pp13/70
November 2013 GCRP

nationalgrid

Stage 01: Workgroup Report

Grid Code

GC0063 - Power Available

What stage is this document at?

01	Workgroup Report
02	Industry Consultation
03	Report to the Authority

This proposal seeks to modify the Grid Code to...

This document contains the findings of the Workgroup which formed on 11 September 2012 and concluded on 29 October 2013.

Published on: **06 November 2013**

The Workgroup recommends:
GC0063 should be progressed to industry consultation...

High Impact:
None identified

Medium Impact:
Owners, Operators and Developers of Power Park Modules

Low Impact:
Owners and Developers of Offshore Networks

Contents

Any Questions?

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About this document

This document is a Workgroup Report which contains the discussions and recommendations of the Power Available Workgroup.

Document Control

Version	Date	Author	Change Reference
0.1	15 October 2013	National Grid	Draft Workgroup Report
1.0	**Error! Reference source not found.**	National Grid	Final Workgroup Report

1 Executive Summary

Background

1.1 The Grid Code Review Panel established the Power Available Workgroup in July 2012 following the completion of the C/11 Workgroup (BM Unit Data from Intermittent Generation).

1.2 Prior to establishing the C/11 Workgroup, the Grid Code Review Panel recognised that the existing Grid Code data requirements were developed at a time when the predominant sources of energy were not intermittent and that predicting the output is easier when compared with intermittent sources. The C/11 Workgroup was established to consider whether the Grid Code data requirements needed to be amended to facilitate the participation of generation powered by intermittent sources in the Balancing Mechanism.

1.3 The C/11 Workgroup made a number of recommendations concerning the Physical Notification and Output Useable[1] data flows and in addition to investigate (i) a new 'Power Available' signal (or another solution) used as a proxy for Physical Notifications for the management of Bid/Offers in real time and (ii) changes to the provision of MEL.

1.4 A Power Available Workgroup was subsequently convened to consider the C/11 recommendations as defined within the Power Available Workgroup Terms of Reference that were approved by the Grid Code Review Panel.

The Power Available Workgroup

Benefits

1.5 At a high level, the proposals discussed as part of this Power Available Workgroup can help to facilitate:

- The efficient integration, participation and operation of renewable generation into the energy market;
- The opportunity for renewable generation to earn additional revenues from the provision of Balancing Services, for example reserve, Bid Offer Acceptances (BOAs) and frequency response;
- Reduction in the necessity of taking actions on out of merit alternatives; and
- Enhanced system security by providing more options for the provision of balancing services particularly in regions where less generation with controllable fuel sources is present.

1.6 In so doing, it would improve the efficient operation of the system and allow all BSUoS payers to benefit from reduced costs of the balancing mechanism.

Workgroup Considerations

1.7 The Power Available (PA) Workgroup sought to better articulate the current and anticipated deficiencies in data flows that currently exist and will become

[1] Output useable is defined in Grid Code as a forecast (daily or weekly) value based on the intermittent power source being at a level which would enable the genset to generate at Registered Capacity.

increasingly dominant in the future with the growth of intermittent generation. The identified deficiencies fell into two broad categories: accurate settlement of Bid Offer Acceptances (BOAs); and operational data necessary for the System Operator to operate the Transmission System in an economic and efficient manner. The workgroup recognised that one solution to address both potential categories of deficiency may be possible however these would need to be progressed under separate governance arrangements.

Accurate BOA volume settlement

1.8 The PA Workgroup considered data flows that were relevant to accurate BOA volume settlement and further noted that the volume of BOAs (Bids) from intermittent sources in 2013 (Oct 12 – Sept 13) represent ~2.1% of the total volume. It also noted that the solutions being considered for operational data could equally apply to accurate BOA settlement if required, however this would need to be progressed through Balancing and Settlement Code governance arrangements if this was considered necessary by BSC parties. Therefore, the PA Workgroup focused on the first broad category; operational data for the system operator.

Operational Data for the System Operator

1.9 The Workgroup recognised that when a wind generator has reduced its output, there is no visibility of what the potential headroom could be for the provision of reserve or frequency response if the System Operator required it for operational balancing of the system.

1.10 A number of options to overcome this deficiency were considered by the Workgroup:

1.11 Option 1 - Standardisation of MEL which would require a signal that would be expected to vary with forecast wind output, where the update frequency was a variable to be determined;

1.12 Option 2 - Dynamic MEL (Power Available signal used to calculate MEL), with an update frequency of [10 minutes]; and

1.13 Option 3 - Power Available Data via SCADA i.e. the submission of Power Available as an operational metering signal which would be fed to the National Grid Control Centre via SCADA with the definition of MEL used to indicate electrically connected capacity.

1.14 At the heart of these options is the Power Available signal. Power Available is an indication of the maximum achievable output which could be delivered by a wind farm under the current prevailing weather conditions when, for example, the current output may have been reduced for the provision of balancing services to the system operator. It is defined as:

A value in accordance with good industry practice, recorded in real time, representing the sum of the potential **Active Power** available from each individual **Power Park Unit** within the **Power Park Module** calculated using any applicable combination of meteorological (including wind speed), electrical or mechanical data measured at each **Power Park Unit**. The **Power Available** shall be a value of between 0MW and **Registered Capacity** which is the sum of the potential **Active Power** available of each **Power Park Unit** within the **Power Park Module.** A turbine that is not generating will be considered as not available.

1.15 Whilst the means by which it may be provided and the frequency of update may be different, the underlying nature of the signal is the same and is based on the prevailing wind speed and characteristics of the wind turbines.

However, option 1 and 2 requires the generator to create a MEL profile going forward and therefore would also need to include a forecast element. Conversely, option 3 would require a frequently updated spot value of Power Available which the System Operator would use to derive a profile going forward.

1.16 After consideration of the advantages and disadvantages of these options, the Workgroup concluded that option 3 (the Power Available Data Feed to National Grid Control Centre via SCADA data connections) would best address the deficiencies identified.

1.17 However, there remain a number of questions regarding the costs of implementation and whether the proposals should apply retrospectively that require further analysis in order to inform any decision made. The workgroup considered that it is appropriate to seek wider views on these matters and the content of this report via a consultation on the workgroup report.

2 Purpose & Scope of Workgroup

2.1 At the July 2012 Grid Code Review Panel (GCRP), National Grid presented the concepts of Power Available and High Wind Speed Shutdown (minutes 2589 and 2607-2618) where it was proposed that a Workgroup should be established to examine whether the development of a power available signal would be appropriate for implementation by wind generators.

2.2 The GCRP agreed that this issue required further investigation and approved the draft Terms of Reference presented by National Grid (minutes 2590 and 2615 and pp12/34). The GCRP also recommended that, for efficiency, it may be appropriate to hold a joint Workgroup to discuss the two concepts, whilst ensuring that the two sets of terms of references were fully addressed. This report addresses the issue of Power Available.

Terms of Reference

2.3 A full copy of the Terms of Reference can be found in Annex 1 the Scope of which are given below:

The Workgroup shall consider and report on the following:

- Clearly define the defect that Power Available attempts to resolve by:
    - Quantifying the current accuracy of FPNs (PN at gate closure) from intermittent generators
    - Quantifying the volume of energy curtailed from intermittent generators
- Identify how the concept of Power Available can be implemented by:
    - Creating a technical standard to calculate Power Available across different turbine manufacturers
    - Identify the method by which data will be collected
    - Identify the obligations on wind farms to collate data
    - Identify how data will be aggregated and converted into a Power Available signal
    - Assess the accuracy (based on time intervals) required for the provision of such data
    - Identify the technical equipment required
- Examine any required information systems changes
- Quantify the benefits to wind farms that can be gained from Power Available by:
    - Examining the potential volumes of generation that can utilise such a signal for settlement purposes, within both current and future connections
- Review the information that is currently available to wind farm operators and assess the value of this to National Grid as National Electricity Transmission System Operator (NETSO).
    - Take into account any analysis carried out by the High Wind Speed Shutdown (HWSS) Workgroup
- Identify additional items of information which could be of benefit and assess the value of providing these to National Grid as NETSO
- Assess the investment required to implement a minimal Power Available signal versus a highly accurate signal aggregated on a per turbine basis
- Examine how Power Available will operate under different scenarios such as:
    - high wind speed shutdown
    - turbine faults
- Assess whether retrospective application of Power Available will be appropriate
- Assess whether other renewables should be taken into account

Workgroup Meeting Dates

M1 - 11 September 2012
M2 - 09 October 2012
M3 - 08 November 2012
M4 - 10 December 2012
M5 - 12 February 2013
M6 - 14 March 2013
M7 - 01 May 2013
M8 - 11 June 2013
M9 - 11 September 2013
M10 - 29 October 2013

- Take account of and feed into the "High Wind Speed Shutdown" work being carried out under a Grid Code Workgroup
- Take account of the work in C/11 – BM Unit data from Intermittent Generation. This proposed a concept of calculating a generator's Maximum Export Limit (MEL) based on predicted/actual wind speed
- Take account of relevant international practice and the approach taken in European Code development.

Timescales

2.4 It was agreed that this Workgroup would report back to the November 2013 GCRP.

3 An Introduction to the System Operator Challenge

3.1 The Grid Code was written at a time when there were very low volumes of generation from intermittent power sources connected to the system. The Grid Code requires generators with intermittent power sources, such as wind, wave, or photo voltaic, to interact with the System Operator in the same way as a traditional generator with a controllable power source.

3.2 The System Operator receives a number of data items from generators (these are described in more detail in section 5) however two key data submissions are Physical Notifications (PN) and Maximum Export Limits (MEL). Essentially, PN indicates what a generator intends to output (typically between MEL and the SEL) and the MEL indicate what a generator is capable of outputting at any specific time if requested by the System Operator. Amongst other things, PN and MEL allow the System Operator to:

- Calculate the total generation volume connected to the system and forecast to be connected going forward;
- Calculate the available reserve on the system provided by the market;
- Determine transmission constraints;
- Amend generation output via Bid Offer Acceptances (BOAs) to match demand and manage constraints through the Balancing Mechanism;
- Hold additional reserve on generation to meet operational requirements; and
- Despatch frequency response from generation in order to manage the system frequency within operational and statutory limits.

System Balancing

3.3 The Grid Code envisages that the System Operator aggregates the sum of all notified PNs and compares this with the forecast demand profiles. The SO then plans to take balancing actions to modify the notified total generation to meet the forecast demand. Some of these planned actions can be short term actions that can be taken in real time. Others, such as the starting up or shutting down of entire BM Units requires action to be taken many hours in advance.

3.4 The main way in which the System Operator balances generation and demand in real time is by issuing Bid Offer Acceptances (BOAs) that vary generator outputs. BM Participants can submit a series of prices to offer to increase their output from a BM Unit from their PN up to their MEL, and a bid to reduce their output.

3.5 This process works well with where the Generating plant operators can control the power source. However, the System Operator is uncertain how effective this process is for generation with an intermittent power source given that the BM Participant will be unable to accurately forecast its output 1 hour ahead of real time.

3.6 The System Operator may also take BOAs, or other balancing actions, to resolve constraints on the Transmission System. These may be thermal constraints, determined by the maximum total post fault capacity of all the circuits connecting one area of the system or may be due to voltage or stability constraints.

Frequency Response

3.7 Frequency response is despatched by instructing a generator to operate in a frequency responsive mode of operation. The volume of response is determined through the Grid Code requirement and confirmed through compliance tests following commissioning which is based on the registered capacity of each Generating Unit or Power Park Module. These tests are used to derive the Frequency Response Matrix but the actual frequency response in the operational timeframe is determined by establishing the output of the generator relative to the Maximum Export Limit and deriving the frequency response capability at that operating point from the tested frequency response matrices. Typically, the System Operator will change the operating point of the generator via a BOA to obtain the required frequency response capability.

Intermittent Generation trends

3.8 The projected amount of renewable generation that are contracted to connect to the system within the next 5 years can be shown in the chart 'Contracted future renewable generation' below, with the majority of the new connections being from wind farms. This chart is based on data in National Grid's Transmission Entry Capacity (TEC) Register.

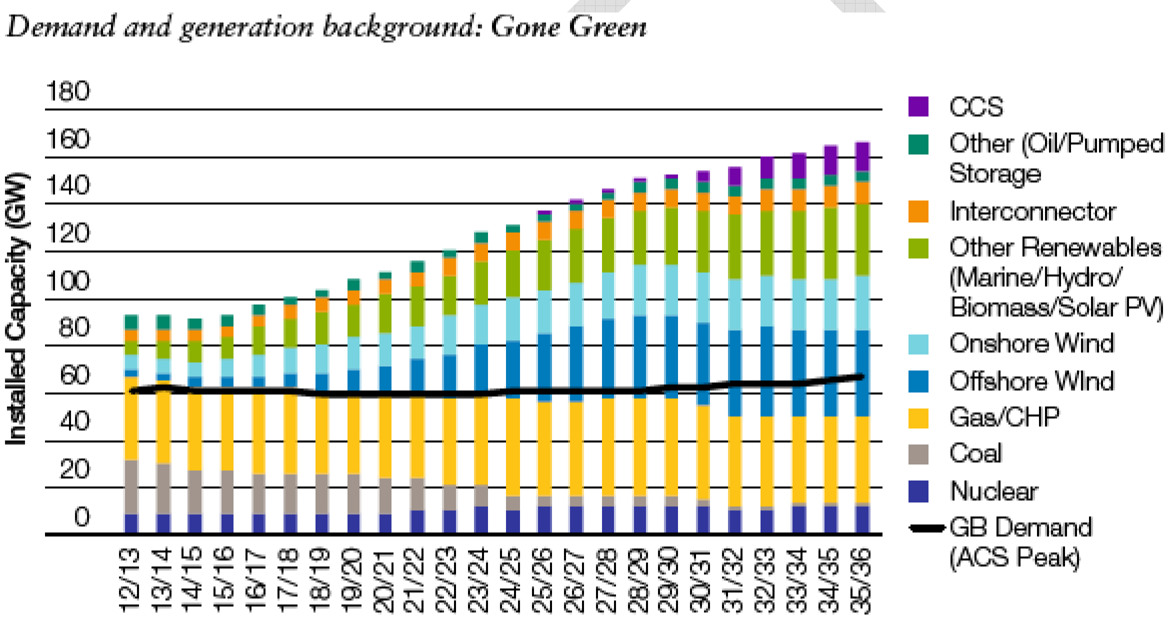


Figure 1 : Demand and Generation Background: Gone Green 2013.

3.9 A clear understanding of generator capable output and any associated uncertainties is required by the System Operator in order to manage the system efficiently and this will become more significant with the growth in intermittent generation. In addition the System Operator is also continuing to improve its wind forecasting capability to support its operational decisions in advance of real time. The wind forecasting process deployed by the System Operator is described in section 5.33.

3.10 At present, BOAs would normally only be taken on wind generation to manage specific system constraints, rather than just to balance energy. However, the System Operator considers this likely to change in the next few years as wind generation forms a greater proportion of the overall generation mix. National Grid has already had occasions of wind generation contributing up to 25% of minimum demand on a windy summer night.

3.11 As intermittent generation grows in volume, the System Operator expects the provision of balancing actions and frequency response from intermittent generation to grow. This will particularly be the case during periods of low demand and high wind where provision of services from intermittent generation may be the most economic solution. If this were not possible, services would need to be procured from other sources (e.g. interconnectors, generation, demand, energy storage) that would not ordinarily operate during such market conditions and therefore likely to be a more expensive option. In addition to this, wind power is technically well placed to provide rapid frequency response which will be required during periods of low system inertia that result from lower demand minimums and reduced levels of rotating plant synchronised to the system.

3.12 There are parts of the National Electricity Transmission System (NETS) where wind generation is providing an increasingly dominant contribution to flows across constrained boundaries and therefore intermittent generation may be the most economic option available to manage the constraint. These constrained boundaries will vary with but include planned transmission outages, connection of generation under the Connect and Manage regime and insufficient transmission capacity to cater for the available generation and prevailing demand.

3.13 Given these trends, the System Operator needs to consider whether it is able to efficiently manage the Transmission System going forward with the data flows it is currently entitled to receive as defined in the Grid Code and subsequently provided by intermittent generation. The remaining sections of this report address the terms of reference of this Workgroup.

4 Specific Issues for the System Operator

4.1 This section describes 3 areas which are problematic for the System Operator to efficiently manage the Transmission System. These are:

- Awareness of head room from intermittent generation when curtailed;
- The provision of frequency response from intermittent generation; and
- For MEL and PN data, the difference between data submitted and the actual physical outturn.

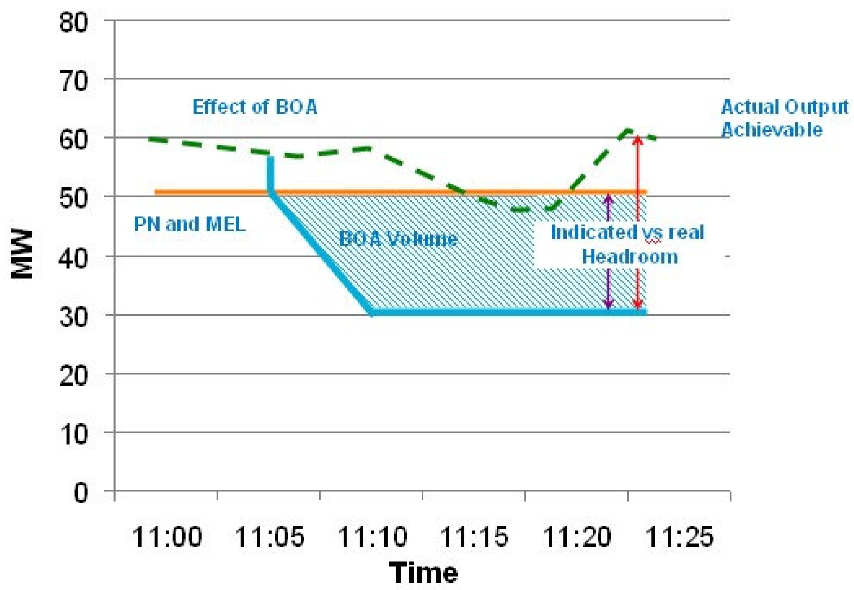
4.2 The System Operator performs a residual balancing role and the costs of actions it takes to ensure the system is operated in a safe, secure and economic manner are recovered from consumers through the Balancing Services Use of System (BSUoS) Charge.

Headroom from Intermittent Generation

4.3 As noted in section 3, the System Operator may require generation to reduce or increase output by Bid Offer Acceptances in the Balancing Mechanism. At present, this occurs infrequently for intermittent generation and typically only behind an export constrained boundary, however given the anticipated growth in wind generation, the System Operator expects this to become more common in future. Generally, there is no indication of whether wind generator reductions can be reversed, i.e. whether they have the capacity to increase their output following an earlier BOA Acceptance to reduce output. This lack of visibility of headroom from wind generators can lead to other plant types being despatched to increase output, which may be less economical than despatching a wind farm. Similar considerations may apply to other forms of variable generation.

4.4 In discussing the lack of visibility of headroom from wind farms, the example below demonstrates this where a Bid/Offer Acceptance (BOA) to reduce a generator's output does not give an indication of what their potential capability can be after the BOA has been issued. As noted in paragraph 3.3, any discrepancies between these data flows and the actual positions they are intended to represent create errors and uncertainties which, in aggregate, can lead to wider imbalances between generation and demand, less optimal management of system reserve (headroom), frequency response and constraints with consequential increased costs passed on to end consumers.

Figure 2: Illustration of the potential difference between data submitted and actual PN and MEL

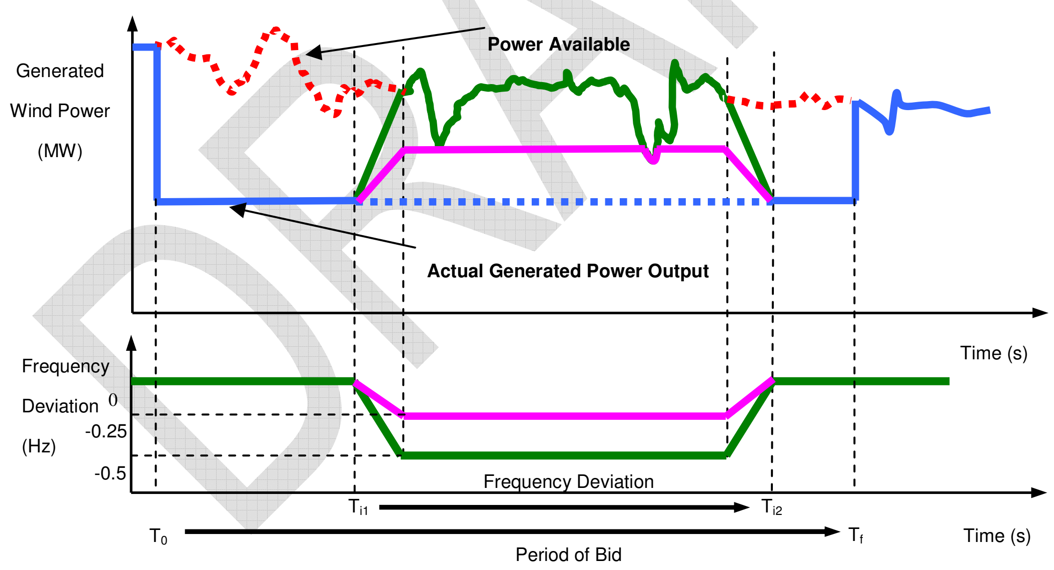


Frequency Response from Intermittent Generation

4.5 Under the Grid Code, the majority of Generating Units[2] or Power Park Modules installed within a Large Power Station are required to have a frequency response capability. In the operational phase, a number of these Generators will be instructed to Frequency Sensitive Mode and required to provide frequency response to ensure that the system frequency is maintained within specific limits should there be a loss of Generation or change of Demand. As this relies on forecasted output through the combination of Maximum Export Limits (MELs) and PNs, it is important to ensure that this remains accurate to set the baseline for such balancing services. Without this, the System Operator cannot be certain of the frequency response capability at a point in time.

4.6 The requirement for Power Park Modules forming part of a Large Power Station (which includes wind farms) to contribute to and have the capability to provide frequency control was introduced into the Grid Code in June 2005 following consultation H/04. Whilst wind generation is not widely used for contributing to primary and secondary frequency response at the current time, this is likely to change in the future as greater volumes connect and displace plant with controllable fuel sources. Experience to date has demonstrated that providing the wind resource is sufficient, wind farms can provide very good and fast acting response capabilities. Figure 3 below provides an example of how a wind farm can provide low frequency response.

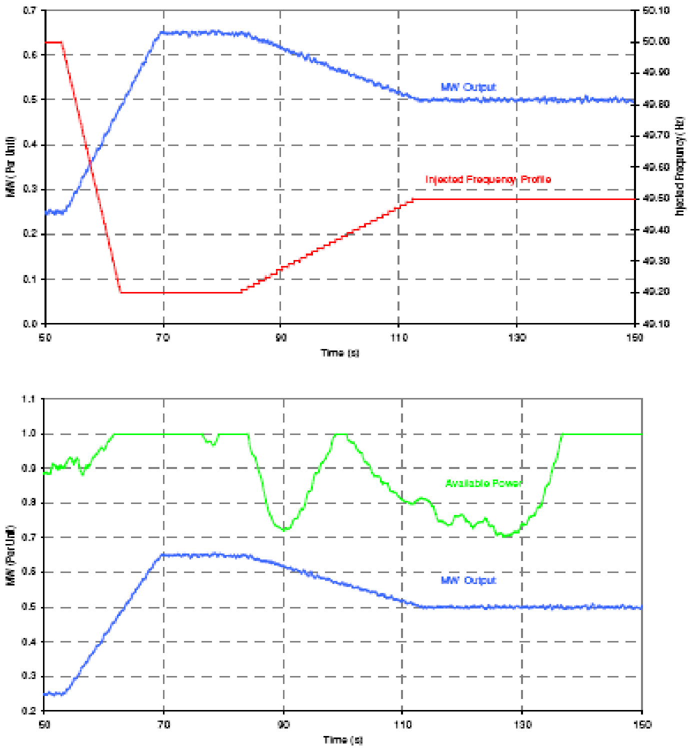
Figure 3: Example of provision of low frequency response from wind generation



4.7 The actual response from a wind farm in its ability to provide frequency response is shown below which was recorded during a Grid Code Compliance test.

[2] The obligations on Generating Units and Power Park Modules within a Large Power Station to provide frequency response are dependent upon size, type, location and Completion Date and defined in CC.6.3.7(e) and CC.6.3.7(f) of the Grid Code.

Figure 4: Example of frequency response from wind farm during a Grid Code Compliance test



Physical Notification and MEL accuracy

4.8 This is discussed in more detail in section 5 however, the accuracy between the Physical Notification at gate closure and the actual outturn does vary between different generation types. For example, PNs from generators with a variable primary energy source such as wind may not be as accurate as those from thermal or hydro generation.

4.9 There is also an observed variation in accuracy between wind generators with some generators relying on default data. PNs are also submitted for each half hour trading period and the output from a generator with a variable primary energy source is likely to vary within a trading period.

4.10 As the nature of wind can be unpredictable, it is difficult for wind generators to provide a highly accurate PN for two reasons. Day ahead PN submissions may be subject to significant forecasting errors. Hour ahead PN resubmissions for a whole half hour trading period are an estimate of the average output for that trading period and while the PNs may be subject to less forecasting error over the whole trading period (compared to day ahead), the PNs ignore the reality that wind power may vary significantly within that period.

4.11 The average PN following error is described in more detail in section 5.6, however, this means that the System Operator cannot always make operational decisions based on PN data submitted from wind generators.

4.12 As noted in the preceding paragraphs, MEL is used by the System Operator to determine the level of frequency response that a generator is capable of providing and the head room that is available. MEL is interpreted in a number of ways by wind farm operators and updated with varying frequency from hourly to monthly. The System Operator cannot reliably use MEL data for the calculation of frequency response and head room at this time.

5 Current Information Provision and its use

5.1 To help define the scope of the issues, the Workgroup discussed what information and data was currently being provided by wind generators and how this was used by National Grid. The objective was to consider whether the current data was sufficient for the System Operator and to ascertain whether new items were required. The main data items are set out below:

Pre Gate Closure Data

- Physical Notifications
- Bid/Offer data

Post Gate Closure Data

- Operational Metering Data
- Maximum Export Limits (MEL)
- Dynamic Parameters
- Wind speed and direction on a Power Park Module basis rather than from individual turbines.

Historic Recorded Data

- Recorded information received from data loggers such as Dynamic System Monitoring and Ancillary Services Monitoring equipment
- Historic recorded data from Compliance Tests including a Power Available Signal for frequency response testing purposes and test results

Planning Code Data

- Static data received under the Grid Code used for offline modelling and analysis purposes (Power Park Module MW, MVA and Performance Chart, Power Park Unit data including Control System Parameters and Power output / wind speed curves).

5.2 The generator licence requires the Generator to comply with the Grid Code.

Physical Notifications (PN)

5.3 Under BC1.4.2 of the Grid Code, generators are required to provide the best estimate (Physical Notification or PN) of their output for each half hour of the following day, which may then be revised up to an hour before real time (Gate closure). This then becomes their Final Physical Notification which is then used by the System Operator to determine the current generator output and forecast output going forward.

5.4 The Grid Code defines the PN as:

"Data that describes the BM Participant's best estimate of the expected input or output of Active Power of a BM Unit and/or (where relevant) Generating Unit, the accuracy of the Physical Notification being commensurate with Good Industry Practice.'

What is MEL?

The MEL is used by NGET to determine the amount of power available to the System Operator over and above that indicated by the PNs. Under BC1.A.1.3.1 of the Grid Code, as "A series of MW figures and associated times, making up a profile of the maximum level at which the BM Unit may be exporting (in MW) to the National Electricity Transmission System at the Grid Entry Point or Grid Supply Point, as appropriate.

A PN can be profiled within a settlement period.

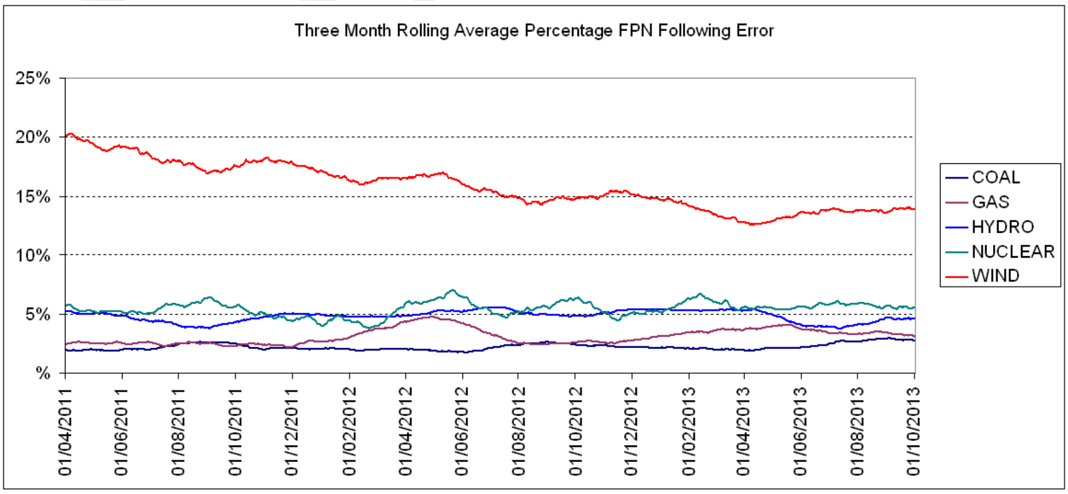
5.5 A recent Grid Code change, C/11, removed the obligation for wind generators to follow their Physical Notification (PN), provided that they follow good industry practice i.e. submit PNs that are a true and accurate reflection of their estimated output. This was introduced because wind generators can find it difficult to follow PNs due to the variable nature of their primary fuel source. However, if the generator participates within the BM, in times of system stress, a £0 BOA may be issued to the generator to return to their PN..

5.6 Currently, in operational timescales, National Grid control engineers can elect to use either Physical Notifications (PNs) from a wind farm or existing MW metered output from the wind farm in calculating expected total generation between four hours ahead and real time. The reason for this is partly historic in that in the early days of wind power in 2005 and 2006 there was little enthusiasm from wind farms at that time to submit PN data. Many chose to submit nothing and others chose to submit zero. It was at this stage that it was decided that an internal wind power forecasting capability would need to be developed within National Grid. Over the intervening years there has been a vast improvement in the quality and frequency of the data being submitted by wind farms.

5.7 In terms of timing, National Grid requires accurate PN data 90 minutes ahead of real time in order to plan the system effectively, There are three critical decision points where accurate information is important. At the day ahead stage (24 hours ahead of real time) National Grid requires accurate information to enable assessment of margins and headroom on the system. The critical point for deciding whether extra generation is needed to be warmed up and made ready to generate is 4 hours ahead of each cardinal point on the demand curve. After gate closure (1 hour ahead) adjustments are performed by Engineers at the Electricity National Control Centre to manage frequency and constraints. These adjustments and the settlement of them are performed relative to the PN submitted.

Current accuracy of PNs at Gate Closure compared with actual outturn from intermittent generators

5.8 Figure 5 below highlights the inaccuracy levels from wind generation 1st January 2011. Giving a 3 month rolling average from the start of April 2011.



5.9 Percentage PN Following Error is defined as:

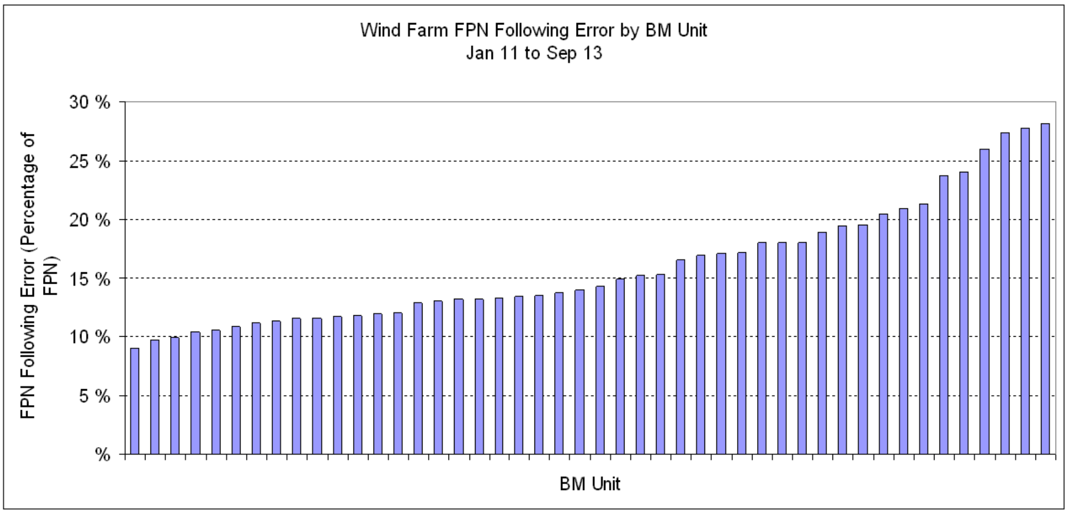
$$PNaccuracy(\%) = \frac{Average(ABS(PN_{GateClosure} \pm BOAs - MeteredOutput))}{MaxMeteredOutput}$$

5.10 The PN accuracy is defined as the average absolute difference in MWh per settlement period between the expected value (PN at Gate Closure modified by BOAs) and actual metered output, divided by the maximum metered output from the BMU. For example, a 100MW BMU that submitted a PN of 25MW with double that (50MW) for the metered output would yield an accuracy of 25%.

5.11 The analysis has been based on all data since 1st January 2011 giving a 3 month rolling average from the start of April 2011.the absolute difference in MW between expected (PN at Gate Closure) and actual metered output divided by PN at gate closure (FPN). The analysis was done for all BMUs with a maximum metered output greater than 10MW.

5.12 Figure 6 below illustrates the average PN following accuracy by Balancing Mechanism Unit (BMU) individual wind BMUs above 10 MW between January 2011 and September 2013.

Figure 6: PN following accuracy by Wind BM Unit (Jan 2011 – Sept 2013)



5.13 The average PN following error for wind BMUs is 15.9%. This compares to 2.9% for coal, 3.1% for gas, 4.9% for hydro and 5.5% for nuclear.

Maximum Export Limits (MEL)

5.14 In addition to providing PNs, BM Participants (generators) also submit Maximum Export Levels (MELs) for each settlement period. This is the maximum power that a BM Unit chooses to make available via the Balancing Mechanism during the settlement period. The MEL is used by NGET to determine the amount of power available to the System Operator over and above that indicated by PNs and is used in the despatch of frequency response and to determine reserve levels provided by the market.

5.15 The MEL is submitted by a generator to indicate the amount of capacity that is available on a particular unit in order to help the System Operator with reserve scheduling. This may be submitted within gate closure and can be different from a generator's PN. It is defined in the Grid Code as:

> *"A series of MW figures and associated times, making up a profile of the maximum level at which the BM Unit may be exporting (in MW) to the National Electricity Transmission System at the Grid Entry Point or Grid Supply Point, as appropriate."*

5.16 For wind generation, MEL can be perceived as being based on actual or predicted wind speed in order to calculate the actual or forecast maximum capacity respectively. However, this would require frequent updates to MEL which may not be practical compared to submissions from generation with controllable fuel sources.

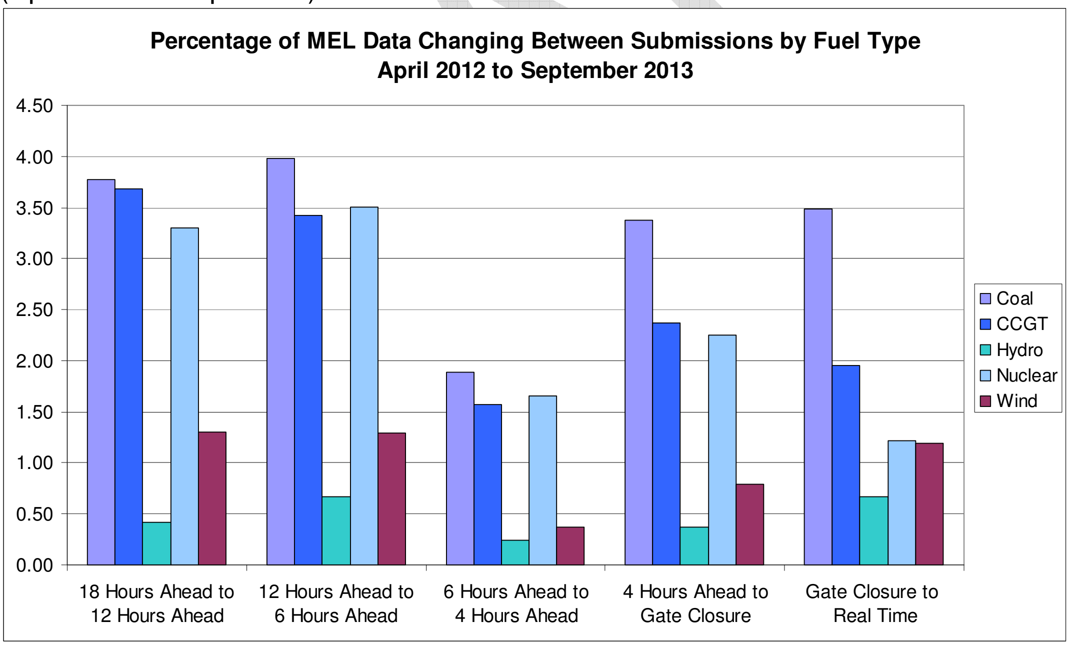
5.17 The Workgroup acknowledge that, across the industry, there are different practices for submitting MEL, some parties put in MEL as installed capacity, some set MEL to PN and other provide a more dynamic MEL (i.e. a MEL dependent upon the actual availability and output of the plant at any one time).

5.18 Maximum Export Limit (MEL) is very important to National Grid to allow awareness of how much margin is available on the system. For a marginal power station with a controllable fuel source, the difference between the PN and the MEL gives an indication of the headroom or spare capacity that is available to be instructed if needed.

5.19 Currently, 1.4% of MEL submissions by Power Park Modules are changed between gate closure and real time. This compares to 1.3% for nuclear, 2.2% for CCGT and 3.8% for coal.

5.20 The graph below shows the percentages of MEL submissions that are changed (y axis) for each fuel type that are over various time frames. The data relates to the period April 2012 and September 2013. Generally, wind MELs are changed less frequently than other fuel types, with the exception of hydro, across all time scales.

Figure 7: Percentage of MEL data changing between submissions by fuel type (April 2012 – Sept 2013)



5.21 If the submitted MEL was dependent on wind output, there would be a greater variation whereas, if MEL was based on the available capacity, there would be less variation. Figure 7 suggests that the MEL data is generally submitted on the later basis.

Bid / Offer data

5.22 Bid / Offer data specifies MW operating points and the costs associated with deviating generation from its current operating point as indicated by its Physical Notification. These are very important in the decision making process at the National Electricity Control Centre. When Bids and Offers need to be accepted to manage system issues they are taken in cost order with the cheapest option taken before the more expensive option, unless system constraints dictate otherwise. In this way, the need to optimise the geographical distribution of plant on the electricity transmission system is achieved in the most economic way.

Wind speed / direction

5.23 Wind Speed and Wind Direction is currently received from 50% of the BMU wind farms. This is around 45 sites at the present time. This information is used for two purposes. Firstly to verify the quality of the wind speed and direction forecasts provided by our weather forecast provider. If these forecasts are found to be inaccurate relative to the measured wind speed and direction at the wind farm site, then adjustments are made to the forecasting models to take this into account in the short term and feedback is given to the weather companies so that improved weather forecasts can be received in the longer term. Secondly the wind speed and wind direction measurement data is used to build more accurate models that enable more accurate forecasting by the System Operator.

Operational Metering

5.24 National Grid as System Operator, require Operational Metering Data which is used for control of the Transmission System in real time. At the present time, National Grid require aggregated wind speed and direction (amongst other operational metering signals e.g. MW, MVAr's, Voltage, tap position and frequency) for each Power Park Module, the requirements for which are specified in the Bilateral Agreement. At the present time if a fault occurs to the operational metering, National Grid would generally require it to be repaired within 5 days of notification of the fault unless otherwise agreed.

5.25 All the operational metering signals are generally treated in the same way within the Bilateral Connection Agreements, and it is usual practice for the generator to provide the specified operational metering signals to the Grid Supply Point. National Grid would then take these signals and provide the communications routes back to the National Electricity Control Centre at Wokingham. In terms of ongoing maintenance, National Grid will pay for the communications infrastructure from its Control Centre to the Grid Supply Point and the Generator will pay for the communications infrastructure from the Grid Supply Point to the Power Park Modules.

5.26 An example setting out the Bilateral Connection Agreement schedule and its description of the communication routes is described in Annex 3.

Power Available signal for testing frequency response

5.27 Generators are required to provide a Power Available ("Avail") signal to National Grid for compliance testing purposes only. These requirements are detailed in OC5.A.1.3 (c) and CC.6.6.2 of the Grid Code but in summary when a wind farm is undertaking compliance testing for frequency response testing purposes, they will be required to supply a Power Available signal with a sampling rate of typically 10Hz. This signal however should not be confused with operational metering signals which are provided to National Grid for the purposes of operating the Transmission System.

Frequency Response

5.28 As noted in section 3.7 above, Frequency response from wind is despatched by instructing a generator to operate in Frequency Sensitive Mode (FSM). The volume of response provided is calculated using the de-load point from MEL and making reference to a frequency response capability matrix for the generator concerned.

5.29 The Workgroup noted that some wind farms are capable of providing frequency response in two ways:

- Maintaining a set de-load from the maximum operating output given the prevailing wind conditions (i.e. the wind turbine output would follow the wind output less a fixed headroom)might not be universal, level of de-load is much less than just curtailing; some wind turbines can operate in this way;

- Operate at a fixed specified loading point below the maximum (i.e. the level of headroom and hence reserve would vary depending on wind speed in reference to the fixed loading point of the wind farm) varying output because of frequency changes only); all wind turbines can operate in this way;

5.30 The latter mode of operation is used in the GB. There is no suggestion that this will change, however it is worth noting that either mode of frequency response requires the same data flow to calculate the frequency response capability that is provided.

Wind Farm Data Collection and Signal Processing

5.31 In terms of data and signal processing, the required operational metering data is currently limited to aggregated wind speed and direction for each Power Park Module with a refresh rate of 5 seconds or better. The wind farm developer determines how to derive these signals either from a met mast or via transducers from the wind turbines themselves. It should be noted that such signals may already be available from the Wind Farm SCADA system which the wind farm owner and manufacturer will use for operational purposes.

Data Communications between wind farms and the System Operator

5.32 The System Operator receives data from all generators via Electronic Data Transfer (EDT), Electronic Data Logging (EDL) and Supervisory Control and Data Acquisition (SCADA). These are described in more detail in Annex 3 however the key characteristics are as flows:

- EDT – Generator data received from the Trading Point responsible for the wind farm. PN's and Bid Offer data are provided to the System Operator via this medium.

- EDL – communication between the System Operator and Generating Unit or Power Park Module control point where BOA acceptances are issued and ancillary services instructions given such as frequency response and reactive power. Dynamic parameters such as MELs may also be communicated by this medium.

- SCADA – all operational metering data and in the case of wind farms, wind speed and direction.-

- Contingency communications (e.g. fax)

How is current data used to derive System Operator forecast output?

5.33 The Workgroup questioned how current data on wind speed and PNs from wind farms was used to help derive a forecast of output and whether this had a large margin of error.

5.34 In the timescale 0 to 6 hours ahead, the aggregate wind forecast is a combination of the metered output (Persistence forecast) and the wind power forecast that has been derived from the weather forecast. The two results are combined together in a linear way. At the real time point (0 hours ahead) the forecast and the metered values are equal. At 3 hours ahead the result is 50% metering and 50% forecast. At 6 hours ahead the result consists of 100% of the wind power forecast and 0% metering. This is shown in Figure 8 below.

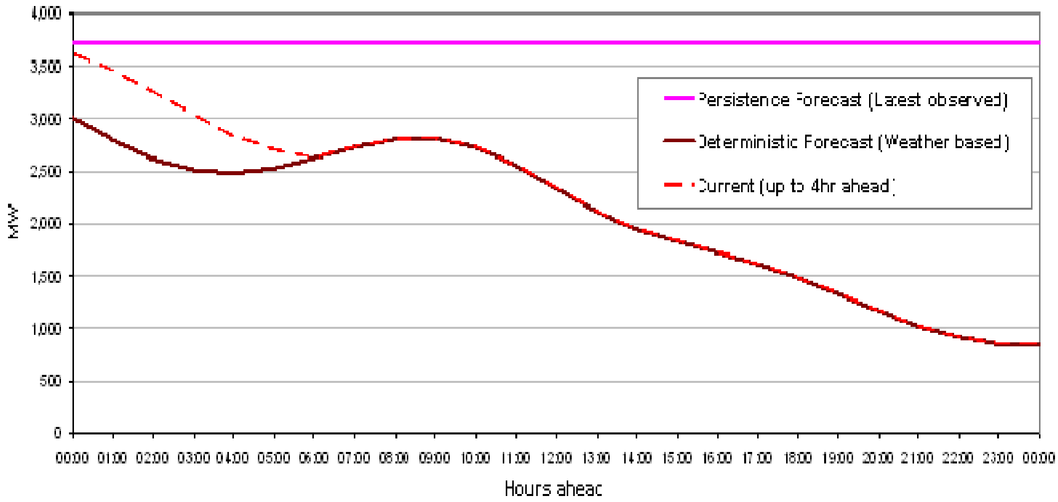


Figure 8: Wind Power forecast combining deterministic and persistence methodologies

5.35 The forecast output is constantly updated on a rolling basis as new metering data is received by the System Operator.

Wind Farm Operators' Wind Forecast Data

5.36 It was noted that wind farm operators that are party to the BSC require forecasting data flows for both trading purposes and the calculation of PNs. Some parties use a common forecasting system and data set for both trading and operational purposes whereas other parties take a separate approach.

5.37 At gate closure two data streams are submitted by, or on behalf of Wind Farms:

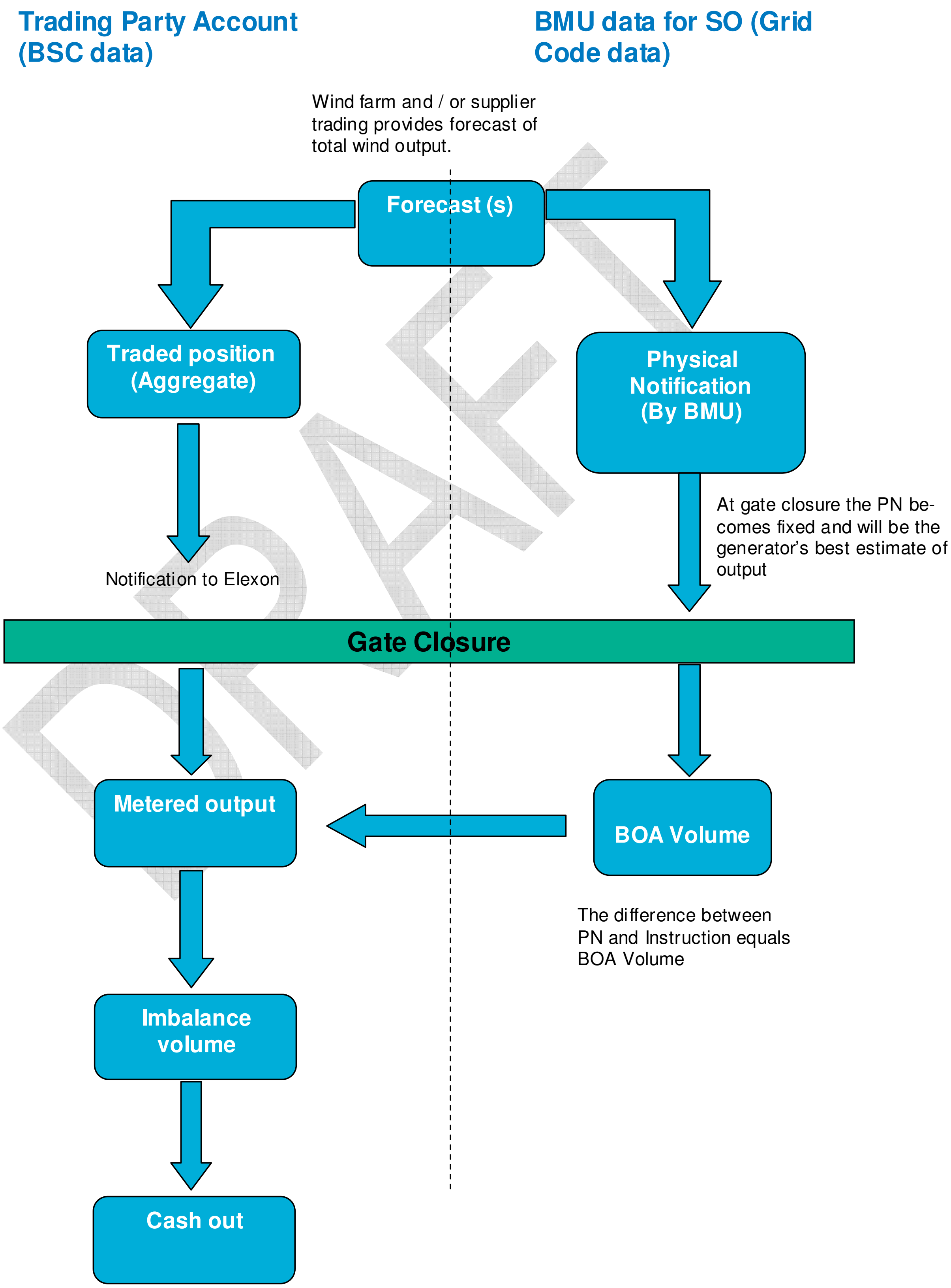
- Notifications from parties representing aggregated traded positions (MWh/Settlement Period) are submitted to the Energy Contract Volume Aggregation Agent (currently Elexon)

- Physical Notifications for each BMU are submitted to the System Operator

5.38 For wholesale energy trading, Trading Parties submit Notifications to the Energy Contract Volume Aggregation Agent (ECVAA, one of the agents mandated by the BSC) prior to gate closure and any differences between the Notified position and metered outputs (MWh / SP) are cashed out at the prevailing cash out price. For physical parties (i.e. generators), the Notified position in effect represents a forecast output at gate closure for the settlement periods concerned.

5.39 Any Bid Offer Acceptance (BOAs) volumes (MWh/SP for a BMU) accepted by the System Operator in the Balancing Mechanism are calculated with reference to the Physical Notification at gate closure and these volumes are added (or subtracted) to the Notified positions. This means that, assuming PNs are accurate; any imbalance exposure associated with BOAs is removed. BOAs are paid at the rates (£/MW) submitted by the wind farm operators into the Balancing Mechanism. The following Figure 9 helps to explain this.

Figure 9: High Level Illustration of BSC and Grid Code data flows



6 Perceived Deficiencies

6.1 The identified deficiencies fell into two broad categories: operational data necessary for the System Operator to operate the Transmission System in an economic and efficient manner; and accurate settlement of Bid Offer Acceptances (BOAs).

Required Operational Data from Intermittent Generation

6.2 Assuming that no changes to wind power output need to be taken, the System Operator is currently able to undertake many of its overall activities where PNs and other data would ordinarily be used by using a combination of forecasting wind power output and wind output metered data. This assumes that wind output is maximised to harness the available wind.

6.3 Within Gate Closure, where an intermittent generator is requested to deviate from its preferred operating point (assumed to be maximised to harness the available resource) to a specified output via a BOA, the System Operator is uncertain what the potential output that Power Park Module could return to, should the need arise. This data would enable the System Operator to manage reserve levels and frequency response capability more efficiently.

6.4 For generation with a controllable fuel source, this is indicated by the Maximum Export Limit; however the current definition of MEL and the subsequent data that is provided from intermittent generation (e.g. wind) does not allow the System Operator to establish the level of headroom that is available for the reasons set out in sections 5.145.14 to 5.21. That is, there is a variation in the interpretation of the definition of MEL by wind farm operators and the level of accuracy that can be achieved.

Bid Offer Acceptance volume (MWh) accuracy

6.5 As already noted, the Grid Code defines the PN as:

> *"Data that describes the BM Participant's best estimate of the expected input or output of Active Power of a BM Unit and/or (where relevant) Generating Unit, the accuracy of the Physical Notification being commensurate with Good Industry Practice"*

A PN can be profiled within a settlement period. Inherently then, the PN data contains forecast data going forward.

6.6 BOAs can be issued to deviate intermittent generation to specific operating points, however the cost of taking a BOA is calculated with reference to the Physical Notification and submitted price. Any significant discrepancies between actual output and PN may therefore lead to an uneconomic decision by the System Operator and an incorrect settlement of a BOA.

6.7 The workgroup concluded that it was possible to use any of the options that were considered to address operational considerations in order to calculate BOA volumes for Settlement. Reference was also made to a BSC modification proposal P197 that had previously considered how BOA volumes could be calculated where MEL was re-declared below its PN. Therefore the workgroup considered it sensible to independently progress accurate settlement of Bid Offer Acceptances (BOAs) through Balancing and Settlement Code governance arrangements if this was considered necessary by BSC parties.

6.8 The Workgroup recognised that the margin of error was higher within intermittent generation compared to other generation however the materiality was not thought to be currently significant but may increase in the future as intermittent volumes increase and the System Operator takes more balancing actions on intermittent generation. The following table shows the volume of BOAs taken between for different generator fuel sources. (1st Oct 2012 – 30th Sept 2013)

	CCGT	COAL	GAS	HYDRO	OCGT	OIL	WIND	Total
Volume of Offers	3,438,367	2,643,013	13,223,389	1,351,042	32,896	11,442	1,078	20,701,227
Volume of Bids	-2,680,321	-9,177,284	-9,657,549	-619,899	-4	-952	-467,835	-22,603,844
Percentage of Offers	16.6	12.8	63.9	6.5	0.2	0.1	0	
Percentage of Bids	11.9	40.6	42.7	2.7	0	0	2.1	

6.9 It was noted that any developments that may have implications on settlement of BOAs may affect Power Purchase Agreements that underpin investments in wind farms. Consequently, concern was expressed over any proposals that may affect settlement. As noted, further consideration of the terms of reference by this workgroup concluded that settlement implications would be most sensibly progressed under BSC arrangements.

Benefits of addressing these perceived deficiencies

6.10 At a high level, overcoming these deficiencies will facilitate the efficient integration, participation and operation of renewable generation to supply electricity to GB consumers.

6.11 It would facilitate the opportunity for wind farms to participate in the provision of Balancing Services (e.g. reserve, BOAs and frequency response) and earn additional revenues.

6.12 It would help avoid the necessity of taking actions on out of merit alternatives.

6.13 Where automation is possible, additional operational burden on renewable generation operators should be reduced.

6.14 It would improve the efficient operation of the system and potentially reduce BSUoS costs

6.15 Facilitating the provision of Balancing Services from intermittent generation will also enhance system security particularly in regions where less generation with controllable fuel sources are present.

7 Description of Options

7.1 In considering the issues highlighted by National Grid, the Workgroup discussed whether or not changes were required to the existing processes or whether solutions could be sought which were outside of the current Grid Code obligations. Three options were found worthy of consideration and are described below

- Option 1 - Standardisation of MEL where the update frequency was a variable to be determined by the Generator;
- Option 2 - Dynamic MEL (Power Available signal used to calculate MEL), with an update frequency of [10 minutes]; and
- Option 3 - Power Available Data Feed to the National Grid Control Centre via SCADA data connections; MEL used to indicate connected capacity

7.2 At the heart of all of the options is the Power Available signal. Power Available is an indication of the maximum achievable output which could be delivered by a wind farm under the current prevailing weather conditions when, for example, the current output may have been reduced for the provision of balancing services to the system operator. It is defined as:

A value in accordance with good industry practice, recorded in real time, representing the sum of the potential **Active Power** available from each individual **Power Park Unit** within the **Power Park Module** calculated using any applicable combination of meteorological (including wind speed), electrical or mechanical data measured at each **Power Park Unit**. The **Power Available** shall be a value of between 0MW and **Registered Capacity** which is the sum of the potential **Active Power** available of each **Power Park Unit** within the **Power Park Module.** A turbine that is not generating will be considered as not available.

Option 1 - Standardisation of MEL

7.3 There is currently inconsistency in BM data provided by wind farm operators. Some BMUs set their MEL to be the Registered Capacity, or some other high fixed value, while others set their MEL equal to their PN.

7.4 Under this option, PNs would continue to be provided by wind farm operators through the BM. BC1.A.1.3.1 is modified to ensure a consistent definition of MEL is used by all wind farms. The MEL would provide the forecast maximum output profile expected forward from real time through the BM. It would be recalculated and submitted periodically and potentially may be provided manually.

7.5 A standard methodology for calculation of MEL would be agreed and would be expected to vary with forecast wind output.

7.6 This may improve the accuracy of total headroom calculated from the sum of synchronised MELs, but may not resolve the problems associated with wind headroom and provision of frequency response following a reduction in output via a BOA. This would depend on the accuracy achieved which would be influenced by the frequency of update.

7.7 Settlement of any BOAs would continue to be against PN.

7.8 Wind farm operators would have to modify their systems to send the data.

Option 2 - Dynamic MEL (Power Available signal is used to calculate MEL)

7.9 Under this option, PNs would continue to be provided by wind farm operators through the BM as now. BC1.A.1.3.1 is modified to ensure a consistent definition of MEL is used by all wind farms. In addition, each wind farm periodically recalculates its current MEL, and re-submits its MEL profile forward from real time through the BM. It is anticipated that this would occur every ten or fifteen minutes and follow a standard methodology for calculation of current MEL. Given the frequency of MEL revisions, persistence modelling could be deployed to generate the profile forward from real time through the BM by the operator. It is anticipated that this will be an automated solution.

7.10 Settlement of any BOAs would continue to be against PN.

7.11 This option could allow National Grid to calculate headroom provided by any wind farms operating below MEL, and could allow wind farms to provide low frequency response, as National Grid would be able to calculate the volume of response currently being provided by a wind farm.

7.12 This option would result in an increased volume of data flowing through the BM and Elexon systems. Wind farm operators would have to modify their systems to send the data, and National Grid would have to modify their systems to make use of the frequently updated MEL data.

Option 3 - Power Available Data Feed to National Grid Control Centre

7.13 Under this option, wind farms would submit PNs as now and, following a standard definition, MEL which would indicate the total connected capacity. However, rather than providing a periodic update of MEL, wind farms would provide a separate periodic value for Power Available, at [X time] intervals direct to National Grid's Electricity National Control Centre. This value would be the maximum output that could be delivered by the wind farm with the current wind conditions, and would be calculated using an agreed standard methodology. The System Operator would use this data, persistence modelling and forecast data to make operational decisions for reserve and frequency response based on its forward projections.

7.14 This signal could potentially be fed over the existing SCADA data connections used to provide operational metering. National Grid would use the data internally for operational purposes, but the settlement process would not be affected.

7.15 As a general comment, discussions held with manufacturers support the view that if a signal is already available within the wind farm SCADA system, it should not be difficult or costly to provide to the System Operator provided such requirements are specified with such signals when requested at the design stage. However, additional work would need to be undertaken to determine whether this signal could be used for the provision of an operational signal to the System Operator.

7.16 Settlement of BOAs would be against PNs as now.

7.17 This option would allow National Grid to calculate headroom provided by any wind farms operating below their current maximum possible output, and could allow wind farms to provide low frequency response, as National Grid would be able to calculate the volume of response currently being provided by a wind farm.

7.18 Providing the total connected capacity through MEL would also assist in the System Operators wind forecasting process. It also has the advantage of allowing the System Operator to have greater visibility of all wind farms not just those which are BM Units in their own right and subject only to Central Volume Allocated (CVA) metering.

7.19 This option does not impact on BM systems. Wind farm operators would have to modify their SCADA systems to send the data, and National Grid would have to modify their systems to make use of the additional information. It was noted that wind speed and direction were already transmitted via SCADA systems at a 5 second interval and it may be no less onerous to provide 5 second interval data rather than, for example, 10 – 15 minute interval data.

Further Refinement of Options

7.20 The workgroup noted that the main difference between the "Standardisation of MEL" and "Dynamic MEL" options was the frequency of data update as that it would be expected to vary with forecast wind output.

7.21 The table below summarises the differences between the three options and describes the features, advantages and disadvantages of each.

7.22 It was noted by the workgroup that the costs for implementing any of these solutions needs further consideration and would benefit from seeking wider views as they vary between Generators and wind farm designs.

Other Considerations

7.23 It was noted by the workgroup that accuracy between of PNs might be improved if the period between gate closure and real time was reduced; however this was not the case for MEL data as this data flow can already be varied within gate closure irrespective of the gate closure period. Consequently, the workgroup did not consider that a shorter gate closure would address the deficiencies identified for MEL.

7.24 The following tables showing the options

FEATURES	**Option 1** Standardised MELs	**Option 2** MEL Updated at Regular Intervals	**Option 3** Power Available Signal to ENCC outside BM systems
Data Exchange			
MEL	Under this option, PNs would continue to be provided by wind farm operators through the BM. BC1.A.1.3.1 is modified to ensure a consistent definition of MEL is used by all wind farms The MEL would provide forecast maximum output profile expected forward from real time through the BM. It would be recalculated and submitted periodically and potentially may be provided manually. A standard methodology for calculation of MEL would be agreed would be agreed and would be expected to vary with forecast wind output.	Under this option, PNs would continue to be provided by wind farm operators through the BM as now. BC1.A.1.3.1 is modified to ensure a consistent definition of MEL is used by all wind farms. In addition, each wind farm periodically recalculates its current MEL, and re-submits its MEL profile forward from real time through the BM. It is anticipated that this would occur every ten or fifteen minutes and follow a standard methodology for calculation of current MEL. Given the frequency of MEL revisions, persistence modelling could be deployed to generate the profile forward from real time through the BM by the operator. It is anticipated that this will be an automated solution.	MELs manually submitted, reflecting availability of individual turbines in the same way as MEL reflects availability of conventional plant. MEL would also be used to warn SO when generators were likely to start generating again post high wind speed shutoff.
PN	No Change	No Change	No Change
Power Avail	N/A	N/A – essentially submitted via MEL	Signal would be provided to SO showing current maximum possible output from windfarm given current wind strength and direction. It is anticipated that this would be via the Scada system, but other data exchange routes could be considered if more cost effective.

Features	**Option 1** Standardised MELs	**Option 2** MEL Updated at Regular Intervals	**Option 3** Power Available Signal to ENCC outside BM systems
Data Volumes	No significant change	Significant increase in volume of BM data sent to National Grid and Elexon / BMRA	No increase in BM data systems. Very small percentage increase in the volume of Scada data received by SO.
Cost (Subject to consultation)			
Implementation	Low but will depend on currently adopted practice	Low for wind farms with existing automated process Medium for wind farms installing new automated process	Low to medium
Ongoing Operation	Potentially medium depending on how implemented	Low for wind farms adopting automated process; medium for those adopting a manual process	Low to very low – maintenance of single additional analogue signal.
Implementation Timescale	Only limited by Grid Code change	Would require time for wind farms to develop and implement automated system if desired	Would require time for integration of signal to Scada systems and modification to SO systems.

Features	**Option 1** Standardised MELs	**Option 2** MEL Updated at Regular Intervals	**Option 3** Power Available Signal to ENCC outside BM systems
Changes to Codes and associated documents	Clarify definition of MEL in Grid Code for intermittent generation	Changes to Grid Code to codify frequency of MEL data. Changes to Procurement Guidelines to clarify how National Grid would assess the value of services from windfarms where current volumes have some uncertainty against services from conventional plant.	Changes to Grid Code to require data – may be different ways to obtain data for new and existing generators Changes to Procurement Guidelines to clarify how National Grid would assess the value of services from windfarms where volumes may change in the future.
Settlement	No Change	No Change	No Change
Delivery of Requirement			
Headroom	SO unable to calculate current headroom provided by any wind farms operating below maximum output	SO able to calculate better estimate of headroom, depending on frequency of update	SO able to calculate headroom
Response Volume	SO unable to calculate current response volume held on any wind farms operating in frequency sensitive mode.	SO able to calculate better estimate of response volume held on any wind farms operating in frequency sensitive mode, depending on frequency of update	SO able to calculate response volumes

Features	Option 1 Standardised MELs	Option 2 MEL Updated at Regular Intervals	Option 3 Power Available Signal to ENCC outside BM systems
ADVANTAGES			
For Wind Farm Operators	Potentially no system and process changes depending on current practice Potentially low overhead	Some operators would not need to change their systems Some access to response and reserve markets	For most operators power available signal is already within control system. For new generators this would probably be the easiest system to implement. Efficient integration, participation and operation of wind generation into the energy market Opportunity for wind generation to earn additional revenues for the provision of services.
For System Operator	No system changes No increased	Some visibility of headroom and response volume.	Clear visibility of system headroom and response volumes. Able to confidently instruct response on wind farms, reducing need to hold other units on system displacing wind. Able to know what generation will return to system at end of an Offer, which could avoid need for additional response holdings in future.
For Consumers	No potential costs passed through. It was noted that this would need to be weighed up against the potential rise in costs elsewhere.	Lower costs than Option 1 due to ability to utilise some response and reserve from wind farms rather than curtailing wind and bringing on conventional plant. Improved security of supply due to improved visibility of headroom and response volumes.	Lower costs than Option 2 due to ability to utilise response and reserve from wind farms rather than curtailing wind and bringing on conventional plant. Improved security of supply due to visibility of headroom and response volumes and provision of services from wider portfolio of generation

Features	Option 1 Standardised MELs	Option 2 MEL Updated at Regular Intervals	Option 3 Power Available Signal to ENCC outside BM systems
DISADVANTAGES			
For Wind Farm Operators	Would have to pay a share of increased balancing costs due to extra response and reserve holdings. Reduced access to response and reserve markets.	Some operators would incur significant additional operational costs. Increased volume of MEL data could cause system issues	Some existing generators could incur costs making data available.
For System Operator	Depending on definition of MEL adopted either SO does not know maximum generation currently available from wind farm or SO does not know if any individual turbines are on outage. SO does not know headroom or response volumes from wind farms and so has to carry additional response and reserve at additional cost to industry	Only partially accurate headroom and response volumes would require additional contingency to be held. Significant increase in BM data could require system expansion. As MEL is short term availability, no way of knowing if individual wind turbines are on outage. With automated systems providing current values, SO would not receive warning that wind farms are going to start generating again post high wind speed shutdown.	Need to modify IS system to handle new data.
For Consumers	Increased costs due to extra balancing costs being passed through. Reduced security of supply due to increased uncertainty in volume of response and headroom.	Additional costs passed on from those wind farms seeing higher operational costs.	Costs incurred by some generators implementing change would be passed on to consumers. This would need to be weighed against the benefits.

8 Power Available Signal

8.1 At the heart of both Standardisation of MEL and Power Available Data Feed to National Grid Control Centre options is the Power Available signal. Whilst the means of provision and the frequency of update may be different, the underlying nature of the signal is the same.

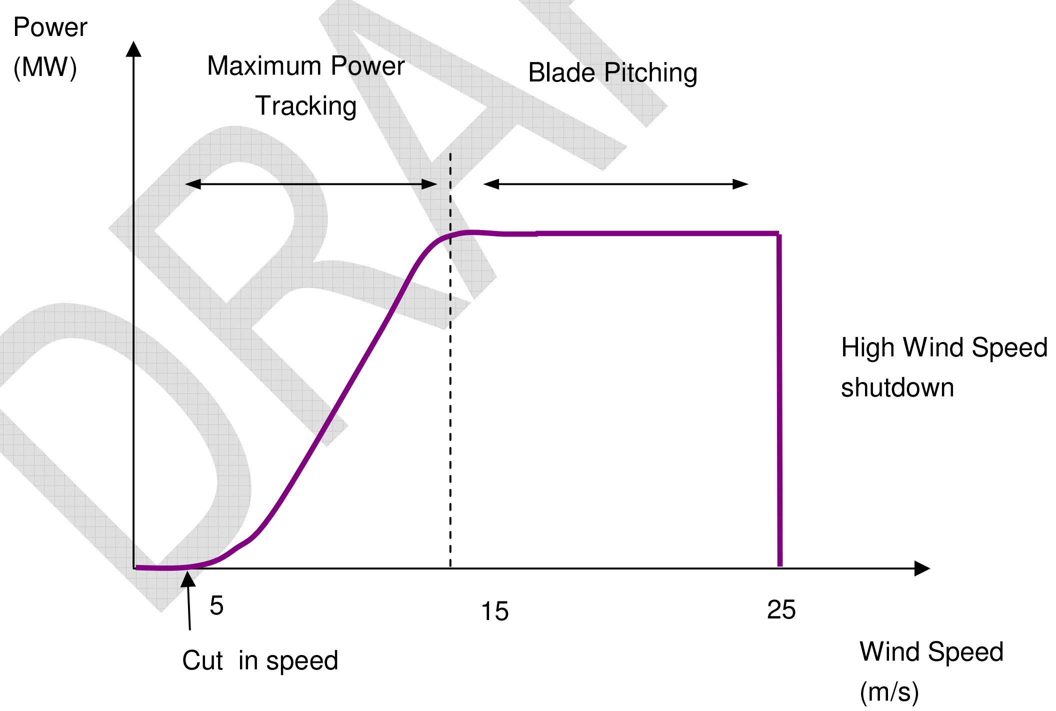
8.2 The mechanical power which can be extracted from a wind turbine is defined by equation (1):-

$$P = 0.5 \rho A C_p(\lambda, \beta) v^3 \qquad (1)$$

Where:- P = The power available from the turbine (Watts)
ρ = The air density (Kg/m^3)
A = swept area (m^2)
Cp = Power Extraction Coefficient which is dependant upon the tip speed ratio (λ) and Blade Pitch (β).
v = Wind Speed (m/s)

More generally, when the term power is plotted against wind speed, the graphical representation results as shown below.

Figure 10: Wind Turbine Power / wind speed curve



8.3 Under Maximum Power Tracking mode the wind turbine is operating at peak output and effectively following equation (1). When the wind speed exceeds its rated value, typically between 11 – 14m/s (depending upon manufacturer and turbine type), blade pitching will be initiated which is required to prevent damage to the turbine structure and generator.

8.4 Since the wind speed across a wind farm site will vary significantly, and knowing that the power output is heavily influenced by the wind speed, the best way of determining the power output from the wind farm is to sum the individual output of each turbine.

8.5 Where there is no curtailment, each turbine will generate an output in proportion to the cube of the wind speed unless the turbine is operating beyond its rated value through operation of the pitching system. Under this mode of operation, the output from the wind farm should be equivalent to the available power from the wind farm.

8.6 Where however a wind farm is operating in a de-loaded mode, for example to provide low frequency response, each turbine will effectively be spilling wind, in which case PN and Power Available will not be the same. The process in which this is achieved and the actual recorded available power when each turbine is de-loaded is more complex to determine, largely as a result of the non linear behaviour of the turbines when they are not operated at peak output. Clearly this becomes an Intellectual Property (IP) issue for the turbine manufactures as there are a number of ways it can be achieved besides the accuracy to which such a signal can be determined.

How should the Power Available signal be calculated?

8.7 The Workgroup considered how the signal should be calculated and whether a formulaic definition should be derived, whether a level of accuracy should be specified or other such method.

8.8 Information provided at the workgroup suggests that most operators already have some form of power available signal or similar that is used for testing frequency response capability and to provide a similar signal to National Grid for operational metering purposes would not be too onerous.

8.9 However, it was noted that where a wind farm was operating to maximise its output (i.e. it was not de-loaded), the Power Available signal could have a small difference to the metered output because of the basis of the Power Available calculation.

8.10 Intellectual property issues were raised with the methods that different manufacturers use to convert raw data into power available. It was noted that these issues can be avoided if data aggregation and conversion into some form of power available signal is done by the wind farm, or at the wind farm control point, rather than by National Grid.

8.11 It was also noted for comparison that the Grid Code defines the PN as ‘Data that describes the **BM Participant’**s best estimate of the expected input or output of **Active Power** of a **BM Unit** and/or (where relevant) Generating Unit, the accuracy of the Physical Notification being commensurate with Good Industry Practice.’

8.12 The Workgroup considered that a similar obligation of best estimate commensurate with good industry practice taking into account prevailing wind speed, direction and number of turbines connected could provide sufficient accuracy without transgressing intellectual property issues or potentially introducing an unnecessary burden on wind farms with accuracy obligations. This later point was of particular concern for some workgroup members who had cited examples of the Irish market requirements on accuracy.

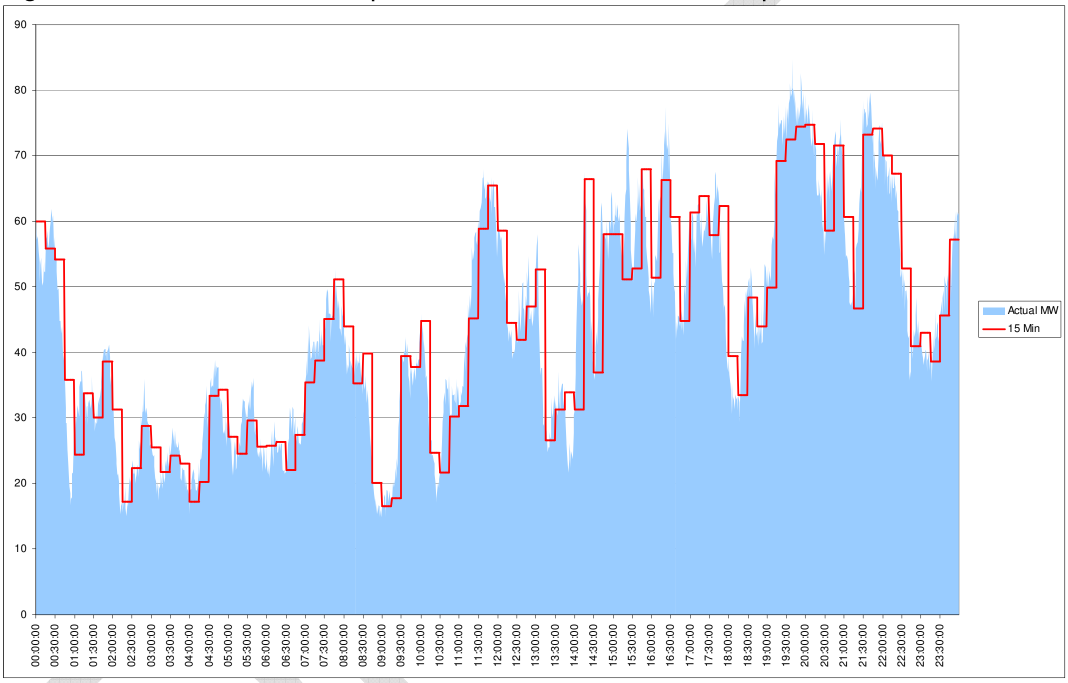
Accuracy required for the provision of data

8.13 The Grid Code defines the PN as *‘Data that describes the **BM Participant’**s best estimate of the expected input or output of **Active Power** of a **BM Unit** and/or (where relevant) Generating Unit, the accuracy of the Physical Notification being commensurate with Good Industry Practice.’* It is envisaged that similar obligations would exist for the provision of a Power Available signal.

How frequently should a signal be provided?

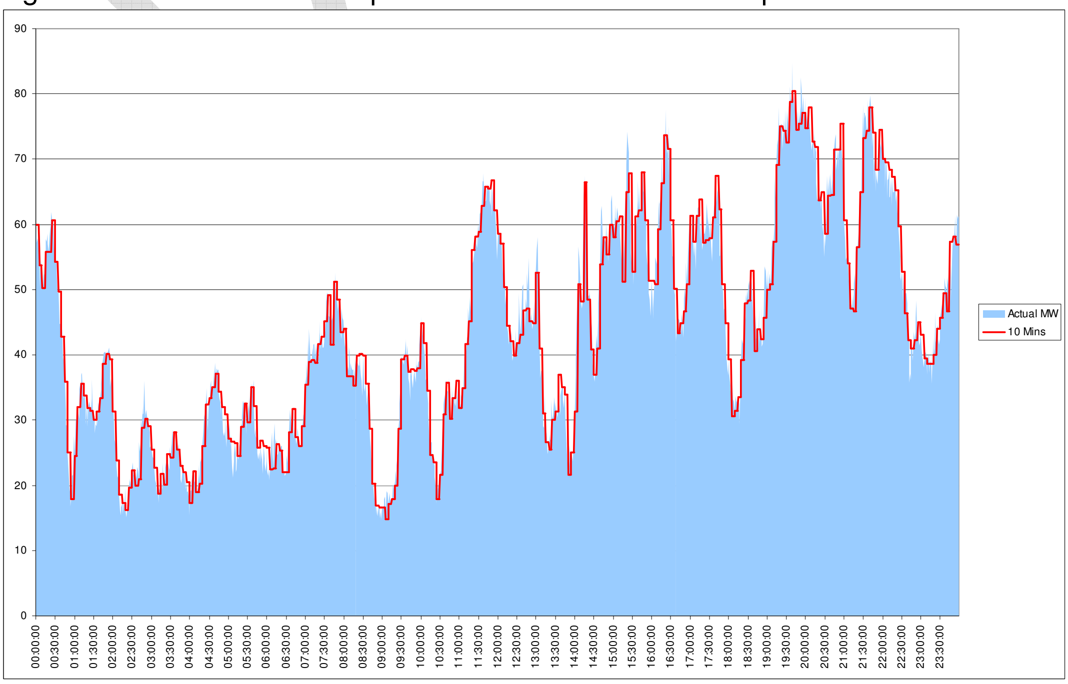
8.14 In assessing the frequency of updates from a potential Power Available signal, the Workgroup noted that it was worth calculating an optimal refresh period. For example, a second by second signal may not provide any additional benefit over a 5 minute signal. As a test of update frequency, actual output, MEL and PN at gate closure from a wind farm BMU, relating to a windy day in February 2013 is plotted below. A possible Dynamic MEL / Power Available signal has been drawn for illustrative purposes only as the value of metered output at the start of the 10 or 15 minute window. It is not intended to suggest that this should form the basis of the calculation of Dynamic MEL or Power Available. These graphs suggest that 10 minutes may be an appropriate refresh period. It was noted that 10 minute data frequencies are typical for SCADA data.

Figure 11: Wind metered output at 15 minute intervals compared with actual



15 Minute Signal

Figure 12: Wind metered output at 10 minute intervals compared with actual



8.15 During the Workgroup discussions, it has been highlighted that a MW Availability figure is required in Ireland to facilitate the market. It was agreed by the Workgroup that NGET's requirement for a dynamic MEL or power available signal would require a different calculation than the one required in Ireland for Settlement purposes. It was also pointed out that not all turbine manufacturers are currently active within the Irish Market.

8.16 Whilst this analysis suggests a 10 to 15 minute interval could achieve a good level of accuracy from a persistency perspective if, for example, the data was provided via the SCADA system, it may be more efficient to provide data at a refresh rate of 5 seconds as currently applied to wind speed and direction.

Power Available under different scenarios

High wind speed shutdown

8.17 It is anticipated that as the power available signal would be calculated by the wind farm, it would take account of data from individual turbines as to whether they were shut down.

Turbine faults

8.18 The turbine is available if is available to produce energy.

Additional items of information which could be of benefit

8.19 The provision of wind speed, direction and MW data on an individual turbine basis could assist National Grid in developing more sophisticated wind power forecasting models, but the workgroup agreed that this was not necessary to address the issues that the Power Available signal sought to address.

Turbine capacity is greater than Transmission Entry Capacity (TEC)

8.20 The Power Available signal should reflect the action of any wind farm active power control excluding BOA action.

9 Impact Assessment

9.1 The Workgroup considered the areas that might be impacted by each of the two options under consideration.

- Code changes
- Wind Farm data management / SCADA configuration
- Impact on current data signals between Generation and System Operator
- Communications
- Operating Procedures
- Dispatch and control systems
- Settlement
- Testing, validation and compliance
- Regulatory Considerations
- Cost of implementation
- Retrospective Application

Option 1 Impact (Standardisation of MEL)

Code changes

9.2 Grid Code BC1.A.1.3.1 will need to be modified to ensure a consistent definition of MEL. The Grid Code will also need to specify which forms of generation this would apply to and when it would become applicable. BC1.4 -Submission of Data would need to be reviewed.

9.3 The text required to give effect to the proposal is contained in Annex 2 of this document.

Wind Farm data management

9.4 A wind farm would need to produce a MEL based on wind speed and other parameters to calculate and submit a profile going forward. This may require a new process to be implemented if parties are not already doing so.

Communications

9.5 No additional communication channels would need to be established as existing arrangements could be used, however the volume and frequency of data may necessitate upgrades to current systems in order to transmit and process the data.

Operating Procedures

9.6 If the MEL data provided is sufficiently robust, the System Operator would be able to enact procedures already established for existing generation with regard to frequency response and calculation of overall reserve.

Dispatch and Control Systems

9.7 If the MEL data provided is sufficiently robust, no changes would be needed to dispatch and control systems. Data received could be used in a similar way to other forms of generation.

Settlement

9.8 No changes would be needed to the settlement systems.

Testing, validation and compliance

9.9 No additional validation is expected although the System Operator would monitor the performance of MEL data.

Regulatory Considerations

9.10 Consideration would need to be given to whether there were sufficient benefits to justify different treatment for particular generators.

Cost of Implementation

9.11 This is yet to be determined but the Workgroup will be seeking information through the proposed consultation on their recommendations.

Option 2 Impact (Standardisation of MEL)

9.12 The workgroup noted that the impacts for option 2 were similar to option 1 however an update frequency of 10 minutes would have a greater impact on wind generator data management and therefore a more significant cost of implementation.

Option 3 Impact (Power Available Signal via SCADA)

Code changes

9.13 Grid Code BC1.A.1.3.1 will need to be modified to ensure a consistent definition of MEL. The Grid Code will also need to specify which forms of generation this would apply to and when it would become applicable. BC1.4. -Submission of Data and CC.6.5.6 – Operational metering also need to be reviewed.

Transmission Licence Condition C16 changes (Procurement Guidelines and Balancing Principles Statement)

9.14 There may also be changes to Licence Condition C16 documents which would need to be reviewed.

Wind Farm data management

9.15 A wind farm would need to produce a MEL based on the turbines available. This will require a new process to be implemented.

9.16 A new Power Available signal would be required from the wind farm to the System Operator. Section 5.27 describes the existing requirement for a Power Available signal to National Grid for compliance testing. Initial investigations suggest that that it is possible to route the signal into the suite of operational signals already provided to National Grid.

Communications

9.17 If existing SCADA systems can be used to convey the Power Available signal, no additional communication links would need to be established, however the SCADA system would need to be amended to accommodate the Power Available signal. Data is currently communicated at 5 second intervals and so the addition of another data item is not thought to be onerous.

Operating Procedures

9.18 The system operator would be able to enact procedures already established for existing generation with regard to frequency response and calculation of overall reserve.

Dispatch and Control Systems

9.19 An additional, intermediate data processing step would need to be introduced to receive the Power Available signal and MEL data and subsequently create a profile that mimicked the MEL profile data received by other generation. This could then be used by existing dispatch and control systems.

Settlement

9.20 No changes would be needed to the settlement systems

Testing, validation and compliance

A testing and compliance process would need to be developed to ensure adherence to the Grid Code. It is anticipated that this could be combined with the current process for testing generator frequency response and reactive capability.

Regulatory Considerations

9.21 Consideration would need to be given to the appropriateness of specific requirements on wind farms or other forms of generation where the primary fuel source cannot be controlled.

Cost of Implementation

9.22 The workgroup recognised that this was likely to be different for parties depending on the systems and processes adopted. The workgroup believed that further information should be sought from the wider community in order to inform this assessment.

10 Implementation Considerations

10.1 The Workgroup considered the aspects of implementation should the proposals be taken forward.

- Retrospective application
- When should new requirements apply from
- Which generation should this apply to?
- Should other renewables be taken into account
- European Network Code implications
- Significant Code Review on Balancing

Retrospective application

10.2 The System Operator noted its preference for the proposed solutions to apply retrospectively so that arrangements for existing and new wind farms were the same however accepted that there were a number of considerations that would need to be taken into account.

10.3 Notwithstanding this, the preference of the majority of the workgroup was that this would not apply retrospectively and that this would need to be justified based on the costs associated with implementation and the benefits that would be achieved.

Retrospective application Option 1 (Consistent MEL)

10.4 It was noted that in order to achieve a consistent MEL from wind farms this would need to apply to both existing and new wind farms and therefore apply retrospectively. The requirement would apply from an agreed date.

Retrospective application Option 2 (Dynamic MEL)

10.5 It was noted that, in order to achieve a Dynamic MEL from wind farms, this would need to apply to both existing and new wind farms and therefore apply retrospectively. However, some distinction could be made between obligations on existing and new generators (e.g. frequency of update)

10.6 It was noted that the implementation of a Dynamic MEL approach was expected to be relatively inexpensive if implemented at the build stage however the costs of retrofitting such a signal would require further analysis. The cost of such a retrofit would have a bearing on whether it was considered appropriate to be applied retrospectively.

Retrospective application of Power Available Signal via SCADA (Option 3)

MEL Data

10.7 The MEL associated with a Power Available signal via SCADA option (option 3) represents the connected capacity applicable and would not need to be updated frequently. This may be implemented easily and therefore it may not be necessary to distinguish between existing and new wind farms as implementation may be low impact and therefore this could be uniformly applied to existing and new wind farms.

Power Available Signal

10.8 It was noted that the implementation of a Power Available signal was expected to be relatively inexpensive if implemented at the build stage however the costs of retrofitting such a signal would require further analysis. The cost of such a retrofit would have a bearing on whether it was considered appropriate to be applied retrospectively.

10.9 If a decision was taken to require a Power Available signal from wind farms and there was a key business need to apply it retrospectively to existing wind farms, then a decision would firstly need to be taken as to which wind farms the requirement applied, what size, and the reason for the requirement. Such a decision would require some further analysis.

10.10 It was noted that the benefits to a wind farm from Power Available may mean that wind farm operators may choose to apply power available to their wind farms in any event.

When should new requirements apply from?

10.11 This will depend on the adopted solution, whether the proposals will apply retrospectively and the consequential time required to implement relevant process and system changes. Further analysis is required however the likely time frame would be 12 to 24 months from any approval date to allow any necessary changes to be implemented.

Which generation should this apply to?

10.12 It is anticipated that the proposals would apply to those generators that Grid Code BC1 and BC2 applies. These generators are currently required to submit MEL data. It was noted by the workgroup that further information should be obtained to understand whether there were particular technology constraints in meeting any new obligations.

Should other renewables be taken into account?

10.13 Whilst the discussions to date have so far concentrated on the requirements from wind generation, consideration also needs to be given as to whether there is a need for a power available signal from other forms of generation.

10.14 For renewable sources of generation powered by an intermittent primary energy source, such as wave, tidal and solar, the workgroup considered that they should be treated in the same way if they meet certain criteria e.g. size (either individually or in aggregation). For other forms of renewable generation such as hydro or cascade hydro and forms of generation with controllable fuel sources such as coal, oil, gas or nuclear the requirement for a Power Available signal is less clear cut, but would need to be supported by their ability to meet their declared PN's, be capable of achieving their declared MELs and demonstrated through past performance.

International practice and approach taken in European Code development

10.15 A presentation was given by a representative from the System Operator for Northern Ireland (SONI) who provided insight into how they manage wind generators through the use of a MW Availability signal. The definition of MW Availability is as follows:

"The amount of Active Power that the Controllable WFPS could produce based on current wind conditions, network conditions and System conditions. The MW Availability shall only differ from the MW Output if the Controllable WFPS has been curtailed, constrained or is operating in a Curtailed Frequency Response mode, as instructed by SONI via the SCADA interface"

10.16 When a Power Park Module is constrained off (output 0MW) in the SONI and EirGrid regions they are considered as available and financial settlement is based on the active power the Power Park Module would have produced.

10.17 In SONI, wind farms are always in Frequency Sensitive Mode and will constantly modulate the active power in response to frequency changes. This can be run in 2 ways: With no curtailment (turbines free running) where high frequency response only is provided; or in MW curtailment mode when SONI will instruct the wind farm to run at a MW curtailment set point between 50% and 100% to provide both high and low frequency response. This is set via an analogue input to the farm.

10.18 In summary the research and discussions held to date indicate that the requirement for a MW availability signal is based on the type of wholesale electricity market and the size of the power system. In GB for example where a forwards market is used (ie Generators and Suppliers strike contracts in advance and the System Operator simply balances the differences in real time – ie self despatch) certain information and data can be achieved through the signals of the wholesale market (ie PN's and MEL).

10.19 On the other hand a number of other markets use the "Pool" type system in which Generation is scheduled at the day ahead stage on the basis of the total system demand and Transmission System Constraints. On this basis the requirements and operational metering signals required for managing wind generation are very different to that of the forwards market described above where trading position can be used to provide an indication of the Available Power.

10.20 The size of the Power System, its interconnection with other nations and the plant mix all has an impact on the ability of an operator to mange wind generation. For example, Denmark was one of the first countries to embrace Wind Generation on a large scale against a comparatively modest demand. Owing to the large number of interconnectors to the wider European System and the large volume of hydro generation in Norway, integration of wind power into the Danish Power System has been possible. If these facilities had not been available, control of system frequency would have been more challenging.

European Network Codes

10.21 As part of the Third Energy Package which became European Law in 2009, a new set of European Network Codes (ENCs) are being written with the intention of helping to meet the 3rd package objectives of enabling single European energy markets for gas and electricity, promoting the connection of renewable energy sources and enhancing security of supply.

10.22 The ENC Requirements for Generators (RfG) was the first network code on electricity developed by ENTSO-E. It is also the first of the connection codes (the others being the Demand Connection and HVDC codes) which together set out the technical requirements upon parties connecting to the transmission and distribution systems. The RfG code is seen as one of the main drivers for creating harmonized solutions and products necessary for an efficient pan-European (and global) market in generator technology. The purpose of the code is to bring forward a set of coherent requirements in order to meet these challenges of the future and to help provide crucial tools for all network operators to plan and operate the system against the background of a rapidly changing energy mix, while delivering security of supply for consumers.

10.23 The draft code was first submitted by ENTSO-E to ACER in June 2012; the subsequent ACER opinion highlighted changes required to achieve greater alignment with the framework guidelines which were addressed by ENTSO-E in their resubmission of the code to ACER in March 2013. On 27 March 2013, ACER issued a recommendation to the European Commission to adopt the Network Code on “Requirements for Generators” (NC RfG).

10.24 The European Commission anticipate taking the code through the process of comitology and writing it into European Law by Q1 2014. The code sets out that it is to apply to all new generators, defined as those which are not connected to the system 2 years after its entry into force (so probably during 2016) and for projects under construction that have at this point also not let contracts for major plant items. All parties will be required to comply with the code by 3 years after its entry into force.

10.25 So far as RfG is concerned, the issue of Power Available is not mentioned however this would not preclude a Power Available signal from being specified at National level as the current draft dated March 2013, Article 9 (4) (d) states “With regard to information exchange: 1) Power Generating Facilities shall be capable of exchanging information between the Power Generating Facility Owner and the Relevant Network Operator and/or the relevant TSO in real time or periodically with time stamping as defined by the Relevant Network Operator and/or the Relevant TSO whilst respecting the provisions of Article 4(3). In addition, the ENTSO-E RfG Code states the Relevant Network Operator in coordination with the Relevant TSO shall define while respecting the provisions of Article 4(3) the contents of information exchanges and the precise list and time of data to be facilitated.

Significant Code Review for Balancing

10.26 The Workgroup noted that a Significant Code Review (SCR) was being carried out by Ofgem in the area of Electricity Balancing. As this Workgroup had discussed issues which may be covered by the SCR such as PN accuracy for settlement, it was worth keeping abreast of such developments. For example, potential charges for information imbalance. However, the Workgroup recognised that the discussions around a Power Available signal should still continue in parallel whilst being mindful of the SCR to avoid any duplication of work.

11 Assessment

Impact on National Electricity Transmission System (NETS)

11.1 The proposed changes will allow the System Operator to more efficiently manage the electricity system by enabling the efficient use of wind farms in balancing the system. Specifically, this will enable efficient management of reserve and frequency response that is not viable with the current data flows.

Impact on Greenhouse Gas emissions

11.2 The proposed modification will facilitate the efficient growth of renewable generation which will reduce greenhouse gas emissions from alternative forms of generation.

Assessment against Grid Code Objectives

11.3 This is covered in section 12.6.

Impact on core industry documents

11.4 The proposed modification does not impact on any core industry documents

Impact on other industry documents

11.5 The proposed modification may have an impact on Mandatory Service Agreements that describe the frequency response capability of BMUs. The capability is determined by calculating the difference between operating point and MEL.

Implementation

11.6 The Workgroup proposes that, should the proposals be taken forward, the proposed changes be implemented {xx} business days after an Authority decision.

12 Impact on the Grid Code

12.1 GC0063 requires amendments to the following parts of the Grid Code:

- Text

12.2 The text required to give effect to the proposal is contained in Annex 1 of this consultation.

Impact on National Electricity Transmission System (NETS)

12.3 The proposed changes will clarify the relationship between PPMs and BMUs meaning that networks can be controlled more effectively via the monitoring and despatch of BMUs.

Impact on Grid Code Users

12.4 The proposed modification will relax the obligation on Users to submit immediate revisions to the PPM Availability Matrix under BC1. Users will have to provide information setting out how PPMs relate to the relevant BMU via the PPM Availability Matrix under BC1 and OC2.

Impact on Greenhouse Gas emissions

12.5 The proposed changes will not have a material impact on Greenhouse Gas emissions but will minimise a risk of unnecessary curtailment under outage conditions.

Assessment against Grid Code Objectives

12.6 National Grid considers that the proposed changes would better facilitate the Grid Code objective:

(i) to permit the development, maintenance and operation of an efficient, coordinated and economical system for the transmission of electricity;

The proposed change improves the information provided to NGET by establishing a clear relationship between Power Park Modules and Balancing Mechanism Units meaning that generation and transmission system operation can be co-ordinated more effectively.

(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);

The proposed change allows information on the configuration of Power Park Modules and their relationship to Balancing Mechanism Units to be conveyed without placing any restrictions on connection design.

(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

The proposed change reduces the volume of information required to be exchanged between generators and NGET but provides for appropriate operational liaison to ensure the transmission system can be operated efficiently safely and securely.

(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 has a neutral impact on this objective

Impact on core industry documents

12.7 The proposed modification does not impact on any core industry documents

Impact on other industry documents

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

Implementation

12.9 National Grid proposes that, should the proposals be approved, the proposed changes be implemented 10 business days after an Authority decision.

13 Workgroup Next Steps

13.1 The Workgroup recommends:

An Industry Consultation is undertaken to ascertain wider views on the findings of this workgroup report and obtain specific information on implementation costs to inform any decisions made.

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nationalgrid

Power Available

TERMS OF REFERENCE

Governance

1. The Workgroup was established by Grid Code Review Panel (GCRP) at the July 2012 GCRP meeting.

2. The Workgroup shall formally report to the GCRP.

Membership

3. The Workgroup shall comprise a suitable and appropriate cross-section of experience and expertise from across the industry, which shall include:

Name	Role	Representing
Michael Edgar	Chair	National Grid
Robyn Jenkins	Technical Secretary	National Grid
Graham Stein	National Grid Representative	National Grid
Tony Johnson	National Grid Representative	National Grid
Steve Lam	National Grid Representative	National Grid
Andrew Kensley	National Grid Representative	National Grid
	Industry Representative	Transmission Users
	Industry Representative	Wind Turbine Manufacturers
	Industry Representative	Wind Industry Experts
	Authority Representative	Ofgem
	Observer	

Meeting Administration

4. The frequency of Workgroup meetings shall be defined as necessary by the Workgroup chair to meet the scope and objectives of the work being undertaken at that time.

5. National Grid will provide technical secretary resource to the Workgroup and handle administrative arrangements such as venue, agenda and minutes.

6. The Workgroup will have a dedicated section on the National Grid website to enable information such as minutes, papers and presentations to be available to a wider audience. The link to the Grid Code Workgroups page is:

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

Scope

7. The Workgroup shall consider and report on the following:

   - Clearly define the defect that Power Available attempts to resolve by:

    - Quantifying the current accuracy of FPNs from intermittent generators
    - Quantifying the volume of energy curtailed from intermittent generators
- Identify how the concept of Power Available can be implemented by:
    - Creating a technical standard to calculate Power Available across different turbine manufacturers
    - Identify the method by which data will be collected
    - Identify the obligations on wind farms to collate data
    - Identify how data will be aggregated and converted into a Power Available signal
    - Assess the accuracy (based on time intervals) required for the provision of such data
    - Identify the technical equipment required
- Examine any required information systems changes
- Quantify the benefits to wind farms that can be gained from Power Available by:
    - Examining the potential volumes of generation that can utilise such a signal for settlement purposes, within both current and future connections
- Review the information that is currently available to wind farm operators and assess the value of this to National Grid as National Electricity Transmission System Operator (NETSO).
    - Take into account any analysis carried out by the high wind speed shutdown Workgroup
- Identify additional items of information which could be of benefit and assess the value of providing these to National Grid as NETSO
    - Take into account any analysis carried out by the high wind speed shutdown Workgroup
- Assess the investment required to implement a minimal Power Available signal versus a highly accurate signal aggregated on a per turbine basis
- Examine how Power Available will operate under different scenarios such as:
    - high wind speed shutdown
    - turbine faults
- Assess whether retrospective application of Power Available will be appropriate
- Assess whether other renewables should be taken into account

8. The Workgroup will also:

- Take account of and feed into the "high wind speed shutdown" work being carried out under a Grid Code Workgroup

- Take account of the work in C/11 – BM Unit data from Intermittent Generation. This proposed a concept of calculating a generator's Maximum Export Limit (MEL) based on predicted/actual wind speed

- Take account of relevant international practice and the approach taken in European Code development.

Deliverables

9. The Workgroup will provide updates and a Workgroup Report to the Grid Code Review Panel which will:

   - Detail the findings of the Workgroup;

   - Draft, prioritise and recommend changes to the Grid Code and associated documents in order to implement the findings of the Workgroup; and

   - Highlight any consequential changes which are or may be required,

   - Provide a recommendation on how to progress the solution(s)

Timescales

10. It is anticipated that this Workgroup will provide an update to each GCRP meeting and present a Workgroup Report to the January 2013 GCRP meeting.

11. If for any reason the Workgroup is in existence for more than one year, there is a responsibility for the Workgroup to produce a yearly update report, including but not limited to; current progress, reasons for any delays, next steps and likely conclusion dates.

Annex 2 - Proposed Legal Text

This section contains the proposed legal text to give effect to the Workgroup proposed three options. The proposed new text is in red and is based on Grid Code Issue X Revision XX.

Option 1– Legal Text
PA via Standardised MEL – Option 1

Glossary and Definitions

Power Available	A value in accordance with good industry practice, recorded in real time, representing the sum of the potential **Active Power** available from each individual **Power Park Unit** within the **Power Park Module** calculated using any applicable combination of meteorological (including wind speed), electrical or mechanical data measured at each **Power Park Unit**. The **Power Available** shall be a value of between 0MW and **Registered Capacity** which is the sum of the potential **Active Power** available of each **Power Park Unit** within the **Power Park Module.** A turbine that is not generating will be considered as not available.

Balancing Codes

BC1.A.1.3.1 Maximum Export Limit (MEL)

A series of MW figures and associated times, making up a profile of the maximum level at which the **BM Unit** may be exporting (in MW - taking all **Plant** and weather related conditions into account) to the **National Electricity Transmission System** at the **Grid Entry Point** or **Grid Supply Point**, as appropriate.

For a **Power Park Module** such as a wind farm, the Maximum Export Limit should reflect the maximum **Active Power** output from each **Power Park Module** based on a profile derived from **Power Available**. The availability of any **Power Park Unit** within a **Power Park Module** shall be declared by the **Generator** under BC1.A.1.8.

Option 2– Legal Text
PA via Dynamic MEL – Option 2

Glossary and Definitions

Power Available — A value in accordance with good industry practice, recorded in real time, representing the sum of the potential **Active Power** available from each individual **Power Park Unit** within the **Power Park Module** calculated using any applicable combination of meteorological (including wind speed), electrical or mechanical data measured at each **Power Park Unit**. The **Power Available** shall be a value of between 0MW and **Registered Capacity** which is the sum of the potential **Active Power** available of each **Power Park Unit** within the **Power Park Module.** A turbine that is not generating will be considered as not available.

Balancing Codes

BC1.A.1.3.1 Maximum Export Limit (MEL)

A series of MW figures and associated times, making up a profile of the maximum level at which the **BM Unit** may be exporting (in MW - taking all **Plant** and weather related conditions into account) to the **National Electricity Transmission System** at the **Grid Entry Point** or **Grid Supply Point**, as appropriate.

For a **Power Park Module** such as a wind farm, the Maximum Export Limit should reflect the maximum **Active Power** output from each **Power Park Module** based on a profile derived from **Power Available** which is updated at 10 minute time intervals. The availability of any **Power Park Unit** within a **Power Park Module** shall be declared by the **Generator** under BC1.A.1.8.

Option 3– Legal Text

PA via Standardised MEL – Option 3

SCADA Data

Glossary and Definitions

Power Available	A value in accordance with good industry practice, recorded in real time, representing the sum of the potential **Active Power** available from each individual **Power Park Unit** within the **Power Park Module** calculated using any applicable combination of meteorological (including wind speed), electrical or mechanical data measured at each **Power Park Unit**. The **Power Available** shall be a value of between 0MW and **Registered Capacity** which is the sum of the potential **Active Power** available of each **Power Park Unit** within the **Power Park Module.** A turbine that is not generating will be considered as not available.
Headroom	The **Power Available** (in MW) less the actual **Active Power** exported from the **Power Park Module** (in MW).

Connection Conditions

CC.6.5.6 Operational Metering

CC.6.5.6 (d) In the case of a **Power Park Module** ~~an~~ additional energy input signals (e.g. wind speed, wind direction and **Power Available**) may be specified in the **Bilateral Agreement**. The signals would ~~may~~ be used to establish the potential level of energy input from the **Intermittent Power Source** for monitoring pursuant to CC.6.6.1 and **Ancillary Services** and will, in the case of a wind farm, be used to provide **NGET** with advanced warning of excess wind speed shutdown and to determine the level of **Headroom** available from **Power Park Modules** operating in **Frequency Sensitive Mode** for the purposes of calculating overall **System** response and reserve. For the avoidance of doubt, a **Power Available** signal would represent the sum of the potential output of all available and operational **Power Park Units** in the **Power Park Module** and will be provided automatically to the **Power Park Module** control system. The refresh rate of the **Power Available** signal being specified in the **Bilateral Agreement.**

Balancing Codes

BC1.A.1.3.1 Maximum Export Limit (MEL)

A series of MW figures and associated times, making up a profile of the maximum level at which the **BM Unit** may be exporting (in MW - taking all **Plant** and weather related conditions into account) to the **National Electricity Transmission System** at the **Grid Entry Point** or **Grid Supply Point**, as appropriate.

For a **Power Park Module** such as a wind farm, the Maximum Export Limit should reflect the maximum possible **Active Power** output from each **Power Park Module** based only on the data submitted within the **Power Park Module Availability Matrix** as defined under BC.1.A.1.8 and not the **Power Available** which would include the weather corrected MW output from each **Power Park Unit.** For the avoidance of doubt, in the case of a **Power Park Module** this would equate to the **Registered Capacity** less the unavailable **Power Park Units** within the **Power Park Module.**

Extract from Bilateral Agreement

Appendix F5 - Schedule 2

Site Specific Technical Conditions - Operational Metering (CC.6.5.6)

Description	Units	Type	Provided by	Notes
MW and MVAr for each Balancing Mechanism Unit and Station Supplies derived from Boundary Point Settlement Metering System	MW MVAr	Signals to have 0.5 second update rate or better and provide input to the Ancillary Services Monitoring equipment	User.	The functionality, performance, availability, accuracy, dependability, security, delivery point, protocol and repair times of the equipment generating and supplying the signals (ie the meters and communication links) shall be agreed with The Company at least 12 months before the Completion Date. User to provide Single Line Diagram showing location of CT/VT equipment and nomenclature of HV Apparatus. The Company will use this information to notify the User of which HV circuit breaker and disconnector positions (ie status indications) are required. The nomenclature of Users equipment should be in accordance with OC11 of the Grid Code.
Voltage for each generator bay connection to The Company [XXXX] kV substation.	kV	Signals to have 0.5 second update rate or better	User. Note the User shall also make this signal available at its own Control Point for responding to Voltage Control Instructions from The Company	
Frequency	Hz	Signals to have 0.5 second update rate or better and provide input to the Ancillary Services Monitoring equipment	User	
Generator circuit HV circuit breaker(s) and disconnector(s) as agreed with The Company	Open / Closed Indication	Status Indication	User.	
Each User transformer Tap Position Indication (TPI) at the Grid Entry Point	TPI	Tap Position Indication	User.	
Representative wind speed and direction of each Power Park Module	m/s Degrees from North in a clockwise direction	Signals to have a 5 second update rate or better	User.	
Power Available	MW	Signals to have [5 second] update rate or better	User	Power Available is defined in the Grid Code and is used by The Company to determine the Headroom available for the purposes of calculating Frequency response volumes and net System reserve. An accuracy of X% (to be determined with manufacturers) would be deemed sufficient for this purpose.

Annex 3 – Communication methods

Electronic Data Transfer (EDT)

CC.6.5.8 (a) of the Grid Code places an obligation on BM Participants to ensure appropriate electronic data communication facilities are in place to permit the submission of data required by the Grid Code to NGET for use in the Balancing Mechanism. The principle method by which this is achieved is through Electronic Data Transfer (EDT) which is specified in the Bilateral Connection Agreement and enables key settlement data to be submitted such as PN's and BOA's. For full details of EDT, additional information can be obtained from National Grid's website which is available at:-

http://www.nationalgrid.com/uk/Electricity/Codes/gridcode/ges/ewelecstandards/

Electronic Data Logging (EDL)

CC.6.5.8 (b) of the Grid Code places an obligation on i) any User who intends to participate in the Balancing Mechanism or ii) any BM Participant who is required to provide all part 1 Ancillary Services specified in CC.8.1 of the Grid Code to have appropriate automatic logging devices installed at the Control Point of its BM Units to submit and receive instructions from NGET as required by the Grid Code. The principle method by which this is achieved is through Electronic Data Logging (EDL) which is specified in the Bilateral Connection Agreement and enables instructions to be issued from NGET to the Generator, for example BOA's or Ancillary Services Instructions. Equally the User will need to respond to instructions from NGET in addition to submitting dynamic parameters such as run up / run down rates or Maximum Import Limits (MIL) or Maximum Export Limits (MEL). For full details of EDL, additional information can be obtained from National Grid's website which is available at:-

http://www.nationalgrid.com/uk/Electricity/Codes/gridcode/ges/ewelecstandards/

Supervisory Control and Data Acquisition (SCADA)

Supervisory Control and Data Acquisition (SCADA) is the principle way in which NGET receives operational metering data at its control centre for the purposes of operating the Transmission System in real time. In general, User's of the Transmission System will need to provide operational metering signals (in respect of their plant) in accordance with the terms of the Bilateral Agreement. For a wind farm this would include data such as MW's, MVAr's, voltage, tap position, wind speed and wind direction. These signals will then interface to the nearest Transmission substation from where the Transmission Owner will provide the SCADA outstation interface equipment. These operational metering signals, together with additional transmission system data signals are then routed back to the National Electricity Control Centre.

Operational Metering Schedule

Appendix F5 - Schedule 2

Site Specific Technical Conditions - Operational Metering (CC.6.5.6)

Description	Units	Type	Provided by	Notes
MW and MVAr for each Balancing Mechanism Unit and Station Supplies derived from Boundary Point Settlement Metering System	MW MVAr	Signals to have 0.5 second update rate or better and provide input to the Ancillary Services Monitoring equipment	User.	The functionality, performance, availability, accuracy, dependability, security, delivery point, protocol and repair times of the equipment generating and supplying the signals (ie the meters and communication links) shall be agreed with The Company at least 12 months before the Completion Date. User to provide Single Line Diagram showing location of CT/VT equipment and nomenclature of HV Apparatus. The Company will use this information to notify the User of which HV circuit breaker and disconnector positions (ie status indications) are required. The nomenclature of Users equipment should be in accordance with OC11 of the Grid Code.
Voltage for each generator bay connection to The Company [XXXX] kV substation.	kV	Signals to have 0.5 second update rate or better	User. Note the User shall also make this signal available at its own Control Point for responding to Voltage Control Instructions from The Company	
Frequency	Hz	Signals to have 0.5 second update rate or better and provide input to the Ancillary Services Monitoring equipment	User	
Generator circuit HV circuit breaker(s) and disconnector(s) as agreed with The Company	Open / Closed Indication	Status Indication	User.	
Each User transformer Tap Position Indication (TPI) at the Grid Entry Point	TPI	Tap Position Indication	User.	
Representative wind speed and direction of each Power Park Module	m/s Degrees from North in a clockwise direction	Signals to have a 5 second update rate or better	User.	

Note: For the avoidance of doubt the term ‘Boundary Point Metering System’ is that as defined in the Balancing and Settlement Code. In the event that any part of the User’s Operational Metering equipment, including the communications links to The Company’s [XXXX]kV substation fails, then the User will be required to repair such equipment within 5 working days of notification of the fault from The Company unless otherwise agreed. The User shall also provide facilities to allow The Company to monitor the health of the Operational Metering equipment up to the Grid Entry Point.