WFPS Meteorological Signals Provision

EIRGRID

Contents

1 DOCUMENT VERSION HISTORY

Document Version History		
Version	**Date**	**Comment**
0.1	10/08/2017	First draft
0.2	23/3/2018	Second draft
0.3	7/6/2018	Third draft
0.4	28/6/2018	Fourth draft

2 INTRODUCTION

Meteorological data signals from WFPS are a requirement under TSO Grid Code WFPS 1.7.1.2 and DSO Distribution Code DCC11.5.1.6 for all WFPS with a MEC in excess of 10MW. These signals are essential in providing high quality forecasting now and into the future to maintain system security. The respective distribution and grid codes state that the acceptable sources for meteorological data signals is from a meteorological mast at the WFPS site or from a means of the same or better accuracy. The source of meteorological data signals needs to reliably provide data that improves the wind power generation forecast otherwise they are of no value.

EirGrid is working with a third party to publish a report 'Met Mast and Study Alternatives' which aims to clarify what the current acceptable alternative sources other than a meteorological mast are. The purpose of this guideline document is to:

1. Set out the acceptable measurement equipment for the provision of meteorological data signals;
2. Set out suitable locations for the measurement equipment;
3. Frequency, accuracy and measurement resolution of the data signals;
4. Standing data requirements;
5. Maintenance protocols;
6. Performance monitoring of data signals.

Once the report is finalised EirGrid will review this document and make any necessary updates to reflect recommendations.

3 GRID CODE REFERENCES

The Grid and Distribution Codes[1] include the following in relation to meteorological data signals (Note that the wording of the codes are identical in both the grid code and distribution code therefore only the grid code is referred to from here on):

WFPS 1.7.1.2 ***Signals List #2***

WFPS 1.7.1.2.1 **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**:

		[Units, Range]
a)	Wind speed (at hub height or as agreed with the TSO) - measurand signal;	[m/s, 0-70]
b)	Wind direction (at hub height or as agreed with the TSO) - measurand signal;	[deg, 0-360]
c)	Air temperature - measurand signal;	[deg C, -40-70]
d)	Air pressure - measurand signal.	[mBar, 735-1060]

[1] Grid Code Version 6.0 and Distribution Code 5.0 at the time of writing.

WFPS 1.7.1.2.2 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.**

WFPS 1.7.1.6 Time Delays and Data Quality

WFPS1.7.1.6.1 Digital signal changes from the **Controllable WFPS** shall be relayed to the **TSO Telecommunication Interface Cabinet** within 1 second of the associated change of state event. Analogue signal changes shall be relayed within 5 seconds and with an error of 0.5% or less, with the exception of the Meteorological Data required as per **PPM 1.7.1.2.1**, which shall be updated within 5 seconds and with an error of 2.5% or less.

The Grid Code provides the following definitions:

Controllable WFPS	A site containing at least one WTG can automatically act upon a remote signal from the TSO to change its Active Power output
Generating Unit	Any apparatus which produces electricity and, for the purpose of SDC1 and SDC2, shall include a CCGT Installation or a CCGT Unit, where running arrangements and/or System conditions apply
Meteorological Mast	A device erected at the Controllable WFPS which has the capability measure representative wind speed, wind direction, air temperature and air pressure to a degree of accuracy corresponding to the appropriate prevailing European Standard at that time.
TSO Telecommunication Interface Cabinet	The physical interface point between the TSO's telecommunications equipment and the Controllable WFPS's control equipment.
Wind Turbine Generator	A Generation Unit(s) generating electricity from wind.

4 PROVISION OF METEOROLOGICAL SIGNALS

Current Grid Code requirements allow for meteorological data signals from a meteorological mast located at the Controllable WFPS site or from another source with the same or better accuracy than a meteorological mast. The TSO's preference as per the Grid Code remains a hub height met mast.

Alternative sources are not defined in the Grid Code but are detailed in this document in the following section and require agreement from the TSO.

4.1 Acceptable Source

Every WFPS with a MEC in excess of 10 MW is required to make four meteorological data signals (as set out in WFPS 1.7.1.2.1) available at the designated TSO Telecommunication Cabinet Interface. The following are acceptable sources for those meteorological data signals unless otherwise agreed with the TSO (Again note that the use of any source other than a met mast at hub height requires discussion and agreement with the TSO):

WFPS with a MEC in excess of 15 MW:

1. A meteorological mast at WTG hub height
    a. If there are more than one WTG hub height on site an average of the on-site turbine heights is acceptable.
2. A meteorological mast with a height of minimum 30m. Plus an additional source of wind speed signal from WTG hub height (or the minimum turbine hub height where heights vary within the WFPS). The additional wind speed source will be from a single nacelle mounted cup anemometer or Lidar suitably located within the WFPS site.

WFPS with a MEC in excess of 10 MW but less than or equal to 15 MW:

- Sources as outlined in (1) and (2) above are acceptable or;

3. A neighbouring WFPS meteorological mast with a height of minimum 30m. Plus an additional source of wind speed signal from WTG hub height (or the minimum turbine hub height where heights vary within the WFPS). The additional wind speed source will be from a single nacelle mounted cup anemometer or Lidar suitably located within the WFPS site.

If a WFPS is using a neighbouring WFPS meteorological mast the neighbouring WFPS must agree in writing to this arrangement. A copy of this agreement shall be provided to the TSO (wind.forecasting@eirgrid.com). The WFPS is responsible for meeting and continuing to meet the minimum requirement for the provision of meteorological data signals. If the neighbouring WFPS meteorological mast is producing data signals which do not meet the required minimum standards the WFPS must provide alternative meteorological data signals from one of the three sources, (1) to (3), listed in this section.

4.2 Acceptable Location of Equipment

The location of equipment used for meteorological data measurement will be sited in such a way as to ensure maximum accuracy of weather conditions at the WFPS and avoid, as much as possible, disturbance arising from turbulence and wake effects.

For sources (1) and (2) in section 4.1 the meteorological mast will be located

i. Within the WFPS site and be no more than 5 km from the furthest turbine in the WFPS site.

For source (3) in section 4.1 the meteorological mast will be located

i. Within the neighbouring WFPS site and be no more than 5 km from the furthest turbine in the WFPS site.

For sources (1), (2) and (3) in section 4.1 the meteorological mast will be located

ii. In such a way as to reasonably avoid wake effects in the prevailing wind direction from turbines in the WFPS.
iii. In such a way as to reasonably avoid turbulence from complex terrain and be expected to experience the same weather patterns as the turbines on site.

For source (2) and (3) in section 4.1 the nacelle mounted cup anemometer or Lidar shall be located on a turbine within the WFPS site and in such a way as to;

i. Reasonably avoid wake effects in the prevailing wind direction from other turbines in the WFPS;

ii. Reasonably avoid turbulence from complex terrain and be expected to experience the same weather patterns as the remainder of the turbines in the WFPS site.

4.3 System accuracies and Measurement resolution

The meteorological data signals provided shall be as detailed in Table 1: Meteorological data signal accuracy and resolution and Table 2: Meteorological data variable and their error threshold limit. The WFPS shall provide an updated signal every 1 minute.

	Unit	Range	System Accuracy	Measurement Resolution
Wind speed	m/s	0 - 70	≥ 5% improvement	0.1m/s
Wind direction	deg	0 - 360	Statistical and Variance test within acceptable limits as per Table 2	1.0 deg
Air temperature	deg C	-40 - 70		0.1 deg C
Air pressure	mBar	735 - 1060		1 mBar

Table 1: Meteorological data signal accuracy and resolution

	Maximum Bias	Maximum MAE	Minimum Correlation	Measurement Unit
Wind speed	3.00	3.00	0.65	m/s
Wind direction	13.00	20.0	0.55	deg
Air temperature	2.00	2.50	0.75	degC
Air pressure	50.00	85.0	0.90	mBar

Table 2: Meteorological data variable and their error threshold limit for statistical tests

4.3.1 Wind Speed

Wind speed is the most critical variable for an accurate wind power forecast. A WFPS should deliver wind speed data signals that describe the wind farm power output (MW) with a certain accuracy excluding periods where there are dispatch signals or wind farm outages.

The Available Active Power (AAP) is a signal received by EirGrid from the wind farm and is defined in the Grid Code as '*The amount of Active Power that the Controllable WFPS could produce based on the current wind conditions. The Available Active Power shall only differ from the actual Active Power if the Controllable WFPS has been curtailed, constrained or is operating in a restrictive Frequency Response mode'*. The AAP signal itself is subject to EirGrid quality standards[2].

Hence the target is that the reported measured wind speed data signal from a WFPS shall be an improvement over the forecasted wind speed in predicting WFPS power output (MW) compared to the AAP of the WFPS.
The improvement will be calculated as follows:

- Predicted wind farm power output (MW) using forecasted wind speed (refer to this as F).
- Predicted wind farm power output (MW) using measured wind speed at the wind farm site (refer to this as M).
- Calculate the MAE of F compared to the AAP of the WFPS (refer to this as X).
- Calculate the MAE of M compared to the AAP of the WFPS (refer to this as Y).
- X-Y=Z

The required standard is Z ≥ +5%; the measured wind speed should be an improvement of at least 5% over the forecasted wind speed in predicting WFPS power output. A positive number will indicate an improvement of the predicted WFPS power output using measured wind speed over the forecasted wind

[2] http://www.eirgridgroup.com/site-files/library/EirGrid/QualityStandardforWindfarmActivePower.pdf

speed. A negative number will indicate the measured wind speed was worse than the forecasted wind speed in predicting WFPS output.

The same methodology will be used to calculate wind power generation from forecast wind speed and measured wind speed. The data period will be the same taking account of missing data from both forecast and measured wind speed.

4.3.2 Other Variables

Bias, MAE and Correlation

The wind direction, air temperature and air pressure are less critical meteorological variables than wind speed. Measuring data signal accuracy for these variables is therefore adequate using a range around the forecast of the variable. The forecast is used as the reference as it has a known accuracy level. Statistical tests are used to provide the best possible data basis for the interpretation of the data accuracy. The statistical tests are:

- Bias – result of systematic error that either over or under estimates the true value. The bias number should be low.

- Mean Absolute Error – a measure of how close forecasts or predictions are to the eventual outcome. It is a measure of difference between two continuous variables, in this instance the forecast and measured meteorological data values.

- Correlation – is a measure of the strength and direction of the linear relationship between two variables i.e., in this instance the forecast and measured meteorological data values.

The desired aim is to have Correlation + MAE + BIAS within acceptable threshold error limits (allowing for known forecast error) as detailed in *Table 2: Meteorological data variable and their error threshold limit*. The three tests together show a complete picture of the accuracy of the measured data compared to the forecast data.

Ensemble Based Variance

Another necessary test is ensemble based variance which is meteorological and statistical and will take into account rapid local changes in the weather not present in the forecast. Ensemble based variance sets a minimum requirement of data being inside the ensemble spread with a minimum band around the mean. The band width around the mean will update every hour depending on the weather at the WFPS; providing a wider band when required during rapid weather changes.

The advantage of the ensemble based variance test is that in a given month where there has been very uncertain weather with rapid changes the correlation test may fail but the variance test will succeed. In this scenario the meteorological data will be accepted within limits as the ensemble variance test is more intelligent.

All statistical tests are required to give a complete overall picture of the quality of the meteorological data signal. For instance if the correlation for all WFPS is poor in a given month it was a month with a very challenging weather pattern. However, if only a small number of WFPS have poor correlation results then it is the quality of the meteorological data signal of these WFPS which is the cause.

4.4 Standing data

To ensure high quality wind forecasting the SEMO Generation Unit registration form will specify the co-ordinate position of each wind turbine within the WFPS.

The following information regarding meteorological equipment will be included in Appendix A of the WFPS Meteorological Equipment Requirements document:

i. Source of meteorological data signals submitted to the TSO;
ii. Meteorological mast or relevant nacelle co-ordinate position within the WFPS;
iii. The height(s) of the measurements;
iv. High wind speed shutdown information.

The following information regarding meteorological equipment will be included in Appendix B of the WFPS Meteorological Equipment Requirements document:

v. Setup calibration results and data ranges;
vi. Description of data validation steps;
vii. Description of data handling and sampling methods;
viii. Copy of manufacturer's recommendations and guidelines for installation, calibration, testing and maintenance.

On installation of the meteorological equipment the WFPS shall fill out a hard copy of Appendix A and B of the WFPS Meteorological Equipment Requirements document and e-mail a copy to the TSO (wind.forecasting@eirgrid.com) within 2 weeks of installation.

4.5 Maintenance

To ensure submission of high quality meteorological data it is essential that appropriate routine maintenance of the meteorological equipment is scheduled and carried out as per manufacturer's recommendations. The WFPS shall maintain a log of the following information in Appendix C:

ix. Time and date of maintenance.
x. Procedure of checks and maintenance.
xi. Result of checks and maintenance.

If any maintenance, repair or replacement of meteorological equipment alters the data (i-iv listed in Appendix A) the WFPS shall update a copy of Appendix A of the WFPS Meteorological Equipment Requirements document and e-mail it to the TSO (wind.forecasting@eirgrid.com) within 2 weeks of the amendment.

If replacement of meteorological equipment alters the data (v-viii listed in Appendix B) the WFPS shall update a copy of Appendix B of the WFPS Meteorological Equipment Requirements document and e-mail it to the TSO (wind.forecasting@eirgrid.com) within 2 weeks of the amendment.

5 PERFORMANCE MONITORING OF DATA SIGNALS

The TSO expect to issue a report once every quarter to each WFPS detailing the performance of meteorological data signal provision and quality for the previous quarter. The report will state whether the data provided meets the minimum standards as set out in Section 4.3.

A breach of the minimum requirement for the provision of meteorological data signals is deemed to have occurred if the meteorological data signals do not meet the minimum requirements as set out in Section 4.3 for one quarter. The quarterly performance report will highlight the problematic signal. The WFPS will have three months to rectify the issue. The TSO may issue the WFPS with more frequent progress reports to assist the WFPS in improving the signal quality during this period.

If a WFPS is using a neighbouring WFPS meteorological mast a breach of the minimum requirement for the provision of meteorological data signals is deemed to have occurred if the meteorological data signals do not meet the minimum requirements as set out in Section 4.3 for a three month period. The neighbouring WFPS will have a further three month period to rectify the issue. If after this time the minimum requirements are not demonstrated to be met the WFPS will implement an alternative method of provision of meteorological data signals acceptable under these guidelines.

If a WFPS does not improve sub-standard meteorological data signal quality in the given three month period a non-performance process will be initialised requiring the WFPS to apply for a temporary derogation to rectify the issue.

6 FUTURE PROVISION OF METEOROLOGICAL SIGNALS

TSO will review this document as and when relevant information and data becomes available.

7 ACRONYM

DSO	Distribution System Operator
MAE	Mean Absolute Error
MEC	Maximum Export Capacity
Lidar	Light Detection and Ranging
TSO	Transmission System Operator
WFPS	Wind Farm Power Station
WTG	Wind Turbine Generator