**Grid Code Review Panel**

# CONSTANT TERMINAL VOLTAGE

**Date Raised:** 17 July 2013

**GCRP Ref:** pp13/40[1]

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| **Summary** |
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| Constant terminal voltage requirements set out in Grid Code Connection Condition CC.6.3.4 |

| **Users Impacted** |
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| ***High –*** Generating Units, Power Park Modules, DC Converters and OTSDUW Plant and Apparatus<br>***Medium –*** None Identified<br>***Low –*** None Identified |

## Description & Background

***Background***

Grid Code Connection Condition CC.6.3.4 (a) specifies that the Reactive Power Output of any Onshore Generating Unit, Onshore DC Converter and Onshore Power Park Module or OTSDUW Plant and Apparatus under steady state conditions should be fully available within the voltage range of ±5% at 400kV, 275kV and 132kV.

The issue relates to the first part of CC.6.3.4(a) where Generating Units, Power Park Modules, DC Converters and OTSDUW Plant and Apparatus are required to satisfy the above requirement. The latter part of CC6.3.4(a) relates solely to Onshore Power Park Modules connected at or below 33kV where the requirement is modified to take account of the connecting transformer not owned and controlled by the generator.

In order to design and operate the Transmission System in a safe, secure and economic manner and ensure the flow of Active Power across the network, National Grid as System Operator will need to maintain a voltage profile across the network. The principle way in which this is achieved is through the provision of Reactive Power supplied by connected Generating Units.

Under CC.6.3.2 of the Grid Code, Synchronous Generating Units are required to have a reactive capability at the Generating Unit terminals of 0.85 power factor lag (overexcited) to 0.95 Power Factor lead (under excited) at the rated MW output and meet the supplied performance chart at other active power loading levels.

The additional requirement of CC.6.3.4 effectively requires the full reactive capability of the Generating Units (as specified in CC.6.3.2) to be fully available for any HV voltage change of between ±5% of nominal at 400kV, 275kV, 132kV and below

In practice the way in which this is achieved is for a Synchronous Generating Unit is for the Automatic Voltage Regulator (AVR) to control the terminal voltage to a constant value

[1] The Code Administrator will provide the paper reference following submission to National Grid.

(typically 21kV for a 500MW Generating Unit) and the onload tap changer on the Generator Transformer to adjust the MVAr output by variation in tap position. In addition CC.6.3.8 (a) (i) of the Grid Code states "A continuously–acting automatic excitation control system is required to provide constant terminal voltage control of the Onshore Synchronous Generating Unit without instability over the entire operating range of the Onshore Generating Unit".

The advantage of this approach is that it enables the MVAr output of the Synchronous Generating Unit to be controlled independently of the machines terminal voltage. A constant voltage at the machines terminals is an important feature for ensuring regulation of station auxiliary supplies. It also provides greater MVAr reserves to the System in the event of a fault or disturbance, this latter point being important in fulfilling the requirements of the SQSS.

***The Issue***

The issue has come to light at a number of Power Stations utilising Synchronous Generating Units where the Generator Transformer tapping range has been insufficiently specified to provide the full reactive capability range over the voltage range specified in CC6.3.4(a). The effect of which being a reduction of MVAr reserves available, and the ability of the Transmission System to recover, particularly post fault.

In some countries it is not common practice to fit on-load tap changers to the Generator Transformer, with system voltage regulation being achieved by adjusting the set point of the AVR. Direct comparison between GB and other countries is complex as the point at which Reactive Capability is delivered (ie at HV or LV) will vary, the security criteria (including the voltage ranges) to which those countries operate (ie N-1 or N-D) together with variations in system topology.

National Grid has run a number of generic studies and identified that for a typical generator transformer with a fixed tap position, to achieve the full reactive range over a ±5% voltage range would require a terminal voltage change in excess of ±10%. This we believe would cause significant issues for the Station's auxiliary supplies unless additional mitigation measures are put in place. The conclusion is that it is essential to install an onload tap changer.

There are however a number of issues worthy of further consideration.

- The need to have full Reactive Capability (0.85 Power Factor Lag) at high system voltages (eg 420kV).
- The need to have full Reactive Capability (0.95 Power Factor Lead) at low system voltages.
- The potential scope for defining a Voltage against Reactive Power capability diagram.
- The impact of adjusting the AVR target voltage away from nominal.

Under Article 13 2(b) of the ENTSO-E Requirements for Generators Code the current proposed requirements define the combined reactive capability in terms of a voltage – Q / Pmax profile at the HV Connection Point (ie the HV side of the Generator Transformer) rather than the Generating Unit terminals. The current ENTSO-E RfG provides little choice in respect of the National selections (other than in respect of the boundary between MVAr import and MVAr export. At the time of writing the reactive capability in GB is expected to be equal to 0.9 Power Factor Lead to 0.9 Power Factor Lag at the HV

Connection Point over a voltage range of ±5%. . In addition Article 12 2(b) requires a Synchronous Power Generating Module to be equipped with a permanent automatic excitation control system in order to provide constant Alternator terminal Voltage at a selectable Setpoint without instability over the entire operating range.

The ENTSO-E RfG comitology process is expected to commence in October 2013 with completion in early 2014. From then, there will be a 2 – 3 year implementation process where the National Codes (ie the GB Grid Code) will need to be amended to ensure it is consistent with the requirements of the ENTSO-E RfG which is expected in 2016 -2017. Where National choices are available, these will be subject to the full Governance arrangements of the GB Grid Code.

In so far as the issue associated with CC.6.3.4 is concerned, the ENTSO-E RfG requirement will remain which is expected to still necessitate the installation of a Generator Transformer fitted with an On-load Tap Changer. There is some scope for National Choice around this requirement although these are limited.

**Proposed Solution**

National Grid acknowledge there are some potential issues associated with CC.6.3.2, CC.6.3.4 and CC.6.3.8 of the Grid Code however there are three options to take this issue forward.

***Option 1*** - Convene a working group to investigate the issues of Constant Terminal Voltage only. National Grid consider this option cannot be considered in isolation and would recommend that it is discounted in favour of either option 2 or 3.

***Option 2*** - Convene a specific working group following the July GCRP to work towards aligning the GB Grid Code with the ENTSO-E RfG Requirements.

***Option 3*** - Address and implement the settings and National Choices under the ENTSO-E RfG implementation programme following the Comitology phase.

**Assessment against Grid Code Objectives**

Will the proposed changes to the Grid Code better facilitate any of the Grid Code Objectives:

***(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;*** and

***(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 proposal will better facilitate objectives (i)(ii) and (iii) to ensure consistency with the ENTSO-E RfG which will be required under European law. Although there are limited National Choices under the ENTSO-E RfG in respect of Reactive Power Capability and HV Voltage variation this would not preclude the need to maintain a constant Generator terminal voltage. Any such change within the framework of the ENTSO-E RfG would provide greater certainty to Generators and manufacturers at the design and operational stages.

**Impact & Assessment**

***Impact on the National Electricity Transmission System (NETS)***

On the basis that any proposed change would be consistent with the ENTSO-E Requirements for Generators no impact is identified on the National Electricity Transmission System or in respect of User's of the Transmission System.

***Impact on Greenhouse Gas Emissions***

No impacts are envisaged on Green House Gas Emissions as a result of any proposed modification.

***Impact on core industry documents***

The proposed modification may potentially impact on the GB Grid Code although such changes would need to included through the ENTSO-E RfG implementation process.

***Impact on other industry documents***

The proposed modification does not impact on any other industry documents.

**Supporting Documentation**

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| Have you attached any supporting documentation | No |
| If Yes, please provide the title of the attachment: | Not applicable |

**Recommendation**

The Grid Code Review Panel is invited to:

Consider the issue and provide guidance/clarification