nationalgrid

GRID CODE

CONSULTATION DOCUMENT

Grid Code short circuit ratio requirement in respect of very Large Synchronous Generating Units

The purpose of this document is to consult on the above Grid Code Modification Proposal with authorised electricity operators liable to be materially affected by the proposed changes

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Prepared by	National Grid

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DISTRIBUTION

Name	Organisation
AEO's	Various
GCRP Members/Alternates	Various
Interested Parties	Various
National Grid Industry Information Website	

A. Introduction

1. National Grid Electricity Transmission plc ("National Grid"), in accordance with its obligations under paragraph 2 of Condition 7 of the Transmission Licence, believes that the time has come to review, in consultation with authorised electricity operators liable to be materially affected thereby, the Grid Code and its implementation in certain respects.

2. This review is concerned with Short Circuit Ratio (SCR). The proposed changes to the Grid Code were discussed at the Grid Code Review Panel meeting held on the 17 September 2009 at National Grid House and Panel members agreed that having taken account of comments received at the Panel meeting National Grid should issue a Consultation Paper.

3. Following receipt of comments from those authorised electricity operators which it has consulted by this Paper, National Grid intends, in accordance with paragraph 2 of Condition 7 of the Transmission Licence, to send to the Authority :-

   (a) a report on the outcome of its review, including this consultation process;

   (b) the proposed revisions to the Grid Code which National Grid (having regard to the outcome of such review) reasonably thinks fit for the achievement of the objectives of the Grid Code referred to in sub-paragraph (b) of paragraph 1 of Condition 7 of the Transmission Licence; and

   (c) any written representations or objections from authorised electricity operators (including any proposals by such operators for revisions to the Grid Code not accepted by National Grid in the course of the review) arising during the consultation process and subsequently maintained.

4. The report will also be made publicly available on National Grid's website.

5. The revisions to the Grid Code proposed by National Grid and sent to the Authority then require approval by that body and will, if approved, come into force on such date (or dates) of which you will be notified by National Grid, in accordance with the Authority's approval.

B. Description of the proposed amendments and their effects

6 Background

6.1 At the May 2008 Grid Code Review Panel, the issue of new generation technologies including nuclear and supercritical coal was discussed. With regard to new nuclear, single synchronous generating unit sizes with a Rated MW output of up to 1800MW have been proposed and for supercritical coal, values of up to 1000MW have been suggested.

6.2 The Grid Code places minimum requirements on the capabilities of synchronous generating units. One such parameter is the SCR which under section CC.6.3.2 of the Grid Code is required to be not less than 0.5.

6.3 The largest synchronous generator currently connected to the National Electricity Transmission System is in the order of 660 MW (776MVA). With the introduction of new generation technologies where individual machine size increases to a rated Apparent Power of 2000MVA, supplying a synchronous generator with an SCR of 0.5 or above becomes more challenging. Not least, the higher the SCR, the larger the machine size, which for a generator with a rated Apparent Power of 2000MVA causes significant manufacturing and transport issues. From Reference [1] "Increasing a generator SCR from 0.4 to 0.5 results in an increase in the total volume of about 5 to 10% depending on the type of the generator"

7. Scope

7.1 This paper only considers the Grid Code SCR requirement in respect of very large Synchronous Generating Units and the threshold at which a relaxation (if any) should be applied. This review has been undertaken in response to the concerns raised in respect of these units.

7.2 It is beyond the scope of this Consultation Paper to undertake a complete and thorough review of the SCR requirement irrespective of Generating Unit size. Although SCR was considered as part of the Reactive Power Working Group [2] published in January 2001, a complete reassessment would be required to cater for the significant differences in Generation and Transmission System background currently envisaged compared to that at the time of the original study.

8. Introduction – Short Circuit Ratio

8.1 The SCR of a synchronous generator is defined in IEC34-4 as "The ratio of the field current for rated armature voltage on open–circuit to the field current for rated armature current on sustained symmetrical short circuit, both with the machine running at rated speed".

8.2 A generator with a higher SCR requires a larger field winding which in most cases requires an increase in the size of the machine. It is for this reason that very large generators may struggle to achieve an SCR of 0.5 or greater.

8.3 The implications of reducing the SCR of a synchronous generator are further clarified in [1] but in summary the SCR has a direct impact on the machine's stability performance. This is likely to result in more onerous excitation system requirements, for example higher ceiling voltages and /or faster rise times. In addition, it also affects the machine's reactive capability in the underexcited mode of operation (ie leading capability). It should also be noted that CC.6.3.15 of the Grid Code places obligations on Generating Units to remain transiently stable for a range of Transmission System faults which may require additional measures or enhanced excitation systems to be employed.

9.0 Manufacturer Capabilities

9.1 Having discussed the impact of short circuit ratio on machine design, it is important to establish if the manufacturers of generating plant with Apparent Power ratings of up to 2000MVA can design, build and supply a machine with a SCR of 0.5 or greater.

9.2 With this in mind, National Grid contacted five major turbo Generator manufactures to establish:-

i) Their ability to manufacture a machine with a rated Apparent Power of 2000 MVA and SCR of 0.5 or greater.
ii) The limit in terms of size, at which a 0.5 SCR can no longer be achieved
iii) The type of excitation system available.
iv) Limitations on reactive capability

9.3 Of the five manufactures contacted, some provided a full response, some provided limited information, some provided no information, and in some cases the data was obtained via alternative sources [3].

9.4 Due to confidentiality issues National Grid is unable to publish the responses received, however general trends can be presented which are believed to be sufficient to draw some conclusions from this work.

9.5 For those manufacturers who currently supply machines with a rated Apparent Power of 2000MVA, the SCR ranges between 0.41 – 0.46. The limitation on SCR is determined largely by transport, but other issues such as country of origin and manufacturing capability play an important factor. Based on the Generator Saturated Reactance values shown in Figure 16 of [3], the SCR at best of the 2000MW Turbogenerator described is 0.43.

9.6 Of those manufacturers questioned, a number do not supply machines with a rated Apparent Power of 2000MVA, but the majority of them advised that the maximum limit at which an SCR of 0.5 could be achieved would be in the order of 1600 MVA.

9.7 With regard to reactive capability, it would appear a reactive range of 0.95 lead to 0.85 lag at the Generator Unit terminals on a rated Apparent Power of 2000MVA is achievable, although the cooling water temperature would need to be limited.

9.8 With regard to excitation, some manufacturers promote rotating systems whilst others use static. Each type is limited on excitation ceiling voltage to about 2 p.u. It would appear from the research carried out that both systems can be employed although it is envisaged that a manufacturer supplying a static system would be reluctant/unable to use a rotating system and vice versa due to changes of an authorised design. Both systems can incorporate a power system stabiliser.

10.0 Conclusions

10.1 The work undertaken has enabled an assessment of the size limits to which manufacturers are capable of supplying a machine which would be compliant with the SCR requirements of the Grid Code.

10.2 Based on the work completed to date, and discussions held, it is concluded that manufacturers can produce a machine of up to a rated Apparent Power of 1600MVA with a short circuit ratio of 0.5. It is clear from the evidence available that manufacturing and supplying a machine with an SCR in excess of this value would become increasingly difficult.

10.3 Connecting large machines with lower SCR capabilities may require excitation systems with higher performance than currently used on such machines.

10.4 If a wider review of SCR is to be undertaken, this can be added to the Grid Code Review Panel Issues list.

11.0 **References**

[1] Specifying a Turbogenerator's Electrical Parameters guided by Standards and Grid Codes – C-E Stephan and Z Baba 2001 – Ref 0-7803-7091-0/01/$10©2001 IEEE.

[2] Grid Code Reactive Power Sub-Group – Report to the Grid Code Review Panel. Available at:- http://www.nationalgrid.com/NR/rdonlyres/D9A1B2C1-20BB-4D1C-8F29-39DFA51081C6/3165/reactwgrep.pdf

[3] Type Testing a 2000MW Turbogenerator K Sedlazeck, C Richter, S. Strack, Siemens Energy, Mulheim, Germany, S Lindholm, J Pipkin, F Fu, B Humphries, L. Montgomery, Siemens Energy Orlando, FL, USA – IEEE paper reference 978-1-4244-4252-2/09/$25.00 © 2009 IEEE.

12. COMMENTS

12.1 National Grid would be grateful to receive your comments on, or any suggestions you may have in relation to, these proposed amendments to the Grid Code. Comments would be welcomed and should be sent to National Grid by close of business on **10th December 2009**. The comments will be reviewed and responded to and National Grid will then prepare its report to the Authority.

12.2 Unless otherwise marked as confidential any responses containing objections to the proposals which are maintained will be published on our website in the copy of the Report to the Authority referred to in paragraphs 3 and 4.

12.3. Your formal responses may be:-

Posted to: Tom Ireland
Electricity Codes
Commercial Frameworks
National Grid Electricity Transmission plc
National Grid House
Warwick Technology Park
Gallows Hill
Warwick
CV34 6DA

Emailed to: thomas.ireland@uk.ngrid.com

Appendix A – Description of the Proposed Grid Code Changes

A.1 Amend CC.6.3.2 (a) of the Grid Code requiring synchronous generators with an Apparent Power rating of less than 1600MVA to be designed with a short circuit ratio of not less than 0.5, and for synchronous generators with an Apparent Power rating of, or in excess of, 1600MVA to be designed with a short circuit ratio of not less than 0.4.

A.2 The proposed changes to CC.6.3.2 of the Grid Code in relation to Short Circuit Ratio are shown in Appendix B.

A.3 It is not proposed to change CC.6.3.2(e) of the Grid Code in respect of Offshore Synchronous Generators. At the present time it is unlikely that a single Synchronous Generator with a rated Apparent Power of 1600MVA would connect to an Offshore Transmission System.

Appendix B

CC.6.3.2 (a) When supplying **Rated MW** all **Onshore Synchronous Generating Units** must be capable of continuous operation at any point between the limits 0.85 **Power Factor** lagging and 0.95 **Power Factor** leading at the **Onshore Synchronous Generating Unit** terminals. At **Active Power** output levels other than **Rated MW**, all **Onshore Synchronous Generating Units** must be capable of continuous operation at any point between the **Reactive Power** capability limits identified on the **Generator Performance Chart**.

In addition to the above paragraph, where **Onshore Synchronous Generating Unit(s)**:

(i) have a **CEC** which has been increased above **Rated MW** (or the **CEC** of the **CCGT module** has increased above the sum of the **Rated MW** of the **Generating Units** compromising the **CCGT module**), and such increase takes effect after 1st May 2009, the minimum lagging **Reactive Power** capability at the terminals of the **Onshore Synchronous Generating Unit(s)** must be 0.9 **Power Factor** at all **Active Power** output levels in excess of **Rated MW**. Further, the **User** shall comply with the provisions of and any instructions given pursuant to BC1.8 and the relevant **Bilateral Agreement**: or

(ii) Have a **CEC** in excess of **Rated MW** (or the **CEC** of the **CCGT module** exceeds the sum of **Rated MW** of the **Generating Units** comprising the **CCGT module**) and a **Completion Date** before 1st May 2009, alternative provisions relating to **Reactive Power** capability may be specified in the **Bilateral Agreement** and where this is the case such provisions must be complied with.

The short circuit ratio of **Onshore Synchronous Generating Units** with an **Apparent Power** rating less than 1600MVA shall be not less than 0.5. The short circuit ratio of **Onshore Synchronous Generating Units** with an **Apparent Power** rating of 1600MVA or above shall be not less than 0.4.

(b) Subject to paragraph (c) below, all **Onshore Non-Synchronous Generating Units, Onshore DC Converters** and **Onshore Power Park Modules** must be capable of maintaining zero transfer of **Reactive Power** at the **Onshore Grid Entry Point** (or **User System Entry Point** if **Embedded**) at all **Active Power** output levels under steady state voltage conditions. For **Onshore Non-Synchronous Generating Units** and **Onshore Power Park Modules** the steady state tolerance on **Reactive Power** transfer to and from the **National Electricity Transmission System** expressed in MVAr shall be no greater than 5% of the **Rated MW**. For **Onshore DC Converters** the steady state tolerance on

Reactive Power transfer to and from the **National Electricity Transmission System** shall be specified in the **Bilateral Agreement.**