

Modification proposal:	Modification to the Grid Code: Grid Code Limits on Rapid Voltage Changes (GC0076)		
Decision:	The Authority ¹ directs that the proposed modification to the Grid Code ² be made		
Target audience:	National Grid Electricity Transmission PLC (NGET), Grid Code users and other interested parties		
Date of publication:	12 August 2015	Implementation date:	26 August 2015

Background

National Grid Electricity Transmission plc (NGET) is the System Operator (SO) for the National Electricity Transmission System (NETS). NGET is responsible for ensuring the stable and secure operation of the whole of the NETS. The Grid Code specifies the technical requirements for users connecting to, and using, the NETS.

The Grid Code Connection Conditions (CC.6.1.7) set out the permissible voltage fluctuations at the Point of Common Coupling. This is the point at which the transmission network connects to a user's sole use assets.

CC.6.1.7 imposes a maximum limit of 3% on the magnitude of voltage fluctuations for sites in England and Wales. For sites in Scotland, there is a cross reference to the Engineering Recommendation P28 for voltage steps, which also imposes a limit of 3%.

The Grid Code does not allow exceptions to these limits for infrequent operational events, such as transformer energisation, or events that can be short lived (<1 s). This requirement, strictly applied, can mean that additional investment is needed to stay within the stated limits. In some cases, for some design choices in certain locations, it is not possible to stay within the 3% limit.

Currently, the Grid Code does not explicitly recognise the concept of a rapid voltage change (RVC). CC.6.1.7 uses the terms "voltage excursions" and "step change", which imply a rapid voltage change (ie almost instantaneous), but does not define it. GC0076 proposes to define more clearly the magnitude and rate of acceptable voltage change, introducing the concept of an RVC for the first time.³ RVCs can occur from operations such as motor start-ups, capacitor switching, transformer energisation, load changes and faults.

The modification proposal

GC0076 (the "modification proposal") was first submitted to the Grid Code Review Panel (GCRP) as an issue paper in May 2011. In January 2014, NGET submitted GC0076 to the GCRP as a revised modification proposal. The proposal was progressed through industry consultation in April 2014. A second industry consultation took place in February 2015. On both occasions, there was majority support for the proposal subject to further improvements suggested by respondents. The proposal which NGET is now seeking our approval for is to relax the existing voltage fluctuation limits to allow for larger voltage changes but for a limited duration and frequency as described below.

¹ The terms 'the Authority', 'Ofgem' and 'we' are used interchangeably in this document. Ofgem is the Office of the Gas and Electricity Markets.

² This document is notice of the reasons for this decision as required by section 49A of the Electricity Act 1989.

³ NGET have defined an RVC as a change in the root mean square value of a voltage signal that moves from a steady state value to a maximum change (ΔV_{max}). After the voltage change has reached ΔV_{max} , the voltage will settle at a new steady state value. A steady state is reached when the rate of change of the voltage is less than or equal to a ½% over 1 second.

NGET looked at a range of literature that included information and analyses on the effects of RVCs. NGET concluded that voltage changes of limited magnitude, duration and frequency affect power quality but do not have a direct impact on the safety and security of a network. The majority of network customers are connected to low voltage networks. As an RVC will lessen as it travels through the system, users are likely to experience a smaller voltage change than at its point of origin. Nevertheless, the impact on all customers, particularly those connected at higher voltages, has to be taken into account.

NGET also looked at the effect of RVCs on electrical equipment and found no evidence that a voltage change of 10% over a limited period would affect equipment or industrial processes connected to the network.

Based on the evidence gathered, NGET considers that the investment case for additional equipment that would be needed to meet the current limits for infrequent operational events is weak. Its proposal to permit larger RVCs will allow transmission users and NGET to use transformers of a standard size and design. This will reduce costs to connect to the NETS.

The proposal creates three categories of RVC. For each category, the frequency and magnitude of the RVCs at the Point of Common Coupling will be limited by the total number and magnitude of the RVCs, with different frequency of occurrences depending on the category of the RVC. The three proposed RVC categories are as follows -

1. Category 1 is for RVCs of a maximum voltage change of 1%. There will be no limit on the frequency and number of occurrences of these RVCs.
2. Category 2 is for RVCs of maximum voltage change between 1% and 3%. The limits have been aligned with Figure 4 of Engineering Recommendation P28 and are limited to a number of occurrences per hour dependent upon the percentage change of the RVC.
3. Category 3 is restricted for RVCs that only occur for infrequent or unplanned operational activities due to commissioning, maintenance and fault restoration. The number of RVCs in this category are to be restricted to no more than four a day and have the following limits -
 - A permitted maximum decreases in voltage of 12% for up to 80ms.
 - A permitted maximum decreases in voltage of 10% for up to 2s.
 - A permitted maximum increases in voltage of 5% for up to 0.5s.
 - The change between the initial and a new steady state voltage is limited to 3%.

The proposal also allows for new connections to be constrained to a lower number of allowed category 2 and 3 events if a higher number of RVCs would be a risk to the NETS or if, in NGET's view, there would be a risk to transmission users.

NGET's recommendation

NGET issued its GC0076 final report to us on 10 July 2015. The final report recommends the introduction of defined limits on RVCs which have been based on the evidence of the impact of voltage changes on the NETS. NGET considers that this proposal sets clearer limits for system users. In its view, the proposal also addresses the issue of investment cost for infrequent large voltage changes that do not have a detrimental impact on equipment or other users of the NETS. The proposal has been refined in light of the consultation responses.

NGET considers that the proposal will better facilitate Grid Code Objectives (i) and (ii) as it will facilitate standard connection arrangements and equipment choices, leading to potentially cheaper connections. NGET also considers that clarifying the applicable limits on the magnitude and duration of RVCs will better facilitate Grid Code Objective (iii). NGET also considers that GC0076 better facilitates Grid Code Objective (iv), as it is consistent with international standards and remains unaffected by any current or proposed European Commission codes or regulations.

Our decision

We have considered the issues raised by the modification proposal and the Final Report dated 10 July 2015. We have considered and taken into account the responses to NGET's consultation on the modification proposal which are included in the Final Report.⁴ We have concluded that -

- implementation of the modification proposal will better facilitate the achievement of the objectives of the Grid Code;⁵ and
- approving the modification is consistent with our principal objective and statutory duties.⁶

Reasons for our decision

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

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

NGET explained that the proposal would reduce the need, in some situations, for additional equipment on the NETS to meet the present CC.6.1.7 voltage fluctuation limits.

NGET addressed a concern in a consultation response that the proposal would impose additional costs to the NETS to stay within the new RVC limits. NGET stated that they complied with the current limits and a relaxation in limits would mean no new network investment would be triggered. NGET use transformers that in general are small in design and would meet the limits in category 2. However, other larger equipment items which NGET require to maintain or reinforce the network could now be accommodated within the restrictions of category 3. Therefore, the proposed changes will remove the need for additional investment in the network to ensure that the current CC.6.1.7 3% limit is not breached in any circumstance.

The proposed RVC limits apply to NGET and so the proposal is expected to lead to reduced cost in maintaining and upgrading the NETS. We agree that this relaxation of the limits will facilitate the development of the NETS in an economic manner.

Objective (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)'

⁴ 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/>

⁵ As set out in Standard Condition C14(1)(b) of NGET's Transmission Licence, available at: <https://epr.ofgem.gov.uk/>

⁶ 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.

NGET considers that the proposal will allow greater use by transmission users of standard transformers and connection arrangements. The principle of this proposal was supported by the majority of consultation responses. One respondent was concerned that the limits for category 2 RVCs were too restrictive in comparison to Engineering Recommendation P28 and would increase costs for power park modules. NGET has addressed this by allowing for a higher number of RVCs to be included in category 2 (depending on the magnitude of the RVC) in alignment with Engineering Recommendation P28.

We agree that this proposal has the potential to allow for reduced connection costs and the use of standard connection arrangements. In turn, this should facilitate a more level playing field for all users of the NETS. We agree that this will have a positive, albeit small, impact on competition in generation.

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 final report explains that voltage changes of limited magnitude, duration and frequency can affect power quality but do not have a direct impact on the safety and security of the NETS. For example, their impact can be observed on perceived levels of electric lighting. However, beyond a certain point, voltage changes can impact adversely on the operation of customers' equipment and it is therefore critical that voltage changes are managed and limited. NGET's research has shown that there is an adequate margin between equipment susceptibility and the effect of the proposed limits. The proposal also retains the provision to limit the number of voltage changes in category 2 or category 3 if voltage changes would constitute a risk to the NETS or the system of any user. NGET considers that the proposal sets clear limits on the magnitude and duration of RVCs which allow for better clarity on the compliance requirements.

One consultation respondent was concerned that security of supply could be impacted as the limits would apply to NGET (ie not only to NETS users). The concern was that the new RVC limits would place restrictions on NGET and this would lead to them breaching these limits in order to ensure security of supply. NGET has explained that it already meets the current, stricter limits. Additionally, it does not envisage a situation which would require it to breach the proposed limits to ensure security of supply. Concerns were also raised about the effects of these higher magnitude RVCs on sensitive equipment, such as Variable Speed Drives. Analysis was done by NGET to show that Variable Speed Drives would not be impacted by the proposed RVC limits.

Although evidence has been presented that the risk to security of supply and electrical equipment will not be material, we consider that there may be some residual risk of unexpected and unacceptable network performance outcomes. We therefore recommend that system monitoring should take place to ensure that any such outcomes are recorded and analysed. If necessary, the learning gained could be used to refine and/or change the RVC limits proposed by this Grid Code modification. NGET has proposed that this can be done by -

- a) A flag in the C17 statements if an inability to restore equipment to service is caused by compliance with the proposed RVC limits.⁷
- b) Analysis of local distribution network users' complaints to ensure equipment is not adversely affected by the proposed RVC limits.

⁷ The C17 statement is a report on the GB transmission system performance by National Grid, as GB System Operator. This is required in accordance with Condition C17 (Transmission system security standard and quality of service) of National Grid's Transmission Licence.

We agree that the new proposed limit will remove any uncertainty about the allowable RVC limits for infrequent operations. This will allow NGET and users to manage these events better. For this reason, we consider that the proposed change is beneficial to Grid Code objective (iii). We accept NGET's case that relaxing the RVC limits will not have a material effect on the security or quality of supply to transmission users, subject to the outputs from the recommended system monitoring.

Finally, we note that the GC0076 Report to the Authority does not reference the Electricity Safety, Quality and Continuity Regulations.⁸ These Regulations set the voltage limits that apply to Great Britain's electricity system and we would highlight the need for electricity transmission and distribution network licensees to comply with the Regulations.

Next steps

Our approval of this modification proposal is subject to the following further actions being taken -

1. The GCRP will initiate a review of the RVC Grid Code limits if there are any relevant recommendations from the Engineering Recommendation P28 Workgroup.
2. Any effects of the new RVC limits are to be monitored and identified in future in the NETS Performance Report to the Authority, produced in accordance with Standard Condition C17 of NGET's Transmission Licence.
3. We consider clarity of the legal text to be important. The equation in the text regarding Category 2 should be corrected to refer to the correct variable $\% \Delta V_{\max}$. Table CC.6.1.7 does not fully describe the time limits of the RVCs that are shown in Figure CC.6.1.7. We direct NGET to amend the Category 2 and Category 3 sections of Table CC.6.1.7 and its footnote in the proposed legal text, as shown in Annex 1 to this letter.

Decision notice

In accordance with Standard Condition C14 of NGET's Transmission Licence, we approve Grid Code modification GC0076 '*Grid Code Limits on Rapid Voltage Changes*'.

We direct that GC0076 is implemented on 26 August 2015. Having considered the proposed legal text, we feel that, to improve clarity, minor changes, as shown in Annex 1, should be made.

Andy Burgess

Associate Partner, Electricity Distribution

Signed on behalf of the Authority and authorised for that purpose

⁸ The Electricity Safety, Quality and Continuity Regulations 2002 can be found at - <http://www.legislation.gov.uk/ukxi/2002/2665/contents/made>

Annex 1

Annex 1 of the final report sets out the legal text proposed by the licensees to implement this modification. As part of our decision to approve this modification proposal, we expect that the following amendments (in red) are made to Table CC.6.1.7 of the proposed legal text.

Category	Maximum number of Occurrences	$\% \Delta V_{\max}$ & $\% \Delta V_{\text{steadystate}}$
1	No Limit	$ \% \Delta V_{\max} \leq 1\% \&$ $ \% \Delta V_{\text{steadystate}} \leq 1\%$
2	$\frac{3600}{0.304 \sqrt{2.5 \times \% \Delta V_{\max}}}$ occurrences per hour with events evenly distributed	$1\% < \% \Delta V_{\max} \leq 3\% \&$ $ \% \Delta V_{\text{steadystate}} \leq 3\%$
3	No more than 4 per day for Commissioning, Maintenance and Fault Restoration	For decreases in voltage: $\% \Delta V_{\max} \leq 12\%^1 \&$ $\% \Delta V_{\text{steadystate}} \leq 3\%$ For increases in voltage: $\% \Delta V_{\max} \leq 5\%^2 \&$ $\% \Delta V_{\text{steadystate}} \leq 3\%$ (see Figure CC6.1.7)

¹ A decrease in voltage of up to 12% is permissible for up to 80ms, as highlighted in the shaded area in Figure CC.6.1.7, reducing to up to 10% after 80ms and to up to 3% after 2 seconds.

² An increase in voltage of up to 5% is permissible if it is reduced to up to 3% after 0.5 seconds.

Table CC.6.1.7 - Limits for Rapid Voltage Changes