GRID CODE

CONSULTATION DOCUMENT

Grid Code Requirements for Technical Performance

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 and forms the basis of the subsequent Report to the Authority

Consultation Ref	D/08
Issue	1.0
Date of Issue	2 July 2008
Responses required by	**30 July 2008**
Prepared by	National Grid

DOCUMENT LOCATION

National Grid website:

http://www.nationalgrid.com/uk/Electricity/Codes/gridcode/consultationpapers/

DISTRIBUTION

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

A. INTRODUCTION

1. Paragraph 2 of Condition C14 of the Transmission Licence granted to the National Grid Electricity Transmission plc ("National Grid") provides that National Grid shall, in consultation with Authorised Electricity Operators liable to be materially affected thereby, periodically review the Grid Code and its implementation. That paragraph also requires National Grid, following such review, to send to the Authority:-

   (a) a report on the outcome of such review;

   (b) any proposed revisions to the Grid Code as National Grid (having regard to the outcome of such review) reasonably thinks fit for the achievement of the objectives set out in sub-paragraph (b) of Condition C14 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.

2. This review examines proposed amendments to the Grid Code such that the detailed technical performance requirements, currently specified in alternative National Grid literature, are incorporated in the Code. The proposals were developed through the Grid Code Compliance Working Group.

3. The proposed changes to the Grid Code were discussed with the Grid Code Review Panel (GCRP) on 15th May 2008. Panel Members agreed that National Grid should issue a Consultation Paper regarding the proposed changes.

4. Comments upon the proposed changes within this consultation should be sent to National Grid by **30th July 2008** as detailed in section C. The comments will be reviewed and responded to.

5. Following this consultation, National Grid will prepare a Report to the Authority detailing National Grid's recommended changes to the Grid Code and all comments/responses received from Authorised Electricity Operators through this consultation. Once sent to the Authority this report will be made available on National Grid's website.

6. Where Authorised Electricity Operators' responses have been marked as confidential they will not be published within the version of the Report to the Authority placed on the National Grid website.

7. The revisions to the Grid Code proposed by National Grid and sent to the Authority, 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

8. Background

8.1 The compliance guidance notes for synchronous and non-synchronous generating units assist developers with the interpretation of the Grid Code and provide enhance understanding of what performance functionality is needed for the secure operation of the GB Transmission System.

8.2 Users have queried the inclusion within the compliance guidance notes of additional detailed performance criteria and test requirements which have not been explicitly cited in the Grid Code or Bilateral Agreements. A review of the compliance guidance notes, by National Grid, identified a numbers of provisions contained within the documents which could be construed as additional detailed Grid Code technical performance requirements.

8.3 The GCRP agreed that to improve User transparency and understanding of their Grid Code obligations, it would be beneficial to codify, within the Code, these technical performance requirements.

8.4 National Grid and GCRP agreed that the Grid Code should contain all relevant and appropriate technical obligations. The compliance guidance notes should provide useful information/assistance to Users regarding how to demonstrate Grid Code compliance i.e. best practice, more effective methods etc.

9. Working Group Discussions

9.1 The rationale behind the proposals was developed through discussions in the Grid Code Compliance Working Group. The Working Group Terms of Reference and the complete record of how the change proposals were developed can be found in the Working Group Report:

https://www.nationalgrid.com/uk/Electricity/Codes/gridcode/workinggroups/ComplianceWorkingGroup/

9.2 The Grid Code Compliance Working Group was established to review and provide recommendations regarding the codification of the compliance process and technical performance obligations.

9.3 It was noted that Grid Code Consultations G/06 (Power Park Modules and Synchronous Generating Units) had codified a number of technical performance requirements specified in guidance notes. Therefore the Working Group discussions focussed on the four remaining areas not covered by the recent Grid Code amendment:

i. Droop Definition
ii. Control System Models
iii. Power System Stabiliser
iv. Operation above 50.5Hz

9.4 The group discussed each area in more detail, highlighting areas of concern and possible amendments to the Grid Code.

9.5 *Droop Definition*

9.5.1 It was noted that Grid Consultation G/06 included a change CC.6.3.7(c)(ii) to improve the interpretation of droop in a wind farm. A similar change to the definition 'Droop' contained with in the Glossary and Definition section of the Grid Code was proposed.

9.5.2 It was also agreed that clarity would be enhanced by simplifying the definition by removing references to plant types. The members agreed to the proposal which would be reflective of group discussions.

9.6 *Control System Models*

9.6.1 The Planning Code requires the submission of control system models for both synchronous and non-synchronous generation to allow National Grid to simulate system behaviour to ensure stable operation. The importance of the control system models representing the behaviour of generating plant as closely as possible was noted.

9.6.2 Grid Code Consultation H/04 (Grid Code Changes to Incorporate New Generation Technologies and DC Inter-connectors (Generic Provisions)) partially addressed the need for the models to be validated for Power Park Modules. It is proposed to extend the requirements that currently apply to Power Park Units to include supplementary control signal modules.

9.6.3 The H/04 Grid Code changes in this area did not apply to synchronous generating units. The proposals included in this consultation are intended to ensure that any models submitted in respect of synchronous generating units contain all of the necessary information to fully represent the control system, and that they have been implemented in simulation studies by the Generator and shown to represent the expected behaviour of the unit. The requirement to compare the performance of the model with machine tests of the actual unit are not required in this proposal, but will be discussed by the Compliance Working Group at a later stage.

9.6.4 Members were in agreement that the changes should be applied to new generation and to existing Generating Units modifying their control systems, not to existing generating units not subject to a modification. An implementation date of January 1st 2009 was agreed.

9.7 *Power System Stabliser*

9.7.1 The introduction of Grid Code Consultation G/06 transferred the majority of the requirements for excitation systems from the Bilateral Agreements into the body of the Grid Code. The guidance notes have additional clarifications on excitation systems which it is proposed to include within the Code

9.7.2 The Grid Code currently states that the Power System Stabiliser should be left in service once commissioned. However, it might be construed that the Power System Stabiliser may be automatically disabled by the functions within the excitation system such as the Under Excitation Limiter. While these limiter functions may curtail the excitation system output, the Power System Stabiliser and Automatic Voltage Regulator should still be active.

9.7.3 It is also proposed that the requirement that Power System Stabilisers fitted to

pumped storage units should be active in both generating and pumping modes should be clarified.

9.7.4 With modern governor systems Generating Units are able to execute fast changes in mechanical power. A Power System Stabiliser may try to counteract this mechanial power change by altering the excitation phasing so when the Generating Unit changes power output, large swings in reactive power output and hence terminal voltage may result. It was noted that this was undesirable for stable voltage control and therefore it was agreed to amend the Connection Conditions accordingly. National Grid has therefore proposed the inclusion of a additional sentence in CC.A.6.2.5.3 outlining this requirement in a generic form.

9.7.5 It was noted that the applicable Connection Condition provisions were already subject to an implementation date to avoid creating adverse issues for existing plant. Therefore, National Grid does not believe that the proposal will impact existing users.

9.8 *Operation Above 50.5Hz*

9.8.1 For Frequency Sensitive Mode (FSM), Generating Units are required to provide response in accordance with the frequency response matrix values agreed in the Mandatory Service Agreement. The High Frequency Response level in the agreement is limited to 50.5Hz. However, if the frequency continues to rise above 50.5Hz, the Grid Code currently requires stations to continue to reduce their output.

9.8.2 This continual reduction capability is critical to system security as the system frequency at this time would already be above its statutory limit indicating the system is under stress. It is imperative that all generating stations, including those not in FSM, are required to reduce output to contain the system frequency rise. This condition if not controlled could lead to the frequency being driven above 52Hz and the collaspe of the GB Transmission System.

9.8.3 National Grid believes that the current Grid Code requirement should be improved by incorporating a more detailed breakdown of the power reduction process, as that adopted for the Limited Frequency Sensitive Mode (LFSM) operation. The existing overall timescales allowed for the reduction in power will remain unchanged and therefore will have no impact on existing generation. This will be reflected in the proposed legal text.

10. <u>Proposed Grid Code Changes</u>

10.1 It is proposed to amend the existing defintion of ‘Droop’ such that the description provides additional clarity to Users regarding the exact meaning of the term.

10.2 It is proposed to amend the Planning Code (PC.A.5.3.2) such that the control system models for synchronous generating units are verified before being submitted to NGET. The proposals will not apply to control systems on existing synchronous generating units unless they are subject to modifications. The requirements to validate Power Park Unit models (PC.A.5.4.2) will be extended to include supplementary control signal module models.

10.3 The Connection Conditions (CC.A.6) will be amended such that the technical performance requirements for Power System Stabilisers are clearly defined within the Code. The changes will provide clarity and understanding for Users.

10.4 It is proposed to amend the Balancing Code 3 such that the provisions for FSM incorporates a detailed breakdown of the power reduction process. This would align the technical performance requirements for FSM with the technical approach adopted for LFSM.

10.5 The proposed amendments to the relevant clauses of Balancing Code 3 (Frequency Response Process), Connection Conditions, Planning Code and Glossary and Definitions are shown in Appendix A.

11. Impact on GB Transmission System

11.1 The proposed changes would not have any adverse impact on the GB Transmission System.

12. Impact on Grid Code Users

12.1 The proposals will provide additional transparency to Users regarding the technical performance obligations which are necessary to achieve Grid Code compliance.

13. Assessment Against Grid Code Objectives

13.1 The proposed changes outlined in D/08 Report to the Authority would better facilitate Grid Code Objectives:

iii) to promote the security and efficiency of the electricity generation, transmission and distribution system in Great Britain

by ensuring that the Grid Code is inclusive of all generic technical performance requirements.

14. Impact on Industry Documents

14.1 *Impact on Core Industry Documents*

14.1.1 None.

14.2 *Impact on other Industry Documents*

14.2.1 None.

C. RESPONSES

15. This section will contain a summary of responses received during the Consultation and will be completed as part of the Report to the Authority.

16. Views are invited upon the proposals outlined in this report. Especially views on the following areas would be welcomed:

- Impact of the proposals on Grid Code users.
- Any improvements or changes to the proposals that in a respondent's view would better facilitate the objectives of the Grid Code.

17. Your formal responses may be:-

Posted to: Richard Dunn
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Regulatory Frameworks
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Gallows Hill
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Appendix A: Proposed Grid Code Changes

Glossary and Definitions Changes

GLOSSARY AND DEFINITIONS

Droop The ratio of the per unit steady state change in speed, or in **Frequency** ~~in the case of a **Generating Unit,** or in **Frequency** in the case of a **Power Park,**~~ to the per unit steady state change in power output ~~of the **Generating Unit** or **Power Park.**~~

Planning Code Changes

PLANNING CODE

PC.A.5.3.2 …….

(c) Excitation Control System parameters

Note: The data items requested under Option 1 below may continue to be provided in relation to **Generating Units** on the **System** at 09 January 1995 (in this paragraph, the "relevant date") or the new data items set out under Option 2 may be provided. **Generators** or **Network Operators**, as the case may be, must supply the data as set out under Option 2 (and not those under Option 1) for **Generating Unit** excitation control systems commissioned after the relevant date, those **Generating Unit** excitation control systems recommissioned for any reason such as refurbishment after the relevant date and **Generating Unit** excitation control systems where, as a result of testing or other process, the **Generator** or **Network Operator**, as the case may be, is aware of the data items listed under Option 2 in relation to that **Generating Unit**.

Option 1

DC gain of **Excitation Loop**
Rated field voltage
Maximum field voltage
Minimum field voltage
Maximum rate of change of field voltage (rising)
Maximum rate of change of field voltage (falling)

Details of **Excitation Loop** described in block diagram form showing transfer functions of individual elements.
Dynamic characteristics of **Over-excitation Limiter**.
Dynamic characteristics of **Under-excitation Limiter**

Option 2

Excitation System Nominal Response
Rated Field Voltage
No-Load Field Voltage
Excitation System On-Load Positive Ceiling Voltage
Excitation System No-Load Positive Ceiling Voltage
Excitation System No-Load Negative Ceiling Voltage

Details of **Excitation System** (including **PSS** if fitted) described in block diagram form showing transfer functions of individual elements.

Details of **Over-excitation Limiter** described in block diagram form showing transfer functions of individual elements.

Details of **Under-excitation Limiter** described in block diagram form showing transfer functions of individual elements.

The block diagrams submitted after 1 January 2009 in respect of the **Excitation System** (including the **Over-excitation Limiter** and the **Under-excitation Limiter**) for **Generating Units** with a **Completion date** after 1 January 2009 or subject to a **Modification** to the **Excitation System** after 1 January 2009, should have been verified as far as reasonably practicable by simulation studies as representing the expected behaviour of the system.

(d) Governor Parameters

Incremental Droop values (in %) are required for each **Generating Unit** at six MW loading points (MLP1 to MLP6) as detailed in PC.A.5.5.1 (this data item needs only be provided for **Large Power Stations**)

Note: The data items requested under Option 1 below may continue to be provided by **Generators** in relation to **Generating Units** on the **System** at 09 January 1995 (in this paragraph, the "relevant date") or they may provide the new data items set out under Option 2. **Generators** must supply the data as set out under Option 2 (and not those under Option 1) for **Generating Unit** governor control systems commissioned after the relevant date, those **Generating Unit** governor control systems recommissioned for any reason such as refurbishment after the relevant date and **Generating Unit** governor control systems

where, as a result of testing or other process, the **Generator** is aware of the data items listed under Option 2 in relation to that **Generating Unit**.

Option 1

(i) Governor Parameters (for Reheat **Steam Units**)

HP governor average gain MW/Hz
Speeder motor setting range
HP governor valve time constant
HP governor valve opening limits
HP governor valve rate limits
Reheater time constant (**Active Energy** stored in reheater)

IP governor average gain MW/Hz
IP governor setting range
IP governor valve time constant
IP governor valve opening limits
IP governor valve rate limits

Details of acceleration sensitive elements in HP & IP governor loop.
A governor block diagram showing transfer functions of individual elements.

(ii) Governor Parameters (for Non-Reheat **Steam Units** and **Gas Turbine Units**)

Governor average gain
Speeder motor setting range
Time constant of steam or fuel governor valve
Governor valve opening limits
Governor valve rate limits
Time constant of turbine
Governor block diagram

The following data items need only be supplied for **Large Power Stations:-**

(iii) Boiler & Steam Turbine Data

Boiler Time Constant (Stored **Active Energy**)
s
HP turbine response ratio:
proportion of **Primary Response**
%
arising from HP turbine.

HP turbine response ratio:
proportion of **High Frequency Response**
%
arising from HP turbine.

[End of Option 1]

Option 2

(i) Governor and associated prime mover Parameters - All **Generating Units**

Governor Block Diagram showing transfer function of individual elements including acceleration sensitive elements.
Governor Time Constant (in seconds)
Speeder Motor Setting Range (%)
Average Gain (MW/Hz)
Governor Deadband (this data item need only be provided for **Large Power Stations**)

- Maximum Setting ±Hz
- Normal Setting ±Hz
- Minimum Setting ±Hz

Where the **Generating Unit** governor does not have a selectable deadband facility, then the actual value of the deadband need only be provided.

The block diagrams submitted after 1 January 2009 in respect of the Governor system for **Generating Units** with a **Completion date** after 1 January 2009 or subject to a **Modification** to the governor system after 1 January 2009, should have been verified as far as reasonably practicable by simulation studies as representing the expected behaviour of the system.

(ii) Governor and associated prime mover Parameters - **Steam Units**

HP Valve Time Constant (in seconds)
HP Valve Opening Limits (%)
HP Valve Opening Rate Limits (%/second)
HP Valve Closing Rate Limits (%/second)
HP Turbine Time Constant (in seconds)

IP Valve Time Constant (in seconds)
IP Valve Opening Limits (%)
IP Valve Opening Rate Limits (%/second)
IP Valve Closing Rate Limits (%/second)
IP Turbine Time Constant (in seconds)

LP Valve Time Constant (in seconds)
LP Valve Opening Limits (%)
LP Valve Opening Rate Limits (%/second)
LP Valve Closing Rate Limits (%/second)
LP Turbine Time Constant (in seconds)

Reheater Time Constant (in seconds)
Boiler Time Constant (in seconds)

HP Power Fraction (%)
IP Power Fraction (%)

(iii) Governor and associated prime mover Parameters - **Gas Turbine Units**

Inlet Guide Vane Time Constant (in seconds)
Inlet Guide Vane Opening Limits (%)
Inlet Guide Vane Opening Rate Limits (%/second)
Inlet Guide Vane Closing Rate Limits (%/second)
Fuel Valve Constant (in seconds)
Fuel Valve Opening Limits (%)
Fuel Valve Opening Rate Limits (%/second)
Fuel Valve Closing Rate Limits (%/second)

Waste Heat Recovery Boiler Time Constant (in seconds)

(iv) Governor and associated prime mover Parameters - Hydro Generating Units

Guide Vane Actuator Time Constant (in seconds)
Guide Vane Opening Limits (%)
Guide Vane Opening Rate Limits (%/second)
Guide Vane Closing Rate Limits (%/second)
Water Time Constant (in seconds)

[End of Option 2]

PC.A.5.4.2 The following **Power Park Unit, Power Park Module** and **Power Station** data should be supplied in the case of a **Power Park Module** not connected to the **Total System** by a **DC Converter**:

(a) **Power Park Unit** model

A mathematical model of each type of **Power Park Unit** capable of representing its transient and dynamic behavior under both small and large disturbance conditions. The model shall include non-linear effects and represent all equipment relevant to the dynamic performance of the **Power Park Unit** as agreed with **NGET**. The model shall be suitable for the study of balanced, root mean square, positive phase sequence time-domain behaviour, excluding the effects of electromagnetic transients, harmonic and sub-harmonic frequencies.

The model shall accurately represent the overall performance of the **Power Park Unit** over its entire operating range including that which is inherent to the **Power Park Unit** and that which is achieved by use of supplementary control systems providing either continuous or stepwise control. Model resolution should be sufficient to accurately represent **Power Park Unit** behavior both

in response to operation of transmission system protection and in the context of longer-term simulations.

The overall structure of the model shall include:

(i) any supplementary control signal modules not covered by (c), (d) and (e) below.

(ii) any blocking, deblocking and protective trip features that are part of the **Power Park Unit** (e.g. "crowbar").

(iii) any other information required to model the **Power Park Unit** behaviour to meet the model functional requirement described above.

The model shall be submitted in the form of a transfer function block diagram and may be accompanied by dynamic and algebraic equations.
This model shall display all the transfer functions and their parameter values, any non wind-up logic, signal limits and non-linearities.

The submitted **Power Park Unit** model and the supplementary control signal module models covered by (c),(d) and (e) below shall have been validated and this shall be confirmed by the **Generator**. The validation shall be based on comparing the submitted model simulation results against measured test results. Validation evidence shall also be submitted and this shall include the simulation and measured test results. The latter shall include appropriate short-circuit tests. In the case of an **Embedded Medium Power Station** not subject to a **Bilateral Agreement** the **Network Operator** will provide **NGET** with the validation evidence if requested by **NGET**. The validation of the supplementary control signal module models covered by (c), (d) and (e) below applies only to a **Power Station** with a completion date after 1 January 2009.

(b) **Power Park Unit** parameters

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Connection Conditions Changes

CONNECTION CONDITIONS CODE

CC.A.6.2.5.3 The arrangements for the supplementary control signal shall ensure that the **Power System Stabiliser** output signal relates only to changes in the supplementary control signal and not the steady state level of the signal. For example, if generator electrical power output is chosen as a supplementary control signal then the **Power System Stabiliser** output should relate only to changes in generator electrical power output and not the steady state level of power output. Additionally **the Power System Stabiliser** should not react to mechanical power changes in isolation for example during changes in steady state load or when providing frequency response.

CC.A.6.2.5.4 The output signal from the **Power System Stabiliser** shall be limited to not more than ±10% of the **Generating Unit** terminal voltage signal at the **Automatic Voltage Regulator** input. The gain of the **Power System Stabiliser** shall be such that an increase in the gain by a factor of 3 shall not cause instability.

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CC.A.6.2.5.6 The **Generator** will agree **Power System Stabiliser** settings with **NGET** prior to the on-load commissioning detailed in BC2.11.2(d). To allow assessment of the performance before on-load commissioning the **Generator** will provide to **NGET** a report containing:

i. the **Excitation System** model including the **Power System Stabiliser** with settings as required under the **Planning Code** (PC.A.5.3.2(c)).
ii. on load time series simulations of the response of the **Excitation System** with and without the **Power System Stabiliser** to 2% and 10% steps in the reference voltage and a three phase short circuit fault applied to the higher voltage side of the **Generating Unit** transformer for 100 ms. The results should show field voltage, **Generating Unit** terminal voltage, **Power System Stabiliser** output and **Generating Unit Active Power** and **Reactive Power** output.
iii. gain and phase Bode diagrams for the open loop frequency domain response of the **Generating Unit Excitation System** with and without the **Power System Stabiliser**, operating under maximum leading conditions and minimum fault level conditions as agreed with **NGET**. These should be in a format to allow assessment of the phase contribution of the **Power System Stabiliser** and the gain and phase margin of the **Excitation System** with the **Power System Stabiliser**

CC.A.6.2.5.7 The **Power System Stabiliser** must be active within the **Excitation System** at all times when **Synchronised** including when the **Under Excitation Limiter** or **Over-Excitation Limiter** are active. When operating at low load when **Synchronising** or **De-Synchronising** a **Generating Unit** the **Power System Stabiliser**, may be out of service.

CC.A.6.2.5.8 Where a **Power System Stabiliser** is fitted to a **Pumped Storage Unit** it must function when the **Pumped Storage Unit** is in both generating and pumping modes.

Balancing Code 3 Changes

BALANCING CODE 3

BC3.7.1 Plant in Frequency Sensitive Mode instructed to provide High Frequency Response

(c) In addition to the **High Frequency Response** provided, the **Genset** (or **DC Converter** at a **DC Converter Station**) must continue to reduce **Active Power** output in response to an increase in **System Frequency** ~~to~~ above 50.5 Hz ~~or above~~ at a minimum rate of 2 per cent of output per 0.1 Hz deviation of **System Frequency** above that level, such reduction to be achieved within five minutes of the rise to or above 50.5 Hz. For a **Power Station** with a **Completion Date** after 1st January 2009 this reduction in **Active Power** should be delivered in accordance with in (i) to (iv) below. For the avoidance of doubt, the provision of this reduction in **Active Power** output is not an **Ancillary Service**.

(i) The reduction in **Active Power** output must be continuously and linearly proportional as far as practical, to the excess of **Frequency** above 50.5 Hz and must be provided increasingly with time over the period specified in (iii) below.

(ii) As much as possible of the proportional reduction in **Active Power** output must result from the frequency control device (or speed governor) action and must be achieved within 10 seconds of the time of the **Frequency** increase above 50.5 Hz.

(iii) The residue of the proportional reduction in **Active Power** output which results from automatic action of the **Genset** (or **DC Converter** at a **DC Converter Station**) output control devices other than the frequency control devices (or speed governors) must be achieved within 3 minutes from the time of the **Frequency** increase above 50.5 Hz.

(iv) Any further residue of the proportional reduction which results from non-automatic action initiated by the **Generator** or **DC Converter Station** owner shall be initiated within 2 minutes, and achieved within 5 minutes, of the time of the **Frequency** increase above 50.5 Hz.