

MODIFICATION PROPOSAL FORM**WFPS FREQUENCY RESPONSE & RAMP RATES***FORM GC1, PROPOSAL OF MODIFICATION TO GRID CODE.*

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GRID CODE SECTION(S) AFFECTED BY PROPOSAL:	<p>WFPS1.5.2.1, WFPS1.5.2.2 and subsections WFPS 1.5.2.3, WFPS 1.5.3.1 WFPS 1.5.3.2, WFPS 1.7.1.5, 1.7.2.3</p> <p>Note that in the proposal, some renumbering of sections has taken place (WFPS 1.5.2.2 → WFPS 1.5.3 etc.), (WFPS1.5.3→WFPS1.5.4) in order to aid readability. Glossary changes and additions.</p>		
GRID CODE VERSION :	4		

<p>MODIFICATION PROPOSAL DESCRIPTION</p> <p>(MUST CLEARLY STATE THE DESIRED AMENDMENT, ALL TEXT/FORMULA CHANGES TO THE GRID CODE. THE REQUIRED REASON FOR THE MODIFICATION MUST STATED. ATTACH ANY FURTHER INFORMATION IF NECESSARY.)</p>	<p>The purpose of the proposed modification is to clarify the requirements on Ramp Rates and frequency response for windfarms. There are currently 1-minute and 10-minute ramp rate settings defined, but they are subject to confusion and misinterpretation. The Ramp Rate definitions need to be clearer, particularly as significant amounts of wind generation are forecast to connect to the power system over the coming years. This will make it easier to determine how windfarms in aggregate respond to instructions.</p> <p>This proposed modification also introduces a Ramp Rate specifically for frequency response, and a minimum expected time for provision of active power from WFPS for frequency response during frequency excursions. It also clarifies that the expected Active Power Response from the WFPS is based on Available Active Power.</p> <p>It also specifies a settable frequency droop for WFPS, defaulting to 4%. This droop shall apply whenever frequency response is turned on.</p> <p>[Proposed Text below]</p>
<p>IMPLICATION OF NOT IMPLEMENTING THE MODIFICATION</p>	<p>Ramp Rates may be applied in an inconsistent manner by windfarm owners. Also the speed for providing frequency response from WFPS will be unknown, potentially affecting system security in the future.</p>
<p><i>Please submit the Modification Proposal by fax, post or electronically, using the information supplied above</i></p>	
<p>EIRGRID REVIEWER</p>	
<p>EIRGRID ASSESSMENT</p>	

WFPS1.5.2.1 Active Power Control

The **Wind Farm Control System** shall be capable of operating each **WTG** at a reduced level if the **Controllable WFPS's Active Power** output has been restricted by the **TSO**. In this **Active Power Dispatch Mode**, the **Wind Farm Control System** shall be capable of receiving an on-line **Active Power Control Set-point** sent by the **TSO** and shall commence implementation of the set-point within 10 seconds of receipt of the signal from the **TSO**. The rate of change of output to achieve the **Active Power Control Set-point** should be ~~no less than the maximum ramp rate~~ the **Active Power Control Set-Point Ramp Rate** settings of the **Wind Farm Control System**, as advised by the **TSO**, as per WFPS1.5.34. The **TSO** acknowledges that if the **Active Power** output of the **Controllable WFPS** is initially less than the **Design Minimum Operating Level**, and if the **Controllable WFPS** is expected to increase its **Active Power** output, then it may not be able to achieve the specified ramp rate at first, due to **WTGs** going through a start-up sequence. In such a case, **WTGs** shall start up as quickly as the technology allows, and in any case, not longer than three minutes from the time the **Active Power Control Set-point** was received.

~~WFPS1.5.2.2~~**WFPS1.5.3 Frequency Response**~~WFPS1.5.2.2.1~~

WFPS1.5.3.1 In **Wind Following Mode**, the **Frequency Response System** shall have the capabilities as displayed in the *Power-Frequency Response Curve* in *Figures WFPS1.2 and WFPS1.3*, where the power and frequency ranges required for points A, B, C, D, E are defined below in *Table WFPS1.1 and Table WFPS1.2*. The **Frequency Response System** shall adjust the **Active Power** output of the **Controllable WFPS** according to a **Governor Droop**, settable by the **TSO** in a range from 2% to 10% and defaulting to 4%, when operating in the ranges outside the deadband range F_B - F_C in the *Power-Frequency Response Curve*. **Controllable WFPS Frequency Response** and **Governor Droop** shall be calculated with respect to **Registered Capacity**. A **Controllable WFPS** can only give a low frequency response if the **Active Power Control Setpoint** is less than the **Available Active Power**.

~~WFPS1.5.2.2.2~~

~~WFPS1.5.3.2 Under normal **Transmission System Frequency** ranges, the **Controllable WFPS** 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 **Controllable WFPS's Active Power** output, in accordance with the **Frequency/Active Power** characteristic defined by the line 'B'-'A'.~~

When in **Active Power Control Mode**, the **Controllable WFPS** shall always operate in **Frequency Sensitive Mode** with a **Governor Droop** as set out in WFPS1.5.3.1 and with a deadband of +/-15mHz, or as otherwise agreed with the **TSO**.

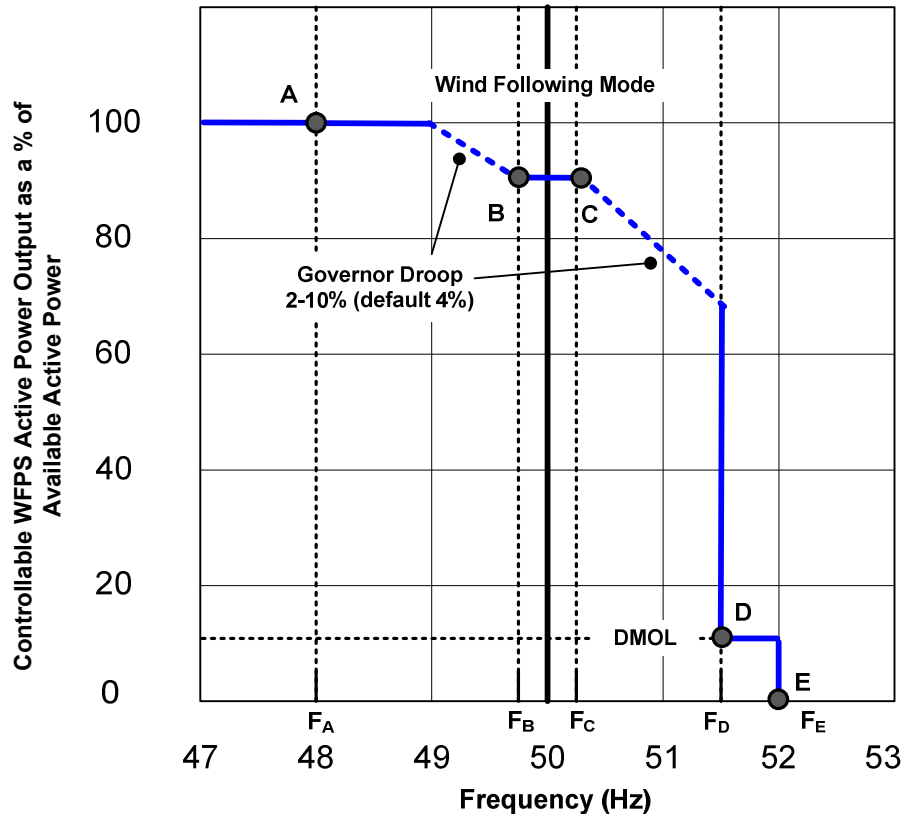


Figure WFPS1.2 –Example of Power-Frequency Response Curve for **Wind Following Mode**

~~WFPS1.5.2.2.3 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 **Controllable WFPS's Active Power** output in accordance with the **Frequency/Active Power** characteristic defined by the line 'A' 'B'.~~

WFPS1.5.3.3 When acting to control **Transmission System Frequency**, the **Controllable WFPS** shall provide at least 60% of its expected additional **Active Power** response within 5 seconds, and 100% of its expected additional **Active Power** response within 15 seconds of the start of the **Transmission System Frequency** excursion outside the range F_B - F_C , or in the case of a **Controllable WFPS** in **Active Power Dispatch Mode**, when the **Transmission System Frequency** goes outside the deadband set out in WFPS1.5.3.2.

~~WFPS1.5.2.2.4 A **Frequency** dead band shall be applied between the **Transmission System Frequencies** corresponding to points 'B' and 'C', where no change in the **Controllable WFPS's Active Power** output shall be required.~~

WFPS1.5.3.4 When the **Transmission System Frequency** is in the range F_C - F_D , the **Controllable WFPS** shall ensure that its **Active Power Output** does not increase beyond the **Active Power** value of the **Controllable WFPS** when the **Transmission System Frequency** first exceeded F_C , due to an increase in **Available Active Power** in that period.

~~WFPS1.5.2.2.5 Once the **Transmission System Frequency** rises to a level above point 'C', the **Frequency Response System** shall act to ramp down the **Controllable WFPS'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 **Controllable WFPS**.~~

WFPS1.5.3.5 If the **Frequency** drops below F_A , then the **Frequency Response System** shall act to maximise the **Active Power** output of the **Controllable WFPS**, irrespective of the **Governor Droop Setting**. If the **Frequency** rises above F_D , then the **Frequency Response System** shall act to reduce the **Active Power** output of the **Controllable WFPS** to its **DMOL** value. If the **Frequency** rises above F_E , then the **Frequency Response System** shall act to reduce the **Active Power** output of the **Controllable WFPS** to zero. 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.

~~WFPS1.5.2.2.6-~~

WFPS1.5.3.6 Points 'A', 'B', 'C', 'D' and 'E' shall depend on a combination of the **Transmission System Frequency**, **Active Power** and **Active Power Control Set-point** settings. These settings may be different for each **Controllable WFPS** depending on system conditions and **Controllable WFPS** location. These settings are defined in *Table WFPS1.1* below.

Point	Transmission System Frequency (Hz)	Controllable WFPS Active Power Output (% of Available Active Power)
A	F_A	P_A
B	F_B	Minimum of : P_B or Active Power Control Set-point (converted to a % of Available Active Power)
C	F_C	Minimum of: P_C or Active Power Control Set-point (converted to a % of Available Active Power)
D	F_D	Minimum of: P_D or Active Power Control Set-point (converted to a % of Available Active Power) or DMOL
E	F_E	$P_E = 0 \%$

Table WFPS1.1: Transmission System Frequency and % Available Active Power Settings for the Points 'A', 'B', 'C', 'D' and 'E' illustrated in Figure WFPS1.2

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 120 **Business Days** prior to the **Controllable WFPS's** scheduled **Operational Date** (refer to ~~1.5.2.3~~ WFPS1.5.3.11 below). The **Controllable WFPS** shall be responsible for implementing the appropriate settings during **Commissioning**.

~~Alterations to the **Active Power Control Set-point** may be requested in real-time by the TSO and the implementation of the set-point shall commence within 10 seconds of receipt of the signal from the TSO. The rate of change of output to achieve the **Active Power Control Set-point** should be no less than the maximum ramp setting of the **Wind Farm Control System**, as advised by the TSO, as per WFPS1.5.3.~~

~~WFPS1.5.2.2.7~~

WFPS1.5.3.7 The table below, *Table WFPS1.2*, 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 (%)
			Registered Capacity ≥ 5 MW
F_A	47.0-51.0 49.5	P_A	50-100
F_B	49.5-54 50	P_B	5015-100
F_C	49.550-50.551	P_C	
F_D	50.5-52.0	P_D	20 15-100 but not less than DMOL
F_E		P_E	0

Table WFPS1.2: Transmission System Frequency & Active Power ranges appropriate to Figure WFPS1.2.

For the **Transmission System Frequency** values in *Table WFPS1.2* above, $F_A \leq F_B \leq F_C \leq F_D = F_E$.

~~WFPS1.5.2.2.8~~

WFPS1.5.3.8 Alterations to the **Controllable WFPS's Active Power** output, triggered by **Transmission System Frequency** changes, shall be achieved by proportionately altering the **Active Power** output of all available **WTGs** as opposed to switching individual **WTGs** on or off, insofar as possible.

~~WFPS1.5.2.2.9~~

WFPS1.5.3.9 No time delays, such as moving average frequency filters, 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 **Controllable WFPS's** appropriate **Active Power** output by taking account of the **Controllable WFPS's Available Active Power** or **Controlled Active Power**.

WFPS1.5.2.2.10

WFPS1.5.3.10 If the **Transmission System Frequency** rises to a level above F_E , as defined by the *Power-Frequency Response Curve in Figure WFPS1.2*, the **TSO** accepts that **WTGs** 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).

WFPS1.5.2.3

WFPS1.5.3.11 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 120 **Business Days** prior to the **Controllable WFPS's** scheduled **Operational Date**. The **Controllable WFPS** 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 **Controllable WFPS** a minimum of **2 two** 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 **Controllable WFPS** shall formally confirm that any requested changes have been implemented within two weeks of receiving the **TSO's** formal request.

~~WFPS1.5.3~~

WFPS1.4 RAMP RATES

WFPS1.5.34.1

The **Wind Farm Control System** 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.~~ There shall be three ramp rate capabilities, designated **Wind Following Ramp Rate**, **Active Power Control Set-Point Ramp Rate**, and **Frequency Response Ramp Rate**. The **Wind Farm Control System** shall operate the ramp rates with the following order of priority (high to low): **Frequency Response Ramp Rate**; **Active Power Control Set-Point**

Ramp Rate; Wind Following Ramp Rate. The **Wind Following Ramp Rate** shall be used during **Start-Up**, normal operation, and **Shutdown**. The **TSO** shall specify the **Wind Following Ramp Rate** and the **Active Power Control Set-Point Ramp Rate** in percentage of **Registered Capacity** per minute. The **Frequency Response Ramp Rate** shall be the maximum possible ramp rate of the **Controllable WFPS** agreed with the **TSO** and with the characteristics as set out in WFPS1.5.2.2.2. The **TSO** acknowledges that rapidly changing wind speeds may cause temporary deviations from the ramp rate settings of the **Controllable WFPS**, but these deviations should not be allowed to exceed 3% of **Registered Capacity**.

WFPS1.5.34.2 It shall be possible to vary ~~each of these two maximum ramp rate settings~~ the **Wind Following Ramp Rate** and the **Active Power Control Set-Point Ramp Rate** each independently over a range between ~~1 and 30 MW~~ 1% and 100% of **Registered Capacity** per minute. ~~The Wind Farm Control System shall have the capability to set the ramp rate in MW per minute averaged over both one and ten minutes.~~

WFPS1.5.3.3 Procedure for Setting and Changing the Ramp Rate Control

The ramp rate settings shall be specified by the **TSO** at least 120 **Business Days** prior to the **Controllable WFPS's** scheduled **Operational Date**. The **Controllable WFPS** 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 **Controllable WFPS** a minimum of two weeks notice if a change is required. The **Controllable WFPS** shall formally confirm that any requested changes have been implemented within two weeks of receiving the **TSO's** formal request.

WFPS1.7 SIGNALS, COMMUNICATIONS & CONTROL

WFPS1.7.1 SIGNALS FROM THE CONTROLLABLE WFPS TO THE TSO

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

- **Signals List #1** - applies to **all Controllable WFPSs**;

In addition, **Controllable WFPSs** 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 - Active Power Control** Data;
- **Signals List #5 - Frequency Response System** Data.

WFPS1.7.1.1 **Signals List #1**

The **Controllable WFPS** shall make the following signals available at the designated **TSO Telecommunication Interface Cabinet** for that **Controllable WFPS**:

- a) **Active Power** output (MW) at the lower voltage side of the **Grid Connected Transformer**;
- b) **Reactive Power** output/demand (+/-Mvar) at the lower voltage side of the **Grid Connected Transformer**;
- c) Voltage (in kV) at the lower voltage side of the **Grid Connected Transformer**;
- d) **Available Active Power** (MW) at the lower voltage side of the **Grid Connected Transformer**;
- e) **Grid Connected Transformer** tap positions;
- f) **Voltage Regulation Set-point** (in kV);
- g) On/off status indications for all **Reactive Power** devices exceeding 5 Mvar¹;
- h) Circuit-breaker and disconnect 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 and disconnect signals required shall be specified by the **TSO** at least 120 **Business Days** prior to the **Controllable WFPS's** scheduled **Operational Date**;
- i) A minimum of four sets of normally open potential free auxiliary contacts in each **Grid Connected Transformer** lower voltage bay for fault indications; and
- j) On/off status of **TSO** remote control enable switch, which disables the ability of the **TSO** to send commands to the **Controllable WFPS**.

For the **Controllable WFPS's** where the Connection Point is at the HV side of the **Grid Connected Transformer**, signals a), b) and c) above will also be required from the HV side of the **Grid Connected Transformer**.

WFPS1.7.1.2 **Signals List #2**

WFPS1.7.1.2.1 **Controllable WFPSs** with a **MEC** in excess of 10 MW shall make the following meteorological data signals available at the designated **TSO Telecommunication Interface Cabinet** for that **Controllable WFPS**:

- | | |
|---|-----------------------|
| | <u>[Units, Range]</u> |
| a) Wind speed (at hub height) - measurand signal; | [m/s, 0-70] |

¹ Typically the position indication from capacitor/ SVC circuit breakers

- b) Wind direction (at hub height) - measurand signal; [deg, 0-360]
- c) Air temperature- measurand signal; [deg C, -40-70]
- d) Air pressure- measurand signal. [mBar, 735-1060]

WFPS1.7.1.2.2 The meteorological data signals shall be provided by a dedicated **Meteorological Mast** located at the **Controllable WFPS** site or, where possible and preferable to do so, data from a means of the same or better accuracy. For **Controllable WFPSs** where the **WTG** are widely dispersed over a large geographical area and rather different weather patterns are expected for different sections of the **Controllable WFPS**, 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 **Controllable WFPS**). 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 120 **Business Days** prior to the **Controllable WFPS's** scheduled **Operational Date**.

WFPS1.7.1.3 Signals List #3

WFPS1.7.1.3.1 **Controllable WFPSs** with a **MEC** in excess of 10 MW shall make the following signals available at the designated **TSO Telecommunication Interface Cabinet** for that **Controllable WFPS**:

- a) **Controllable WFPS 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 %).

WFPS1.7.1.3.2 For **Controllable WFPSs** 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 **Controllable WFPS**, the above data set (ref. WFPS1.7.1.3.1) shall be provided for a number of groups of **WTG** (e.g. 1 signal for each group of XX **WTG** within the **Controllable WFPS**). 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 120 **Business Days** prior to the **Controllable WFPS's** scheduled **Operational Date**.

WFPS1.7.1.4 Signals List #4

The **Controllable WFPS** shall make the following signals available at the designated **TSO Telecommunication Interface Cabinet** for that **Controllable WFPS**:

- a) **Controllable WFPS Active Power Control Set-point** value (MW);
- b) **Controllable WFPS Active Power Control** status indication (ON/OFF).

WFPS1.7.1.5 Signals List #5

The **Controllable WFPS** shall make the following signals available at the designated **TSO Telecommunication Interface Cabinet** for that **Controllable WFPS**:

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

WFPS1.7.2 CONTROL SIGNALS FROM THE TSO TO CONTROLLABLE WFPS

WFPS1.7.2.1 The control signals described in WFPS1.7.2 shall be sent from the **TSO** to the **Controllable WFPS**. The **Controllable WFPS** shall be capable of receiving these signals and acting accordingly.

WFPS1.7.2.2 Active Power Control

An **Active Power Control Set-point** signal shall be sent by the **TSO** to the **Wind Farm Control System**. This set-point shall define the maximum **Active Power** output permitted from the **Controllable WFPS**. The **Wind Farm Control System** shall be capable of receiving this signal and acting accordingly to achieve the desired change in **Active Power** output. This signal shall be in the form of a single analogue value and a strobe pulse to enable.

The **Controllable WFPS** is required to make it possible for the **TSO** to remotely enable/disable the **Active Power Control** function in the **Wind Farm Control System**. The associated status indication is described in WFPS1.7.1.4.

WFPS1.7.2.3 **Frequency Response**

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

The **Controllable WFPS** is required to make it possible for the **TSO** to remotely enable/disable the **Frequency Response System**. The associated status indication is described in WFPS1.7.1.5.

The **Controllable WFPS** shall make it possible for the **TSO** to set the **Governor Droop** value of the **Frequency Response System** in values from 2% to 10%.

GLOSSARY TERMS:

Wind Following Ramp Rate:

The maximum rate of increase of **Active Power** output of a **Controllable WFPS** in response to an increase in wind speed.

Active Power Control Set-Point Ramp Rate:

The rate of increase or decrease of **Active Power** output of a **Controllable WFPS** in response to an **Active Power Control Set-point** instruction.

Frequency Response Ramp Rate:

The minimum rate of increase or decrease of **Active Power** output of a **Controllable WFPS** when acting to control **Transmission System Frequency**.

Governor Droop: The percentage drop in the **Frequency** that would cause the **Generation Unit** under free governor action to change its output from zero to its full **Capacity**. In the case of a **Controllable WFPS**, it is the percentage drop in the **Frequency** that would cause the **Controllable WFPS** to increase its output from zero to its full **Registered Capacity**.

Wind Following Mode:

A mode of operation of a **Controllable WFPS** where the system frequency is within normal range and the **Controllable WFPS** is not under **Active Power Control** by the **TSO**, allowing the **Controllable WFPS** to produce up to 100% of its **Available Active Power**, depending on the Power-Frequency Curve in operation. When operating on Power-Frequency Curve 2, the **Controllable WFPS** is required to maintain its **Active Power** output at a fixed percentage of its **Available Active Power** when **Transmission System Frequency** is within the range F_B - F_C .

Active Power Control Mode:

A mode of operation of a **Controllable WFPS** where the **Controllable WFPS** has been instructed by the **TSO** to maintain its **Active Power** output at the **Active Power Control Set-Point**.

Design Minimum Operating Level (DMOL): The minimum **Active Power** output of **Controllable WFPS** where all **WTGs** are generating electricity and capable of ramping upwards at any of the specified ramp rates (given available wind), and shall not be greater than 12% of **Registered Capacity**.