

Modification proposal:	Modification to the Grid Code: Voltage Unbalance (GC0088)		
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:	7 January 2016	Implementation date:	To be confirmed by NGET

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 NETS is a three phase electrical network. Ideally, the voltage of all phases would be the same. However, for a number of reasons, this ideal is never fully achieved. The degree to which it is not achieved is referred to as a percentage voltage unbalance. Voltage unbalance can have impacts for devices connected to the transmission and distribution networks and so limits for voltage unbalance have to be applied.

The Grid Code Connection Condition (CC.6.1.5 (b)) set the limit for voltage unbalance at any point in the transmission network. It states that the maximum unbalance in the NETS must be below 1% in England and Wales and 2% in Scotland.³ Connection Condition CC.6.1.6 allows a maximum of 2% voltage unbalance for short durations provided that NGET's prior agreement has been sought. For equipment owned by a Distribution Network Operator (DNO) in Great Britain, the limit is 2%.

These limits are set by balancing the requirement to protect equipment connected to the transmission and distribution networks against the network investment cost of reducing voltage unbalance.

The 1% limit that currently applies in England and Wales is claimed by NGET to be lower than is generally accepted internationally and that, as the unbalance level across its network is increasing, complying with it will trigger additional network investment. NGET believes that such investment could be argued to be inefficient.

To address this, NGET carried out analysis to assess the impacts on all parties of raising the England and Wales limit. As a result of this analysis, NGET proposed that a uniform approach should be adopted across Great Britain as follows:

- set a single limit at extra high voltage (EHV) level (above 150kV) of 1.5%; and
- set a single limit at lower voltages of 2%.

Following discussion of this proposal at the Grid Code Review Panel (GCRP) in November 2014, an industry workshop was held in February 2015. This was followed by an industry consultation between 30 July 2015 and 3 September 2015. The only substantial objection

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's report to the Authority states that an extensive search of the CEGB archive (as far back as the 1960s, 1970s and 1980s, Chief Engineer conferences/recommendations) and NGET Policies, Technical Specification and Technical Notes did not reveal any proposal, justification, recommendation or study as to why the limit set in the GB Grid Code is 1% in England & Wales and 2% in Scotland.

to the proposal was that, without detailed studies being carried out, there was an unjustified risk that the consequential reduction in the current limit in Scotland could trigger additional network investment there.

The modification proposal

In the light of the outcome of the industry consultation, NGET decided to submit a modification proposal (GC0088) that leaves the Scottish limits at their current level. It can be summarised as follows:

- a single limit at EHV level (above 150kV) of 1.5% for England and Wales;
- a single limit at EHV level (above 150kV) of 2% for Scotland; and
- a single limit at lower voltages of 2% for GB.

The proposed legal text to give effect to this is set out in Annex 1 of both the GC0088 Final Report and this decision letter.

Further studies are being progressed between National Grid as the NETS System Operator and the Scottish transmission companies. It is intended that the results of this work may enable a further modification proposal to be brought forward to harmonise the limits across GB, as originally proposed for GC0088.

NGET's recommendation

NGET issued its GC0088 Final Report to us on 20 October 2015. A revised version of the Report was then issued and published on 18 November 2015, as explained below. The Final Report recommended the revised voltage unbalance limits set out above. NGET considers that this proposal will better facilitate Grid Code Objectives (i), (ii), (iii) and (iv).

Our decision

We have considered the issues raised by the modification proposal and the Final Report dated 20 October 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 raised a number of questions with NGET about the Final Report following its submission on 20 October 2015. These were not material and have not affected our decision. However, they did reveal some minor errors in the Report which required correction. As a result, NGET issued and published an updated version of the Report (dated 18 November 2015) on its website with the necessary corrections.

We are very aware that higher voltage unbalance levels could increase the risk of damage to, and increase losses within, equipment connected to the transmission and distribution networks. NGET's analysis indicated that raising the limit at EHV level from 1% to 1.5% in England and Wales would be consistent with the principle of achieving equitable sharing of emissions between voltage levels while maintaining the existing limit at lower voltages. As the equipment connected to the power system is able to withstand voltage unbalance up to the limit currently applied at these lower voltages, NGET believes that the proposed change would not affect such equipment. As there was no record of support for the proposal from network users that could be impacted, we asked the GCRP, at its meeting on 25 November 2015, to provide confirmation of users' support for GC0088. This discussion confirmed that the proposed relaxation of the voltage unbalance limit will not cause users any material negative impacts.

⁴ GC0088 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/GC0088/>

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'

We agree that the relaxation of the voltage unbalance limit in England and Wales has the potential to reduce network investment costs in certain situations and for parts of the transmission network.

NGET has estimated that this change could reduce its network investment by some £100 million over the next 5-10 years. More specifically, NGET has identified a number of new connection schemes where meeting the current voltage unbalance limit is expected to be difficult. If only half of these schemes proceed, this change is expected to save a minimum of £15 million. Having asked for more information behind these numbers, we consider NGET's assessment of these savings to be very high level and, on their own, would not provide a robust basis for a cost-benefit analysis. However, as NGET's analysis and the industry consultation confirmed that the proposed relaxation of the voltage unbalance limit will not cause users any material negative impacts, this should lead to a more efficient transmission system overall, which will ultimately benefit consumers. For this reason, we have decided to accept the approximate nature of the expected savings. We will be asking NGET to provide more detailed relevant information about these savings in their RIIO annual reports.

As noted above, we are aware that increased voltage unbalance can have negative impacts for users, including increased losses in rotating machines. These impacts had not been quantified in the Report, which only noted that the proposed limit is below the commonly accepted withstand level for equipment connected to the transmission and distribution networks. We raised this with the GCRP (as referred to above) and the user representatives were encouraged to respond on this point. No concerns were expressed about the proposal. We are therefore content that there are no material downsides to this proposal.

Overall we therefore consider that it better facilitates this objective.

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)'

We agree that this proposal has the potential to allow for reduced connection costs for generation and demand in certain situations and for parts of the transmission network. In

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.

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. For this reason, we consider that the proposal does better facilitate this objective.

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'

While we do not see this proposal having any impact on the security of electricity networks, it will promote the efficiency of the electricity transmission and distribution systems in the national electricity transmission system operator area taken as a whole. For this reason, we consider that the proposal does better facilitate this objective.

Objective (iv) 'to efficiently discharge the obligations imposed upon the licensee by this licence and to comply with the Electricity Regulation and any relevant legally binding decisions of the European Commission and/or the Agency'

NGET considers that the proposal better facilitates this objective. The Final Report sets out that the change proposed is in accordance with the internationally recommended practices suggested by CIGRE⁷ Working Groups and adopted by other major European utilities. This brings the voltage unbalance limit further into alignment with these international practices. However, we are not persuaded that the proposal directly relates to this objective of discharging any legally binding obligations and therefore consider it has a neutral impact.

Further work

While we have decided to approve this proposal, we note that it has not yet been possible to harmonise the voltage unbalance limit across the whole of GB. We would encourage NGET, as the NETS System Operator, and the Scottish transmission companies to complete the further studies they are undertaking as soon as possible so that a decision can be made about this issue with the required level of certainty. We would expect this further work to consider and compare the costs and benefits of adopting the 1.5% limit in Scotland. The studies therefore should explore how the current limit at 2% would facilitate equitable sharing of emissions at EHV and lower voltages while maintaining the 2% limit at the latter. It should also explicitly identify any investment costs that would result from adopting the lower limit at 1.5% in Scotland.

Decision notice

In accordance with Standard Condition C14 of NGET's Transmission Licence, we approve Grid Code modification GC0088 'Voltage Unbalance'.

We direct that GC0088 is implemented on a date to be confirmed by NGET. It should be noted that the legal text to be adopted is as set out in Annex 1 of the revised Final Report to the Authority dated 18 November 2015 and which is replicated in Annex 1 of this letter.

Min Zhu

Associate Partner, Electricity Transmission

Signed on behalf of the Authority and authorised for that purpose

⁷ CIGRE, the Council on Large Electric Systems, is an international non-profit Association for promoting collaboration with experts from all around the world by sharing knowledge and joining forces to improve electric power systems of today and tomorrow.

Annex 1

Annex 1 of the Final Report sets out the legal text proposed by the licensee to implement this modification. The proposed new text is shown in red and is based on Grid Code Issue 5 Revision 14.

Voltage Quality Waveform

CC.6.1.5

All Plant and Apparatus connected to the National Electricity Transmission System, and that part of the National Electricity Transmission System at each Connection Site or, in the case of OTSDUW Plant and Apparatus, at each Interface Point, should be capable of withstanding the following distortions of the voltage waveform in respect of harmonic content and phase unbalance:

(a) Harmonic requirement

...

(b) Phase Unbalance

Under Planned Outage conditions, the ~~maximum~~ **weekly 95 percentile of** Phase (Voltage) Unbalance, **calculated in accordance with IEC 61000-4-30 and IEC 61000-3-13**, on the National Electricity Transmission System **for voltages above 150kV** should ~~remain~~ in England and Wales **be** below ~~1%~~ **1.5%**, and in Scotland below 2%, **and for voltages of 150kV and below, across GB below 2%**, unless abnormal conditions prevail. Offshore requirements (or in the case of OTSDUW, OTSDUW Plant and Apparatus) will be defined in relevant Bilateral Agreements.

The Phase Unbalance is calculated from the ratio of root mean square (rms) of negative phase sequence voltage to rms of positive phase sequence voltage, based on 10-minute average values, in accordance with IEC 61000-4-30.

CC.6.1.6

Across **GB**, under the Planned Outage conditions stated in CC.6.1.5 (b) infrequent short duration peaks with a maximum value of 2% are permitted for Phase (Voltage) Unbalance **for voltages above 150kV**, subject to the prior agreement of NGET under the Bilateral Agreement and in relation to OTSDUW, the Construction Agreement. NGET will only agree following a specific assessment of the impact of these levels on Transmission Apparatus and other Users Apparatus with which it is satisfied.