to 140ms in duration; and (b) which defines the FRT requirements for balanced faults and disturbances in excess of 140ms, referred to as 'Mode B' FRT. It is accepted that generation local to the fault would be permitted to trip (generally through observed instability), but the purpose of 'Mode B' FRT requirements is to ensure that the generation remote from the disturbance remains connected and stable. CC.6.3.15.1 was introduced in June 2005. CC.6.3.15.2 was introduced later, in 2009.

Mode B FRT requires synchronous generating units and PPMs to be capable of withstanding (or riding through) against a defined 'voltage duration curve'. The 'voltage duration curve' is a profile representing the voltage level (as a percentage of the nominal Supergrid voltage) on the y-axis and time on the x-axis, defining the voltage dip and duration a generating unit must withstand (or ride through). It also defines the level of, and point at which, active power must be restored following the restoration of the system voltage.

The modification proposal

GC0062 (the 'modification proposal') relates to Mode B FRT requirements for synchronous generators only. It arose from an issue first raised by a large generator at the Grid Code Review Panel (GCRP) in January 2012 relating to CC.6.3.15.1(b). This highlighted a concern about the ability of synchronous generators to ride through voltage depressions over a timeframe that part of the 'voltage duration curve' requires. This is because synchronous generators, in particular large generators, may experience an increased rotor angle (above 90°) and pole slip as a result of a significant short duration voltage dip which the 'voltage duration curve' requires them to withstand against. This can cause the generator to move out of synchronisation and place undue stresses on the rotating shaft, potentially causing damage to the shaft or equipment connected to it.

[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.

An industry workgroup was established to investigate the matter on the recommendation of the GCRP. The workgroup agreed there was a need to revise the existing Mode B FRT requirements by changing the 'voltage duration curve' and associated legal text for synchronous generators, and clarify a demonstration method for Mode B FRT compliance.

To this end, NGET and generators conducted a number of robust simulation studies to better define the needs of the TS as well as identify a requirement that synchronous generators can meet without risk of instability or damage. The studies were reviewed by the workgroup and used to produce a 'voltage duration curve' that they considered better meets the TS requirements, whilst ensuring generator stability and safety by permitting disconnection prior to incurring instability.

The results of the studies also led the workgroup to recommend a change to the requirement regarding the restoration of active power output following TS voltage recovery (from 0.9p.u. to 1.0p.u.), which it was considered would enhance total grid stability.

Given that the modified 'voltage duration curve' and changes to the requirement for active power recovery are a relaxation to the existing requirements, the workgroup considered it appropriate for the modification to be applied retrospectively. GC0062 therefore proposes that the modification to CC.6.3.15.1 should apply to all synchronous generators with a completion date of 1 April 2005, the date on which these requirements were first introduced. The modification to CC.6.3.15.2 applies to all offshore synchronous generators, regardless of their completion date, as the current requirements stipulate.

As well as modifying the 'voltage duration curve' for synchronous generators, GC0062 splits out both CC.6.3.15.1(b) and CC.6.3.15.2(b) into two sections, with section (1b) relating to synchronous generators, and section (2b) relating to Offshore Transmission System Development User Works (OTSDUW) Plant and Apparatus and PPMs, henceforth referred to as asynchronous generators:

- CC.6.3.15.1(1b): retains all the requirements of existing CC.6.3.15.1(b), but relates only to synchronous generating units with a completion date on or after 1 April 2005, with the following changes:

    - Inclusion of the modified 'voltage duration curve'
    - Requiring active power output to be restored (to ≥90% of the pre-dip level), following Supergrid voltage dips, within 1 second of restoration of the voltage to 1.0p.u of the nominal voltage at the electrical point of connection to the grid.

- CC.6.3.15.1(2b): retains all the requirements of existing CC.6.3.15.1(b), but relates to asynchronous generators only by removing reference to generating units.

- CC.6.3.15.2(1b): retains all the requirements of existing CC.6.3.15.2(b), but relates to offshore synchronous generating units only, with the following change:

    - Inclusion of the modified 'voltage duration curve'
    - Requiring active power output to be restored (to ≥90% of the pre-dip level), following Supergrid voltage dips, within 1 second of restoration of the voltage to 1.0p.u of the nominal voltage at LV Side of the Offshore Platform.

- CC.6.3.12.2(2b): retains all requirements of CC.6.3.15.2(b), but relates to asynchronous generators only, by removing reference to offshore generating units.

GC0062 also proposes changes to Appendix 4 and Appendix 4B of the Connection Conditions which clarify, through examples, the FRT requirements for onshore and offshore generators respectively. The changes separate the requirements for synchronous

generators from asynchronous generators, and include the modified 'voltage duration curve' for synchronous generators. There are also updates to Grid Code references and figure labelling throughout CC.6.3.15.1, CC.6.3.15.2, Appendix 4 and Appendix 4B.

Following workgroup development of GC0062 between December 2013 and December 2015, an industry consultation was held between February and March 2016. There were six responses to the industry consultation, all of which were fully supportive of the modification proposal.

It should be noted that the workgroup thought it beneficial for synchronous generators to demonstrate Mode B FRT compliance, which the Grid Code as currently written does not require. To this end, the workgroup discussed in detail how compliance should be demonstrated. NGET and a number of respondents considered this would provide clarity of Mode B FRT requirements and increase co-ordination of synchronous generators. However, NGET considers that compliance demonstration requires further clarity and it envisages that this will occur when the Requirements for Generators (RfG)[3] Code is implemented (which will require a further, future Grid Code modification).

NGET's recommendation

NGET considers that the proposal strikes the right balance between maintaining the safety, security and economic operation of the TS whilst at the same time defining a set of requirements which a synchronous generating unit can reasonably achieve, with no impact on the reliability of the TS or of synchronous generating units.

NGET considers that GC0062 will better facilitate the following Grid Objectives:

- (i), by providing clarity on how FRT compliance, as required by the modification, should be demonstrated.
- (ii), by facilitating competition through relaxation of the Mode B FRT requirements for synchronous generators to achievable levels, thereby providing easier access to the TS.
- (iii), by balancing the security and robustness of the TS with the capability of synchronous generating units.

NGET considers that GC0062 has a neutral impact against Grid Objective (iv) as it does not conflict with the RfG requirements.

Our decision

We have considered the issues raised by the modification proposal and in the Final Report dated 15 April 2016.[4] We have considered and taken into account the responses to NGET's consultation on the modification proposal which are included in the Final Report.[5] We have concluded that:

- implementation of the modification proposal will better facilitate the achievement of the objectives of the Grid Code[6]; and

[3] The Requirements for Generators (RfG) Code is a European Network Code which will be implemented in the Grid Code through future modifications.
[4] Subsequent to receiving the Final Report, we discussed with NGET some points of clarification. This resulted in NGET making a minor change to 'Annex 3 – Proposed Legal Text' of the Report, which was resubmitted to us on 12 May 2016.
[5] Grid Code proposals, final reports and representations can be viewed on NGET's website at: http://www2.nationalgrid.com/UK/Industry-information/Electricity-codes/Grid-code/Modifications/
[6] As set out in Standard Condition C14(1)(b) of NGET's Transmission Licence, available at: https://epr.ofgem.gov.uk/ http://www2.nationalgrid.com/UK/Industry-information/Electricity-codes/Grid-code/Modifications/

- approving the modification is consistent with our principal objective and statutory duties.[7]

Reasons for our decision

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

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

The modification proposal strikes a better balance between the needs of the TS and the ability of synchronous generators to ride through Mode B faults without risk of damage. Greater confidence in relying on the generators' ability to withstand Mode B faults would help avoid undue cost on the TS to ensure its secure operation, thereby better facilitating the efficient operation of the TS.

(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)'

The modification proposal removes undue risk of damage to synchronous generators whilst ensuring secure operation of the TS. This is particularly relevant for large synchronous generators (>1600MVA) which are permitted to have a lower short circuit ratio, which increases their susceptibility to pole slipping, using standard design approaches. It therefore removes a potential barrier to entry and facilitates the connection of synchronous generators of all sizes. The modification facilitates competition and permits a greater variation in primary energy sources for synchronous generators, including large nuclear generators.

We note that, under the proposed changes, the existing more stringent requirements would remain for asynchronous generators. We note that asynchronous generators can currently meet the requirements, with few cost implications, and therefore the modification will not disadvantage their participation in competition.

For these reasons, we consider that GC0062 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 modification proposal sets requirements that minimise the risk of increased rotor angle resulting in pole slip for all synchronous generators, but for large synchronous generators in particular. It thereby reduces the risk of loss of generation, through tripping or damage, increasing the overall security of the TS.

We acknowledge that, whilst the modification poses less stringent requirements on synchronous generators, simulation studies run by NGET and generators showed the loss of generation from applied realistic Mode B faults to be within the infrequent infeed loss limits set out in the Security and Quality of Supply Standards (SQSS). We note the

[6] As set out in Standard Condition C14(1)(b) of NGET's Transmission Licence, available at: https://epr.ofgem.gov.uk/

[7] The Authority's statutory duties are wider than matters which NGET must take into consideration and are detailed mainly in the Electricity Act 1989 as amended.

modification increases TS security by reducing the risk of failure or damage on synchronous generators, thereby increasing their availability to contribute to the restoration of TS voltage following a Mode B fault. Furthermore, NGET did not identify any material negative impact on the reliability of the TS or synchronous generators as a result of this modification.

We note that Mode B faults are not covered by the SQSS requirements, which cover secured faults only, and are intended to act as a last resort to prevent a total system collapse. The workgroup identified that loss of generation, exceeding the limits set in the SQSS requiring load disconnection, occurs when simulating severe fault conditions. As Mode B faults are not covered by the SQSS, the modification better facilitates this Grid Code objective for the reasons outlined above.

(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.'

The modification proposal has no conflicts with the RfG Code which only relates to FRT requirements for faults cleared within main protection timeframes. Therefore, we note that the modification has a neutral impact on this Grid Code objective.

Decision notice

In accordance with Standard Condition C14 of NGET's Transmission Licence, the Authority hereby approves modification proposal Grid Code GC0062: *'Fault Ride Through'*.

Min Zhu
Associate Partner – Cost & Outputs and Technical
Signed on behalf of the Authority and authorised for that purpose