# Constant Terminal Voltage Control

(Paper by National Grid)

## Introduction

1. The Grid Code provides a framework of technical requirements (Connection Conditions) for Users to comply with in order to ensure safe and secure operation of the National Electricity Transmission System (NETS). Many of the technical requirements in the Connection Conditions (CC) have been in place since privatisation of the industry with periodic additions to reflect new and evolving technology. Occasionally, Users query the interpretation and principles associated with these CCs.

2. A number of Users seeking connection to and use of the NETS have queried National Grid's interpretation of "constant terminal voltage control" as referred to within CC.6.3.8 together with the requirements of CC.6.3.4. This paper presents to the Grid Code Review Panel the interpretation of these CCs as held by National Grid since privatisation.

## Background

3. The requirements of CC.6.3.8 are that a synchronous Generating Unit is operated in constant terminal voltage control. National Grid's interpretation of the term "constant" as used within the context of this requirement is "not varying", hence the interpretation is that once synchronised to the NETS, a Generator should set the excitation system to a target voltage at which all other Grid Code conditions can be met. Normal Generator custom and practice is that this means "1 per unit" rated voltage.

4. Variations in HV system voltage will then cause the Generating Unit to generate or absorb reactive power within the capabilities defined by the performance chart, the format of which is set out in OC2.4.2.1. National Grid then manages the HV system voltage and distribution of reactive power reserves, for security and economic operation, by instructing Generators to vary their reactive power transfer by changing the tap position on their connection transformers.

5. The requirements of CC.6.3.4(a) are that the full reactive power capability should be available from a Generating Unit for variations up to +/-5% of the HV system voltage.

## National Grid's Interpretation

6. Taking the requirements of CC.6.3.4 and CC.6.3.8 in conjunction, National Grid interprets these as meaning that a new Generating Unit and associated Generator Transformer should be designed such that with a single setting of Generating Unit terminal voltage and a sufficient range of tap positions on the associated Generator Transformer, the provision of the full reactive power capability can be achieved for any HV voltage within +/-5% of nominal.

7. There are some existing Generating Units where the range of tap positions on the associated Generator Transformer is documented as insufficient to allow full compliance with this interpretation. These units operate under derogations from CC.6.3.4 granted by the Authority. The derogations state the capability compliant with the National Grid interpretation of CC.6.3.4 as well as the capability that might be achieved from varying the terminal voltage. The fact

that derogations have been granted in respect of these Generating Units leads National Grid to believe that varying terminal voltage is not deemed to be compliant with the relevant CCs.

**A User's View**

8. National Grid has received the specific views of a User whereby the User considers that a change to the generating unit's steady state terminal voltage, where tap change action alone would be insufficient to achieve the power factor range required by CC.6.3.2 for the range of transmission voltage given in CC.6.3.4, is not prohibited by the Grid Code.

9. The User considers that such steady-state change to the terminal voltage would be compliant with the requirement of CC.6.3.8(a) (i) to "…provide constant terminal voltage control of the Onshore Synchronous Generating Unit without instability over the entire operating range…"

10. In support of the above, the User notes the Generator Performance Chart given in OC2 Appendix 1 illustrates the transformer tap limit occurring at a transmission system voltage of 412kV, thereby supporting a change to the generating unit terminal voltage as being required to enable 0.85 pf lagging to be achieved for transmission system voltages between 412kV and 420kV.

11. Whilst the Guidance Notes for Synchronous Generators Version Issue 11 states "….there should be sufficient taps on the Generator step-up Transformer to pass through 0.85 lagging to 0.95 leading reactive power at full load active power even with ±5% variation in voltage at the Grid Entry Point" this requirement is not part of the Grid Code and was not specified in previous issues of the Guidance Notes. Furthermore, it is noted that the latest GCRP Compliance Working Group draft report does not identify any such requirement, other than the requirement to demonstrate reactive capability by both simulation and actual test.

12. The User notes that a number of derogations relating to reactive power capability were issued to pre-vesting generating units during 1990. This was at a time when it was standard practice to control the reactive power output by the use of the step up transformer tap changer only, to the extent that it was considered unnecessary for the Connection Conditions of the Grid Code to explicitly require a tap changer to be installed. It is believed that excitation control systems available today offer are able to contribute within design limits, in terms of capability and operator controllability, to meeting reactive power requirements by changes to the steady state terminal voltage.

**Recommendation**

13. The Grid Code Review Panel is invited to note these differing interpretations of the Grid Code requirements in respect of Constant Terminal Voltage Control, and to consider whether further clarity on the Grid Code requirements is required.