Wind Farm Transmission Grid Code Provisions

A Direction by the Commission for Energy Regulation

1st July 2004
CER/04/237

Introduction

Section 33 of the Electricity Regulation Act 1999 provides for the preparation of a Grid Code by the Transmission System Operator (TSO) in relation to the transmission system subject to the approval of the Commission for Energy Regulation.

Section 33 provides that the Commission may give directions from time to time on the content, review and revision of the Grid Code. This decision sets out one such direction relating to wind generation and the Grid Code. The direction is addressed to ESB National Grid in its capacity as TSO.

Background

Wind Farm developers have expressed difficulty in complying with certain aspects of the current Grid Code (Version 1.1) and have to date sought derogations under CG8.1 from the clauses in the Grid Code where, in their opinion, compliance is not achievable.

In January 2003, CER requested ESB National Grid, as the Transmission System Operator (TSO), to outline a process to modify the Grid Code to deal with the compliance problems of wind farms.

ESB National Grid subsequently established a Consultation Group under the auspices of the Grid Code Review Panel (GCRP). Within this forum the ESB NG's proposed Grid Code for Wind was discussed. The Group consisted of the following members:

- ESB National Grid
- Commission for Energy Regulation (CER)
- ESB Networks
- Irish Wind Energy Association (IWEA)
- Sustainable Energy Ireland (SEI)
- Vestas
- General Electric (GE)
- ESB PG as Conventional Generator Representative
- System Operator Northern Ireland (SONI)

The Group met for the first time in October 2003 and a proposed new Grid Code for Wind was to be sent to the Commission by October 2004.

In light of the moratorium on issuing connection offers to wind farms the Commission requested that the work of the Group be accelerated. The new Grid Code for Wind was seen to be one of the key components of the Commission's decision on the moratorium. A revised date of 9th April 2004 was agreed by which time the Commission would receive ESB National Grid's proposed new Grid Code.

On the 13th April 2003 the Commission published for public consultation ESBNG's proposed operating code entitled 'Wind Farm Grid Code Provisions' (WF1). This operating code, once approved, would be inserted into the existing Grid Code.

Proposed Grid Code Provisions

The following topics were considered by ESB National Grid, the Grid Code Consultation Group and the Grid Code Review Panel[1] (GCRP) and formed the basis for the proposed operating code, WF1:

- Fault Ride Through (WF1.4)
- Frequency (WF1.5)
- Voltage (WF1.6)
- Signals. Communications, Dispatch and Control (WF1.7)
- Minimum Size (WF1.3)

Submissions from Interested Parties

Submissions were received from 12 parties.

The Commission has considered the responses it received. The Commission has received independent technical advice on the points raised.

It has also discussed the issues raised by parties with ESBNG. On this basis some issues within the wind transmission grid code section have been redrafted or amended.

Please refer to Appendix 1 for the final version of the wind farm transmission grid code section.

Application of new Grid Code Section for Wind

The Grid Code applies to all parties connected or in the process of connecting to the system irrespective of what version and what changes have been made.

The Commission recognises that the Grid Code is an evolving document and is subject to ongoing approved modifications. It applies in its most up-to-date form to all transmission connected generators. All connection agreements made with the ESBNG as Transmission System Operator are on the basis that the Grid Code is subject to amendment. The Commission also appreciates the TSO's requirement for all generators connected to the transmission system to comply with the Grid Code.

[1] To see GCRP Meeting Minutes visit: http://www.eirgrid.com/EirGridPortal/uploads/Regulation%20and%20Pricing/GCRP%20Minutes%207-4-04.pdf

Therefore all parties connected to the system or about to connect to the system shall comply with the provisions set out in the revised Grid Code.

That said, the Commission notes that a party connecting or connected to the transmission system may apply for derogation from aspects of the Grid Code under Section GC.8 on the basis that as per the conditions set out in Section GC.8 it would be unreasonable to remedy non-compliance. This could be the case, for example, where a party has been connected for some while and where compliance with a new provision would require major investment which could not reasonably have been anticipated at the time of connection.

Commission's Direction

The Commission hereby approves the new wind farm transmission grid code as set out in Appendix 1 and deems it effective as of today's date.

The Commission directs ESBNG to incorporate WF1 into the Grid Code and implement the provisions with immediate effect for all transmission connected generation.

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Tom Reeves
Commissioner

1st July 2004

Appendix 1

WF1 WIND FARM GRID CODE PROVISIONS

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1.1 WF1.1 INTRODUCTION

All **Generator**s connecting to the **Transmission System** are required to comply with the **Grid Code**. The **Grid Code** was originally developed with synchronous generators in mind. Since **Wind Turbine Generators** (**WTG)** do not have the same characteristics as synchronous generators, it was considered appropriate to develop a new set of **Grid Code** provisions specifically for **Wind Farms**. This section of the **Grid Code** gives the specific requirements for **Wind Farms**.

1.2 WF1.2 OBJECTIVE

The primary objective of WF1 is to establish the technical rules which **Wind Farms** must comply with in relation to their connection to and operation on the **Transmission System**.

1.3

1.4 WF1.3 SCOPE

WF1.3.1 WF1 applies to the following **Users**:

(a) The **TSO**; and

(b) **Grid Connected Wind Farms**.

WF1.3.2 In addition to WF1, **Wind Farms** are required to comply with the following sections of the **Grid Code**:

- GC - General Conditions
- PC - Planning Code
- PCA – Planning Code Appendix
- CC- Connection Conditions excluding:
  - *CC 7.2.5.1*
  - *CC 7.2.5.2*
  - *CC7.3.1.1(a) to (h) and (j) to (u)*
  - *CC7.3.1.2*
  - *CC7.3.5*
  - *CC7.3.6*
  - *CC7.3.7*
  - *CC7.3.8*

- *CC.12.2*
- *CC.12.3*

- OC1
- OC2
- OC4 excluding:
  - *OC4.3.4*
  - *OC4.4.5.3*
  - *OC4.4.5.4*
  - *OC4.4.5.5*
- OC6
- OC7 excluding
  - *OC7.2.4.2*
- OC8
- OC9
- OC10 excluding
  - *OC10.5.7*
  - *OC10.7.1*
  - *OC10.7.2*
  - *OC10.7.3*
  - *OC10.7.4*
  - *OC10.7.6*
- OC11

In the **Grid Code**, where applicable, for the purposes of **Wind Farms** references to **Generation Unit** or **Generator** should be interpreted to mean **Wind Farm**.

1.5 WF1.4 FAULT RIDE THROUGH REQUIREMENTS

WF1.4.1 A **Wind Farm** shall remain connected to the **Transmission System** for **Transmission System Voltage** dips on any or all phases, where the **Transmission System Voltage** measured at the HV terminals of the **Grid Connected Transformer** remains above the heavy black line in *Figure WF1.1*.

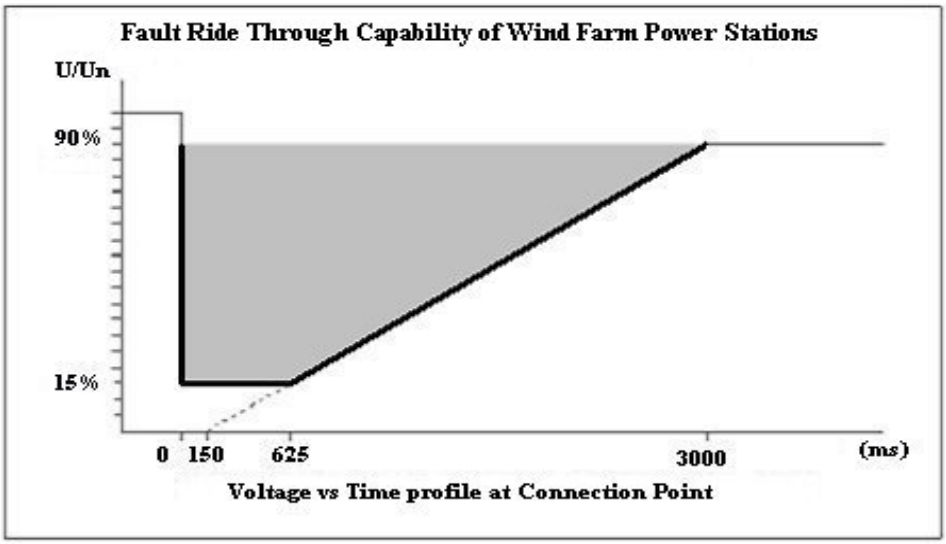


*Figure WF1.1 - Fault Ride-Through Capability of **Wind Farms***

WF1.4.2 In addition to remaining connected to the **Transmission System**, the **Wind Farm** shall have the technical capability to provide the following functions:

a) During the **Transmission System Voltage** dip the **Wind Farm** shall provide **Active Power** in proportion to retained **Voltage** and maximise reactive current to the **Transmission System** without exceeding **WTG** limits. The maximisation of reactive current shall continue for at least 600 ms or until the **Transmission System Voltage** recovers to within the normal operational range of the **Transmission System** (ref. WF1.6.1), whichever is the sooner;

b) The **Wind Farm** shall provide at least 90 % of its maximum **Available Active Power** as quickly as the technology allows and in any event within 1 second of the **Transmission System Voltage** recovering to the normal operating range (ref. WF1.6.1).

WF1.5.1 TRANSMISSION SYSTEM FREQUENCY RANGES

Wind Farms shall have the capability to:

a) operate continuously at normal rated output at **Transmission System Frequencies** in the range 49.5 Hz to 50.5 Hz;

b) remain connected to the **Transmission System** at **Transmission System Frequencies** within the range 47.5 Hz to 52.0 Hz for a duration of 60 minutes;

c) remain connected to the **Transmission System** at **Transmission System Frequencies** within the range 47.0 Hz to 47.5 Hz for a duration of 20 seconds required each time the **Transmission System Frequency** is below 47.5 Hz;

d) remain connected to the **Transmission System** during rate of change of **Transmission System Frequency** of values up to and including 0.5 Hz per second.

No additional **WTG** shall be started while the **Transmission System Frequency** is above 50.2 Hz.

1.5.1 WF1.5.2 FREQUENCY RESPONSE

A **Frequency Response System** shall be installed by the **Wind Farm** to allow for the provision of **Frequency Response** from the **Wind Farm**. The **Frequency Response System** shall provide the functionality as specified in this section WF1.5.2.

WF1.5.2.1 MW Curtailment

The **Wind Farm** shall be capable of operating each **WTG** at a reduced level if the **Wind Farm's Active Power** output has been curtailed by the **TSO** for system security reasons. The **Wind Farm** shall be capable of receiving an on-line **MW Curtailment Set-point** sent by the **TSO** and acting accordingly. For system security reasons it may also be necessary for the **TSO** to constrain off the **Wind Farm**.

WF1.5.2.2 Power-Frequency Response Curve

WF1.5.2.2.1 The **Frequency Response System** shall have the capabilities as displayed in the *Power-Frequency Response Curve* in *Figure WF1.2*.

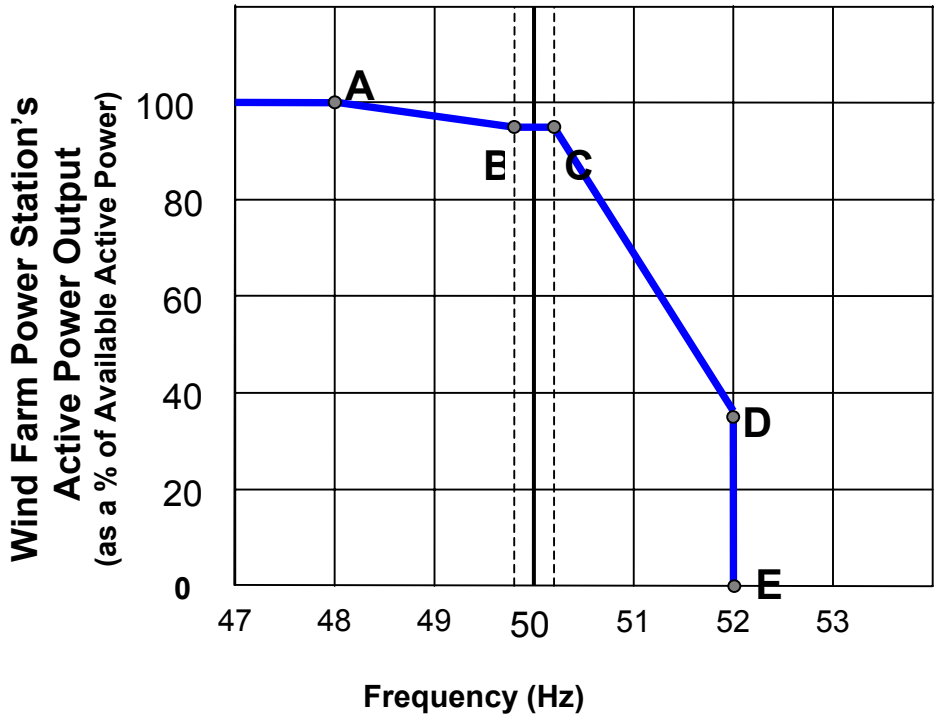


Figure WF1.2 - Power-Frequency Response Curve

WF1.5.2.2.2 Under normal **Transmission System Frequency** ranges, the **Wind Farm** shall operate with an **Active Power** output as set by the line 'B' - 'C'. If the **Transmission System Frequency** falls below point 'B', then the **Frequency Response System** shall act to ramp up the **Wind Farm's Active Power** output, in accordance with the **Frequency/Active Power** characteristic defined by the line 'B'-'A'.

WF1.5.2.2.3 Where the **Transmission System Frequency** is below the normal range and is recovering back towards the normal range, the **Frequency Response System** shall act to ramp down the **Wind Farm Power Station's Active Power** output in accordance with the **Frequency/Active Power** characteristic defined by the line 'A'-'B'.

WF1.5.2.2.4 A **Frequency** dead-band shall be applied between the **Transmission System Frequencies** corresponding to points 'B' and 'C', where no change in the **Wind Farm's Active Power** output shall be required.

WF1.5.2.2.5 Once the **Transmission System Frequency** rises to a level above point 'C', the **Frequency Response System** shall act to ramp down the **Wind Farm's Active Power** output in accordance with the **Frequency/Active Power** characteristic defined by the line 'C'-'D'-'E'. At **Transmission System Frequencies** greater than or equal to 'D'-'E', there shall be no **Active Power** output from the **Wind Farm**.

WF1.5.2.2.6 Points 'A', 'B', 'C', 'D' and 'E' shall depend on a combination of the **Transmission System Frequency**, **Active Power** and **MW Curtailment** set-point settings. These settings may be different for each **Wind Farm** depending on system conditions and **Wind Farm** location. These settings are defined in *Table WF1.1* below.

Poin	***Transmission System Frequency*** *(Hz)*	***Wind Farm Power Station Active Power*** *Output* *(% of **Available Active Power**)*
A	F_A	P_A
B	F_B	Minimum of : P_B or **MW Curtailment Set-point** (converted to a % of **Available Active Power**)
C	F_C	Minimum of: P_C or **MW Curtailment Set-point** (converted to a % of **Available Active Power**)
D	F_D	Minimum of: P_D **or** **MW Curtailment Set-point** (converted to a % of **Available Active Power**)
E	F_E	P_E = 0 %

Table WF1.1: ***Transmission System Frequency*** *and %* ***Available Active Power*** *Settings for the Points 'A', 'B', 'C', 'D' and 'E' illustrated in Figure WF1.2*

Two settings for each of F_A, F_B, F_C, F_D, F_E, P_A, P_B, P_C, P_D and P_E shall be specified by the **TSO** at least 60 business days prior to the **Wind Farm's** scheduled **Operational Date** (refer to 1.5.2.3 below). The **Wind Farm** shall be responsible for implementing the appropriate settings during **Commissioning**. Alterations to the **MW Curtailment Set-point** may be requested in real-time by the **TSO** and these alterations shall be implemented by the **Wind Farm** within one minute of receipt of the appropriate signal from the **TSO**.

WF1.5.2.2.7 The table below, *Table WF1.2,* shows the **Transmission System Frequency** and **Active Power** ranges for F_A, F_B, F_C, F_D, F_E, P_A, P_B, P_C, P_D and P_E.

	Transmission System Frequency *(Hz)*		***Available Active Power*** *(%)*	
			MEC > 10	***5 MW < MEC ≤ 10 MW***
F_A	*47.0-51.0*	P_A	*50-100*	*100*
F_B	*49.5-51.0*	P_B	*50-100*	*100*
F_C	*49.5-51.0*	P_C		
F_D	*50.5-52.0*	P_D	*20-100*	*20-100*
F_E		P_E	*0*	*0*

Table WF1.2: ***Transmission System Frequency*** *&* ***Active Power*** *ranges appropriate to Figure WF1.2.*

For the **Transmission System Frequency** values in *Table WF1.2* above, $F_A \leq F_B \leq F_C \leq F_D = F_E$.

WF1.5.2.2.8 Alterations to the **Wind Farm's Active Power** output, triggered by **Transmission System Frequency** changes, shall be achieved by

proportionately altering the **Active Power** output of all available **WTG**s as opposed to switching individual **WTG**s on or off, insofar as possible.

WF1.5.2.2.9 No time delay other than those necessarily inherent in the design of the **Frequency Response System** shall be introduced. The response rate of each available online **WTG** shall be a minimum of 1 % of **WTG** rated capacity per second (MW/second). The **Frequency Response System** shall continuously monitor the **Transmission System Frequency** in order to continuously determine the **Wind Farm's** appropriate **Active Power** output by taking account of the **Wind Farm's Available Active Power** or **Curtailed Active Power**.

WF1.5.2.2.10 If the **Transmission System Frequency** rises to a level above 'D'-'E', as defined by the *Power-Frequency Response Curve in Figure WF1.2*, the **TSO** accepts that **WTG**s may disconnect. Any **WTG** which has disconnected shall be brought back on load as fast as technically feasible (provided the **Transmission System Frequency** has fallen below 50.2 Hz).

WF1.5.2.3 **Procedure for Setting and Changing the *Power-Frequency Response Curves***

Two *Power-Frequency Response Curves* (Curve 1 and Curve 2) shall be specified by the **TSO** at least 60 business days prior to the **Wind Farm's** scheduled **Operational Date.** The **Wind Farm** shall be responsible for implementing the appropriate settings during **Commissioning**. The **Frequency Response System** shall be required to change between the two curves within one minute from receipt of the appropriate signal from the **TSO**. The **TSO** shall give the **Wind Farm** a minimum of 2 weeks notice if changes to either of the curve's parameters ***(i.e.*** F_A, F_B, F_C, F_D, F_E, P_A, P_B, P_C, P_D or P_E***)***, are required. The **Wind Farm** shall formally confirm that any requested changes have been implemented within two weeks of receiving the **TSO's** formal request.

1.5.2 WF1.5.3 RAMP RATES

WF1.5.3.1 The **Wind Farm** shall be capable of controlling the ramp rate of its **Active Power** output with a maximum MW per minute ramp rate set by the **TSO**. There shall be two maximum ramp rate settings. The first ramp rate setting shall apply to the MW ramp rate average over one (1) minute. The second ramp rate setting shall apply to the MW per minute ramp rate average over ten (10) minutes. These ramp rate settings shall be applicable for all ranges of operation including start up, normal operation and shut down. The **TSO** acknowledges that falling wind speed or **Frequency Response** may cause either of the maximum ramp rate settings to be exceeded.

WF1.5.3.2 It shall be possible to vary each of these two maximum ramp rate settings independently over a range between 1 and 30 MW per minute. The **Wind Farm** shall have the capability to set the ramp rate in MW per minute averaged over both one and ten minutes.

WF1.5.3.3 **Procedure for Setting and Changing the Ramp Rate Limitations**

The ramp rate settings shall be specified by the **TSO** at least 60 business days prior to the **Wind Farm's** scheduled **Operational Date.**

The **Wind Farm** shall be responsible for implementing the appropriate settings during **Commissioning.** The ramp rate settings may need to be changed from time to time depending on system needs. The **TSO** shall give the **Wind Farm** a minimum of two weeks notice if a change is required. The **Wind Farm** shall formally confirm that any requested changes have been implemented within two weeks of receiving the **TSO's** formal request.

1.6 WF1.6 TRANSMISSION SYSTEM VOLTAGE REQUIREMENTS

WF1.6.1 TRANSMISSION SYSTEM VOLTAGE RANGE

Wind Farms shall remain continuously connected to the **Transmission System** at maximum **Available Active Power** or **Curtailed Active Power** output for normal and disturbed system conditions and for step changes in **Transmission System Voltage** of up to 10 %. The following are the ranges which may arise during **Transmission System** disturbances or following transmission faults:

(a) 400 kV system: 350 kV to 420 kV;
(b) 220 kV system: 200 kV to 245 kV;
(c) 110 kV system: 99 kV to 123 kV.

WF1.6.2 AUTOMATIC VOLTAGE REGULATION

WF1.6.2.1 **Wind Farms** shall have a continuously-variable and continuously-acting **Voltage Regulation System** with similar response characteristics to a conventional **Automatic Voltage Regulator** and shall perform generally as described in BS4999 part 140, or equivalent European Standards.

WF1.6.2.2 The **Voltage Regulation System** shall be capable of receiving a **Voltage** set-point for the **Voltage** at the **Connection Point**. The **Voltage Regulation System** shall act to regulate the **Voltage** at this point by continuous modulation of the **Wind Farm's Reactive Power** output, within its **Reactive Power** range and without violating the **Voltage Step Emissions** limits as set out in the IEC standard 61000-3-7:1996 *Assessment of Emission limits for fluctuating loads in MV and HV power systems*. A change to the **Voltage** set-point shall be implemented by the **Wind Farm** within one minute of receipt of the appropriate signal from the **TSO**.

WF1.6.2.3 The slope setting of the **Voltage Regulation System** shall be capable of being set to any value between 0 % and 10 %. The setting shall be specified by the **TSO** at least 60 business days prior to the **Wind Farm's** scheduled **Operational Date.** The **Wind Farm** shall be

responsible for implementing the appropriate settings during **Commissioning**. The slope setting may be varied from time to time depending on **Transmission System** needs. The **TSO** shall give the **Wind Farm** a minimum of two weeks notice if a change is required. The **Wind Farm** shall formally confirm that any requested changes have been implemented within two weeks of receiving the **TSO's** formal request.

WF1.6.2.4 The speed of response of the **Voltage Regulation System** shall be such that, following a step change in **Voltage** at the **Connection Point** the **Wind Farm** shall achieve 90 % of its steady-state **Reactive Power** response within 1 second.

WF1.6.2.5 *Figure WF1.3* shows the relevant points appropriate to the **Voltage Regulation System** for a **Wind Farm**. *X* is the high-voltage (HV) side of the **WTG** transformer, *Y* is the low-voltage (LV) side of the **Grid Connected Transformer** and *Z* is the **Connection Point**.

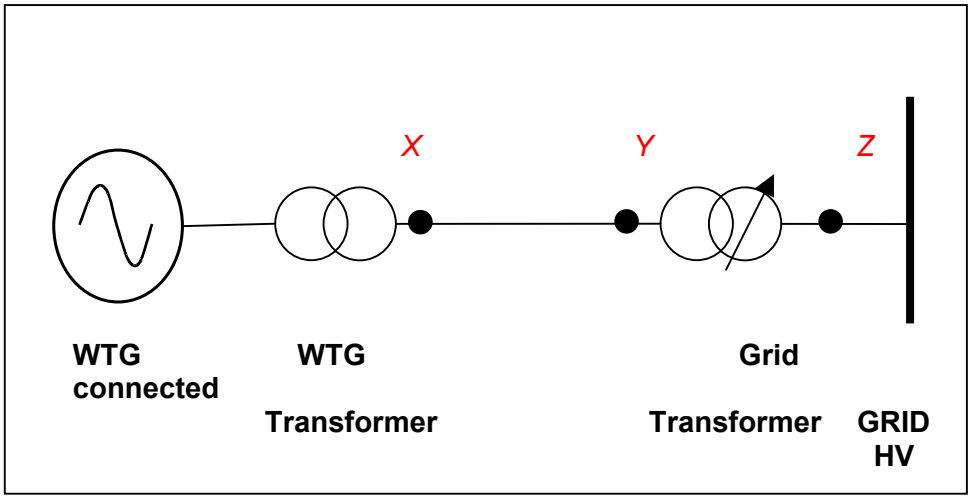
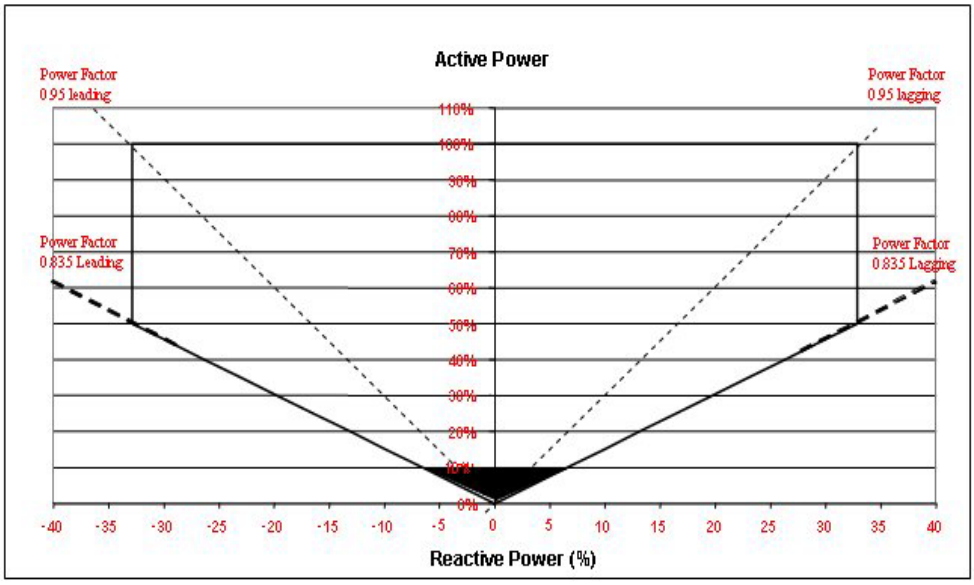


*Figure WF1.3 - Locations for **Voltage Regulation** set-point (Z) and the **Power Factor** range (Y). The high-voltage side of the **WTG** transformer is (X).*

WF1.6.3 REACTIVE POWER CAPABILITY

WF1.6.3.1 **Wind Farms** shall be capable of operating at any point within the **Power Factor** ranges illustrated in *Figure WF1.4,* as measured at the LV side of the **Grid Connected Transformer** (point *Y* in *Figure WF1.3*), for any **Voltage** at the **Connection Point** within the ranges specified in WF1.6.1.

WF1.6.3.2 For **Wind Farms** where the **Connection Point** is remote from the **Grid Connected Transformer**, any supplementary **Reactive Power** compensation required to offset the **Reactive Power** demand of the HV line, or cable, between the **Connection Point** and the **Wind Farm** shall be identified during the **TSO's Connection Offer** process.



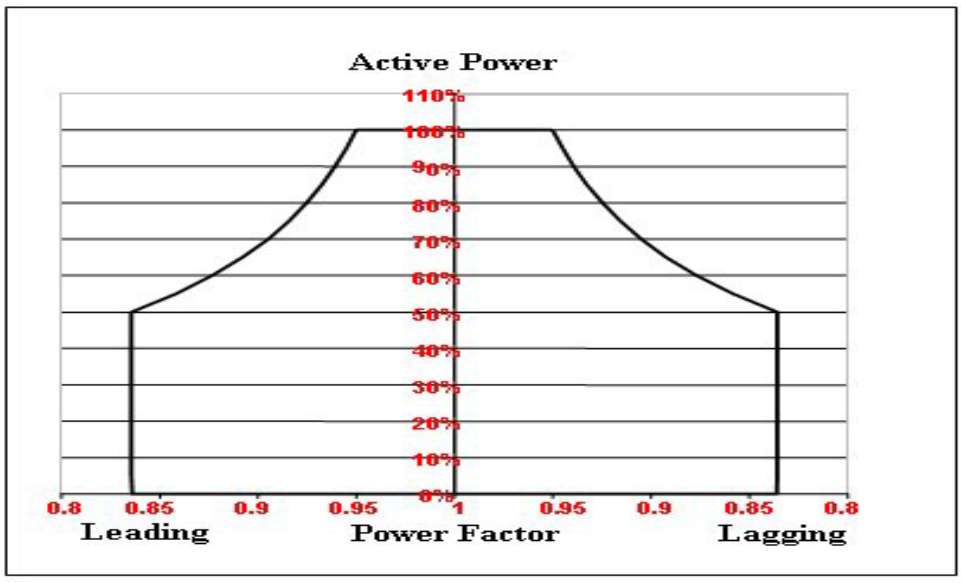


Figure WF1.4 - **Reactive Power** Capability of **Wind Farm Power Station**

WF1.6.3.3 For operation below 10 % of the **Wind Farm's MEC**, the **Wind Farm** shall operate within the shaded triangle in *Figure WF1.4*. However, if this cannot be achieved, then the total charging of the **Wind Farm** network during low load operation (below 10 %) shall be examined during the **TSO's Connection Offer** process. If during this examination it is identified that this charging may cause the voltage on the **Transmission System** to be outside the **Transmission System Voltage** ranges, as specified in WF1.6.1, then the **Reactive Power** requirements will need to be altered.

WF1.6.4 VOLTAGE STEP EMISSIONS

IEC 61000-3-7:1996 *Assessment of Emission limits for fluctuating loads in MV and HV power systems,* gives a table of the emission limits for **Voltage** changes as a function of the number of changes, R, per hour. This standard shall also apply to **Wind Farms**.

WF1.6.5 WIND FARM POWER STATION'S GRID CONNECTED TRANSFORMER

WF1.6.5.1 All relevant references in the **Grid Code** to **Generator Transformers** shall be interpreted to mean the **Wind Farm's Grid Connected Transformer** rather than the individual **WTG** transformers. For **Wind Farms** where the **Connection Point** is remote from the **Wind Farms**, **Grid Connected Transformer** shall be interpreted to mean the HV transformer located at the **Wind Farm**.

WF1.6.5.2 **Wind Farms** shall provide on-load tap-changing (OLTC) facilities for all **Grid Connected Transformers**. All **Wind Farms** shall liaise with the **TSO** on the design specification for the performance of the tap-changing facility of the **Grid Connected Transformer**.

WF1.6.5.3 The **Wind Farm's Grid Connected Transformers** may be connected either:

(a) in delta on the lower **Voltage** side and in star (with the star point or neutral brought out) on the higher **Voltage** side; or
(b) in star on both higher and lower **Voltage** sides with a delta tertiary winding provided.

1.7 WF1.7 SIGNALS, COMMUNICATIONS & CONTROL

WF1.7.1 SIGNALS FROM THE WIND FARM POWER STATION TO THE TSO

Signals from **Wind Farms** to the **TSO** shall be broken up into a number of logical groups. There shall be different requirements for **Wind Farms** depending on the **Wind Farm's MEC**. The following groups shall apply:

- ***Signals List #1*** - applies to **all Wind Farms**;

In addition, **Wind Farms** shall be required to provide signals from *Signals Lists 2, 3, 4 and/or 5*. These lists relate to:

- ***Signals List #2*** - Meteorological Data;
- ***Signals List #3*** **- Availability** Data;
- ***Signals List #4*** - **MW Curtailment** Data;
- ***Signals List #5*** - **Frequency Response System** Settings.

WF1.7.1.1 *Signals List #1*

The **Wind Farm** shall make the following signals available at the **TSO's RTU** designated for that **Wind Farm**:

a) **Grid Connected Transformer** tap positions;
b) **Voltage** (in kV) at the **Grid Connected Transformer's** low voltage terminals;
c) **Active Power** output (MW) at the LV side of the **Grid Connected Transformer**;
d) **Available Active Power** (MW) at the LV side of the **Grid Connected Transformer**;
e) **Reactive Power** output/demand (+/-Mvar) at the LV side of the **Grid Connected Transformer**;
f) **Voltage Regulation System** set-point (in kV);
g) On/off status indications for all **Reactive Power** devices exceeding 5 Mvar;

h) Circuit-breaker position indication shall be required. These may include indications from MV circuit-breakers on individual **WTG** circuits. Signals from individual **WTG** circuit-breakers shall not be required. The actual circuit-breaker signals required shall be specified by the **TSO** at least 60 business days prior to the **Wind Farm's** scheduled **Operational Date**;

i) A minimum of four sets of normally open potential free auxiliary contacts in each **Grid Connected Transformer** LV bay for fault indications.

WF1.7.1.2 ***Signals List #2***

WF1.7.1.2.1 **Wind Farms** with a **MEC** in excess of 10 MW shall make the following meteorological data signals available at the **TSO's RTU** designated for that **Wind Farm**:

a) Wind speed (at hub height) - measurand signal;
b) Wind direction (at hub height) - measurand signal;
c) Air temperature- measurand signal;
d) Air pressure- measurand signal.

WF1.7.1.2.2 The meteorological data signals shall be provided by a dedicated **Meteorological Mast** located at the **Wind Farm** site or, where possible and preferable to do so, data from a means of the same or better accuracy. For **Wind Farm** where the **WTG** are widely dispersed over a large geographical area and rather different weather patterns are expected for different sections of the **Wind Farm**, the meteorological data shall be provided from a number of individual **Meteorological Masts**, or where possible and preferable to do so, data from a source of the same or better reliability for groups of **WTG** (e.g. 1 set of meteorological data for each group of XX **WTG** within the **Wind Farm**). It is expected that **WTG** within an individual group shall demonstrate a high degree of correlation in **Active Power** output at any given time. The actual signals required shall be specified by the **TSO** no more than 60 business days after a **Connection Agreement** has been signed between the **Wind Farm** and the **TSO.**

WF1.7.1.3 ***Signals List #3***

WF1.7.1.3.1 **Wind Farms** with a **MEC** in excess of 10 MW shall make the following signals available at the **TSO's RTU** designated for that **Wind Farm**:

a) **Wind Farm Availability** (0-100 % signal);
b) Percentage of **WTG** shutdown due to high wind-speed conditions (0-100 %);
c) Percentage of **WTG** not generating due low wind-speed shutdown (0-100 %).

WF1.7.1.3.2 For **Wind Farms** with a **MEC** in excess of 10 MW, where the **WTG** are widely dispersed over a large geographical area and rather different weather patterns are expected for different sections of the **Wind Farm**, the above data set (ref. WF1.7.1.3.1) shall be provided for a number of groups of **WTG** (e.g. 1 signal for each group of XX **WTG** within the **Wind Farm**). It is expected that **WTG** within an individual group shall demonstrate a high degree of correlation in **Active Power** output at any given time. The actual signals required shall be specified by the **TSO** at least 60 business days prior to the **Wind Farm's** scheduled **Operational Date.**

WF1.7.1.4 ***Signals List #4***

The **Wind Farm** shall make the following signals available at the **TSO's RTU** designated for that **Wind Farm**:

a) **Wind Farm MW Curtailment Set-point** value (MW);
b) **Wind Farm MW Curtailment** facility status indication (ON/OFF).

WF1.7.1.5 ***Signals List #5***

The **Wind Farm** shall make the following signals available at the **TSO's RTU** designated for that **Wind Farm**:

a) **Frequency Response System** Mode signal (i.e. *Power-Frequency Response Curve 1 or 2*);
b) **Frequency Response System** Mode status indication (ON/OFF).

WF1.7.1.6 Update Rates

WF1.7.1.6.1 Signals from the **Wind Farm** shall be updated at a rate between 1 and 30 seconds at the **Wind Farm's** designated **RTU**, to provide an average value over that rate. The actual rates required shall be specified by the **TSO** at least 60 business days prior to the **Wind Farm's** scheduled **Operational Date**.

WF1.7.2 CONTROL SIGNALS FROM THE TSO TO WIND FARM POWER STATIONS

WF1.7.2.1 The control signals described in WF1.7.2 shall be sent from the **TSO** to the **Wind Farm**. The **Wind Farm** shall be capable of receiving these signals and acting accordingly.

WF1.7.2.2 **MW Curtailment**

A **MW Curtailment Set-point** signal shall be sent by the **TSO** via the **Wind Farm's RTU** to its **Frequency Response System**. This set-point shall define the maximum **Active Power** output permitted from the **Wind Farm**. The **Wind Farm's Frequency Response System** shall be capable of receiving this signal and acting accordingly to achieve the desired change in **Active Power** output. This signal shall most likely be in the form of a single analogue value.

WF1.7.2.3 **Power-Frequency Response Curve Mode**

This signal shall be sent by the **TSO** to the **Wind Farm** in the event that a change from *Power-Frequency Response Curve 1* to *Power Frequency Response Curve 2*, or vice versa, is required.

WF1.7.2.4 **Voltage Regulation**

This signal shall allow the **TSO** to send a kV set-point for **Voltage Regulation** purposes.

WF1.7.2.5 **Black Start Disconnection**

Means shall be provided by the **Wind Farm** to facilitate the disconnection of the **Wind Farm** by the **TSO** and to also prevent re-connection in the event of **Black Start**. It shall be possible for the **TSO** to send a trip and inhibit signal to the circuit-breaker(s) at the **Wind Farm's Connection Point**. The precise circuit-breakers for

which this facility shall be provided shall be specified by the **TSO** no more than 60 business days after a **Connection Agreement** has been signed between the **Wind Farm** and the **TSO. Wind Farms** may only be reconnected (i.e. made live) when the **Network** is fully restored following instruction from the **TSO** and only earlier if the **TSO** deems it acceptable to do so.

WF1.7.3 RESPONSIBLE OPERATOR

A designated **Responsible Operator** shall be contactable by the **TSO** at all times to discuss operational matters without undue delay and in any case within 15 minutes. Following a request from the **TSO**, the **Responsible Operator** shall be present at the **Wind Farm's Connection Point** without undue delay and in any case within one hour and shall be capable of taking any required appropriate actions. The **Responsible Operator** shall be contactable 24 hours a day, 365 days a year.

WF1.7.4 DATA AND COMMUNICATIONS SPECIFICATIONS

WF1.7.4.1 The location of the **RTU** shall be agreed between the **TSO** and the **Wind Farm** no more than 60 business days after a **Connection Agreement** has been signed between the **Wind Farm** and the **TSO**.

WF1.7.4.2 The necessary communications links, communications protocol and the requirement for analogue or digital signals shall be specified by the **TSO** no more than 60 business days after a **Connection Agreement** has been signed between the **Wind Farm** and the **TSO.** Current applicable standards shall apply and the accuracy class for signals shall comply with the prevailing European Standard at that time.

WF1.7.4.3 For loss of communications links, persistence (i.e. continuing to operate with the most recent data set) shall be used in terms of set-points until the designated **Responsible Operator** has been contacted by the **TSO**.

WF1.7.4.4 If **MW Curtailment**, **Frequency Response** or **Voltage Regulation** facilities for the **Wind Farm Power Station** become unavailable, the **Wind Farm** shall contact the **TSO** without undue delay.

WF1.7.4.5 Where signals or indications required to be provided by the **Wind Farm** under WF1.7.1 and WF 1.7.2 become unavailable or do not comply with applicable standards due to failure of the **Wind Farm's** technical equipment or any other reason under the control of the **Wind Farm**, the **Wind Farm** shall, acting in accordance with **Good Industry Practice**, restore or correct the signals and/or indications as soon as possible.

WF1.7.5 MW FORECASTS

MW forecasts shall be provided by **Wind Farms** with a **MEC** in excess of 30 MW. These forecasts shall be provided at 10:00 a.m. on a daily basis for the following 48 hours for each 30 minute time-period by means of an electronic interface in accordance with the reasonable requirements of the **TSO's** data system.

WF1.7.6 WIND FARM POWER STATION MW AVAILABILITY DECLARATIONS

Wind Farm with a **MEC** in excess of 30 MW shall submit **Wind Farm MW Availability Declarations** whenever changes in **Available Active Power** occur or are predicted to occur. These declarations shall be submitted by means of an electronic interface in accordance with the reasonable requirements of the **TSO**'s data system.