INITIAL REVIEW OF GRID CODE COMPLIANCE CAPABILITY FOR NEW GENERATION TECHNOLOGIES

Paper by National Grid

Summary

1. There is currently an exceptionally wide variety of new generation technologies being considered for connection to the GB Transmission System, some already with Connection Agreements. The most significant driver for the deployment of the new generation technologies (rather than continued application of existing generation technologies) is the environmental factor, driving reduction of CO_2 emission per generated kWh. The most advanced position in terms of imminent application relate to supercritical coal and new nuclear technologies. Both of these technologies are known for low levels of flexibility in their MW output.

2. This paper seeks to report on the current position in terms of the prospect of achieving Grid Code (GC) compliance for the new generation technologies. It identifies the key issue as availability of volume of low frequency response, particularly primary response. From the initial review, the prospect of compliance in this respect looks good for the new nuclear plant sampled, while relatively poor for new coal, both the supercritical steam and IGCC versions.

3. Additional GC compliance issues have been identified associated with the size of generator considered, i.e. up to 1800MW for nuclear. This is focused on the ability to construct the largest generators with the short circuit ratio (SCR) and lagging reactive capability required by the GC. Compliance with the GBGC leads to a larger generator frame than would be the case with the "standard product". Compliance is most critical for the very largest units, designed up to the limits of road transport capability in EU.

4. In respect of the high volume of renewable energy, in particular from wind, for 2020 and beyond say 25GW, NGET is concerned with the impact of the otherwise Grid friendly converter technology decoupling the rotor from the system and therefore providing no system inertia.

5. A second consideration associated with the large scale introduction of converters is its impact on small signal system stability. Results from R&D suggest low cost opportunities to improve the system damping. This may improve the system transfer capacity or at least replicate the system benefit of power system stabilizers of the displaced generators.

Background

6. The September 2007 GCRP identified a need for a review of new generation technology and its likely capability or otherwise to meet the GBGC requirements. At the November 2007 GCRP, NGET made a presentation defining the expected issues involved. At the February 2008 GCRP, Users undertook to share with NGET their concerns and their information and NGET undertook to provide an information/discussion paper. This paper is intended to fulfill this undertaking. It represents information collated so far. The background to the expected large change in generation is set out below.

7. The worldwide interest in CO_2 emission has focused on the thermal electricity generating plant. Initially, this has lead to rapid development of electricity generation from renewable energy.

8. A large amount of existing GB generating plant is expected to close, possibly 30% by 2020. For existing large coal and oil fired plant this is driven by compliance with EU Large Combustion Plant Directive combined with the age of the plant. For nuclear plant the main driver is life expiry.

9. Two further significant factors are developments regarding the CO_2 price and the concern for energy security, focused on increasing dependency on gas import.

Key Compliance Issues

Renewables

10. The early focus on wind has in GB lead to installation of 2.3GW capacity. Recent experience has demonstrated that although the GBGC requirements introduced in 2005 are challenging, the required flexibility can and has been delivered by the new technologies. Existing and emerging wind technologies are not expected to have significant Grid Code compliance issues. Plans for further deployment of wind turbine generators exist in the scale of 10s of GW, both onshore and offshore. From about 2015 wave and tidal stream technologies may start to become significant. Both wind and the wave and tidal stream technologies share the increasingly Grid friendly converter technology.

11. In respect of the expected high volume of renewable energy for 2020 and beyond, say order of 25GW, NGET have a concern related to the converter technology decoupling the rotor from the system and therefore providing no system inertia. This will have a material effect on the ability of the system to contain the maximum frequency excursion and recover from large system frequency disturbances, due to less time to respond. The GBGC currently has no explicit requirement for inertia, as this has always been provided naturally. It may be necessary to consider this aspect further, exploring the indicated ease according to R&D and many publications worldwide by which synthetic inertia can be added to the converters.

12. R&D also indicates a potential for relatively inexpensive additions to the converter controllers associated with asynchronous generators to improve power system oscillation damping in a similar manner to the beneficial impact of addition of power system stabilizers to AVRs for synchronous generators. With the expected large scale replacement of synchronous generation plant with asynchronous generation plant, this may develop into a significant issue.

13. In relation to Grid Code for wind turbines, it should be noted that an EU backed initiative called European Wind Integration Study (EWIS) in its draft interim report indicates a plan to bring forward proposals for European wide harmonizing of technical requirements for grid connection of wind farms in its final report due end 2009. These requirements are currently defined in national Grid Codes.

New fossil fuelled generation plant

Carbon Capture & Storage

14. Future low carbon fossil fuelled plant may be fitted with a carbon capture capability. This may be either pre-combustion or post combustion. There appears so far to be no specification for the carbon capture performance and hence development of carbon capture and storage is still in the early stages for GB generation. The challenges if any in terms of GC compliance has therefore not yet emerged. The key aspect looks likely to

be an ability of the chemical plant to cope with rapid changes in throughput, which may in some configurations require a small volume of local storage.

Gas

15. The thermal plant technology currently being deployed is CCGT. Significant volume is already under construction. The CCGT technology is well known. The capability to comply with the Grid Code for CCGTs is now good. This includes the widespread capability of manufacturer to deliver 10% frequency response volume, which became a GC requirement in 2001. For CCGTs the most significant remaining GC challenge is islanding performance. This relates to the capability to rapidly reduce output if isolated in a smaller exporting island. This issue also applies to other large plant. There may be a need to specify this requirement more explicitly. Also proving the relatively new requirement for providing evidence of fault ride through capability has proven to be a significant task. Again this can be expected to also apply to other large plant.

Coal

16. There are several coal technologies under development and consideration. In terms of early deployment in GB the leading coal technology appears to be supercritical steam. IGCC consisting of gasification of coal and use of the syngas in gas turbine is following a few years further behind.

17. Regarding supercritical steam and IGCC NGET have recently discussed the plant flexibility with the main manufacturers.

18. When CEGB built the last coal fired station, a super critical steam design was considered, but not pursued at least in part due to the absence of the stored energy provided by the drum of conventional GB steam plant. The drum is the key to existing coal fired plant delivering the required volume of frequency response, including primary.

19. In the absence of the drum the manufacturers of supercritical coal plants appear unable to offer 10% primary frequency response. A value between 3 and 7% appears possible applying a number of techniques used on plant throughout the world . To get to the upper end of this range, optimized integrated plant design appears essential. It is worth noting that the range of deload points for which the primary frequency response can be delivered could be better than the existing minimum Grid Code requirement. For instance at a deload of 10% only 5% response is required. The best performing supercritical plant may be capable of delivering this. There may be a further challenge in maintaining the frequency response in the early part of the secondary response, say between 30 seconds and 3 minutes due to the storage limitations and the delay for increased firing to deliver increase in electrical power.

20. To deploy GC compliant supercritical steam based coal plant still appears theoretically possible. However, this looks like requiring a major redesign focused on adding substantial storage plant. This would impact on cost, timely availability and possibly even on environmental performance, i.e. thermal efficiency.

21. A second coal technology based on gasification of the coal is called IGCC. The current status of IGCC plant appears significantly less ready for large scale application than supercritical steam. At this early stage achieving frequency response from IGCC appears more challenging than for supercritical steam. This is due to the close interactions between the chemical and heat exchange processes, which may be disturbed by rapid changes.

Nuclear

22. For new nuclear plant, NGET have sought information from candidates among the four safety case applicants. Information received to date has identified nuclear designs with high level of flexibility. Discussions are in progress with manufacturers about how the inherent flexibility also required for other markets, but with significantly different requirements and arrangements, can be exploited in GB. The key challenge is rapid increase in power, i.e. primary frequency response, where our islanded system has different needs from the large markets for nuclear plant such as China, UCTE and US. Part way through this process, the prospect for full compliance looks good. Further work is required to establish the position more firmly and with more manufacturers. It appears that one of the four manufacturers has no desire to make its nuclear plant flexible, but the latter information needs to be confirmed.

23. Additional GC compliance issues have been identified associated with the size of generator considered, i.e. up to 1800MW. This is focused on the ability to construct the largest generators with the short circuit ratio (SCR) and lagging reactive capability required by the GC. Compliant design leads to a larger generator frame than would be the case with the "standard product". These issues are most critical for the very largest units, designed up to the limit provided for in the regulation for road transport in EU. The lowest capabilities appears close to SCR=0.4 rather than the required 0.5 and with a lagging power factor of about 0.9 rather than 0.85.

Conclusions

24. This paper provides a summary of the position with respect to prospect for Grid Code compliance for new generator technologies which NGET has so far established with leading manufacturers.

25. NGET suggest the following actions and work streams arise from the above collated information

    A) NGET bring forward a proposal to the next GCRP for a change in the SCR requirement aimed at overcoming the restriction identified in paragraph 23.
    B) A joint GC/CUSC working group is set up to focus on the frequency response issues identified in paragraphs 16 to 21 for coal fired plant to be established following this GCRP meeting. This WG to also encompass the issues arising from D/07. NGET to draft a remit ahead of the first WG meeting. Following discussion in the WG, bring the remit to the September GCRP.
    C) A joint CUSC/GC working group is established after the September GCRP to deal with the reactive requirement issue identified in paragraph 23. NGET to bring forward to the September GCRP a proposal for the remit.
    D) NGET to keep under review and timely initiate GCRP discussion concerning:
        (i) Development of explicit criteria for islanding performance – fast deloading associated with high frequency – see paragraph 15
        (ii) Possible requirement for synthetic inertia – see paragraph 11
        (iii) Possible requirement for Power Oscillation Damping – see paragraph 12

Recommendations

26. The GCRP is invited to:

a) note the content of this paper

b) share own information on the topics raised

c) discuss the paper including the proposed way forward defined in paragraph 25

d) Agree a way forward,