ROMO WIND
WIND KNOWLEDGE IS WIND POWER

Requirements for Performance Transparency Project and Necessary Information per PTP Wind Turbine

Change Index

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1 Requirements for Performance Transparency Project

1.1 Wind farm and site

1.1.1 Wind farm size, layout and site conditions

In order to get statistical relevant data the minimal number of same turbine types in the wind farm shall be at least nine (9).

The wind farm layout can be line arrangement or area distributed arrangement

In order to be able to make detailed analysis it would be of advantage if each evaluated turbine or at least a relevant subset of the evaluated turbine does also have free inflow sectors. Therefore available site information (e.g. site evaluation reports, topographical maps, site calibration reports) shall be provided to ROMO Wind. At least for the reference turbine (i.e. the turbine for which the iSpin calibration is performed using a reference measurement system) a free inflow sector is needed, which allows wind speed and power curve measurements according IEC 61400-12 in a reasonable time frame. The annual average wind speed should be preferably above 7.5m/s for the sites to perform the measurements and evaluations in a timely manner. The site should be located in a normal climate region.

1.1.2 Special control regimes

The evaluated wind turbines should not be operated with special control regimes.

If this isn't possible, it is mandatory that the turbines in main wind direction and in majority of the time are operated in normal mode. Any special control regimes (e.g. curtailment strategy, de-rating due to utility command, noise reduction etc.) must be made visible and identifiable in the provided SCADA data sets. A list of special operation modes relevant for the wind farm turbines shall be made available to ROMO Wind.

1.1.3 Physical accessibility

The wind farm should be arranged and located in a way that under normal effort the turbines can be visited within two (2) days. In case of offshore wind farm the possible time periods for accessing the wind farm turbines need to be provided.

1.1.4 Data communication

The iSpin system operates independently from the turbine data communication infrastructure.

The data collected by the iSpin controller will continuously be sent to the ROMO Wind Datacentre via the 3G mobile network. Therefor for each wind farm turbine which will be equipped with iSpin system permanent 3G coverage is required.

In case that for offshore sites 3G coverage is not given, ROMO Wind can support Participant for finding alternative solutions.

In order to avoid potential unneeded iSpin service visits ROMO Wind always needs to be informed if a potential lack of data collection from iSpin may be caused by turbine errors. ROMO Wind therefore requests that the wind turbine owner demands that the turbine service company always informs ROMO Wind in case of wind turbine break-down and/or if the turbine is powered off for service activities

1.2 Turbine types

The measurement capabilities of the iSpin system and the suitability for performance monitoring and comparison shall be evaluated for wind turbines of the same type in different wind farms. This wind farms are located in sites of different complexity, i.e. flat terrain, semi-complex terrain, complex terrain or offshore.

Therefore variations of the turbine type (like design changes, hardware and software modifications) which do potentially change the rotor induction and finally the Nacelle Transfer Function (NTF) are not allowed. All turbines of the same type have to have identical operating software and have to fulfill the same manufacture design specification (i.e. same blade version and hub version, etc.). After signing of the participation agreement the Participant shall therefore provide to ROMO Wind per selected PTP turbine a list of key information following the table as listed in chapter 2.

During the measurement phase any change must be made identifiable (what happened?) and traceable (when did it start to happen and when did it stop to happen?) by either providing maintenance log entries, data log entries or by providing a status/operation mode information using within the SCADA data set. Any operational changes extending more than 4 weeks will cause the turbine to be removed from the project. Thus if major service replacements or upgrades of critical components are planned within the next 2 years, the turbines are not qualified for this project.

ROMO Wind expects a site visit by the selected 3rd party consultants to be necessary to assess/check the main characteristics of each PTP turbine.

1.3 Reference measurement system

One key aspect of the Performance Transparency Project is the long term stability of the iSpin nacelle transfer function.

In order to evaluate the long term stability a reference measurement system has to exist in the wind farm to be evaluated. This reference measurement system shall have a setup and arrangement compliant to IEC 61400-12-1 and shall be maintained and operated by the Participanton their costs in parallel to the iSpin system for at least 12 months to capture any influence of seasonal effects.

In case that a met-mast is available which is considered by the Participant to be compliant to the IEC 61400-12-1 requirements, all available met mast documentation (including exact met mast position, boom set-up, data logger type and the latest available 2 weeks met data time series) shall be provided to ROMO Wind to review the status of the met mast and the measurement itself. Depending on this review, ROMO Wind will propose an upgrade/modification of the existing met mast. Effort and costs of this upgrade/modification will be borne by the Performance Transparency Project.

For the complex sites it's mandatory that the reference measurements were performed according to IEC 61400-12-1 with a site calibration. Documentation regarding the site calibration must be made available to ROMO Wind and 3rd party consultants for validation.

In case that in offshore wind farms of the selected turbine types IEC-compliant met masts are not available, alternatively a nacelle based lidar can be used in the wind farm to be evaluated. In this case the nacelle based lidar system will be used to obtain the free wind speed. The procedure for calibration and installation of the nacelle based lidar system should follow the recommendation set in: http://orbit.dtu.dk/files/53801282/Aved_re_campaign.pdf.

1.4 Data provision

iSpin is measuring wind and climate quantities independent from the SCADA and other data logger systems and synchronises the data collection frequently with an internet time server (pool.ntp.org). To generate the turbine specific iSpin free wind speed calibration factor k1 and the iSpin transfer function (iTF) the iSpin measurement data have to be analysed in relation to the reference measurement system.

1.4.1 Reference measurement system

1.4.1.1 Met-mast

In case that the reference measurement system is **met-mast based**, following information shall be provided by the wind farm owner to ROMO Wind.

1. Provision of information concerning met-mast set-up.
   This relates to the met-mast configuration, met-mast sensors (position and calibration sheets), position relative to the turbine, free inflow sector(s), data logger type etc. The met-mast configuration and arrangement towards the reference turbine shall in general follow IEC 61400-12-1. Deviations from the IEC 61400-12-1 shall be stated as well.
2. Provision of measurement data from the met mast
   Following data has to be provided:
   - Date and time stamp.
   - Hub height wind speed: average, max, min and std.dev.
   - Hub height wind direction: average, max, min and std.dev.
   - Further wind speeds (if measured): average, max, min and std.dev.

- Further wind directions (if measured): average, max, min and std.dev.
- Air temperature (hub height and ground level): average, max, min
- Air pressure (hub height): average, max, min
- Air humidity (if recommended for the site): average, max, min
- Precipitation: min, max

Preferably the met-mast measurement data should be provided time stamped and synchronised to an UTC time server with a sampling rate of 1 second. In case the high sampling data is provided in binary format, the format description has to be provided to ROMO Wind. If only aggregated information is available at least time stamped 10min statistic data in CSV-format (UTC+0) has to be provided. Local time zone is also acceptable, but it is mandatory that the time is synchronized to an UTC time server with maximum ±3 seconds deviation to real time. Information whether daylight saving mode is enabled or not has to be provided to ROMO Wind.

1.4.1.2 Offshore projects

In case that in offshore wind farms nacelle based Lidar campaign are be used as methodology of obtaining the free wind speed following information shall be made available to ROMO Wind.:

1. Provision of information concerning measurement chain.
   - Installation and calibration documentation
2. Provision of measurement data from the lidar system, minimum at 2.5 RD in front of the rotor.
   - Date and time stamp
   - Hub height wind speed: average, max, min and std.dev.
   - Hub height wind direction: average, max, min and std.dev.
   - Signal to noise ration.
   - Other data quality identifiers.
   - Further wind speeds ranges (if measured): average, max, min and std.dev.
   - Further wind directions ranges (if measured): average, max, min and std.dev.
   - Air temperature (hub height and ground level): average, max, min
   - Air pressure (hub height): average, max, min
   - Air humidity (if recommended for the site): average, max, min
   - Precipitation: min, max

Preferably the nacelle lidar measurement data should be provided time stamped and synchronised to an UTC time server with a sampling rate of 1 second. In case the high sampling data is provided in binary format, the format description has to be provided to ROMO Wind. If only aggregated information is available at least time stamped 10min statistic data in CSV-format (UTC+0) has to be provided. Local time zone is also acceptable, but it is mandatory that the time is synchronized to an UTC time server with maximum ±3 seconds deviation to real time. Information whether daylight saving mode is enabled or not has to be provided to ROMO Wind.

1.4.2 Turbine signals from 3rd party consultants

During the power curve verification process according IEC 61400-12-1 and -2 certain turbine signals are captured by 3rd party consultants at the reference turbine. Following information shall be made available to ROMO Wind:

1. Provision of information concerning measurement chain.
   - Calibration sheets of current transformer, voltage transducer and power transducer
2. Provision of measurement data from the turbine
   - Date and time stamp
   - Active power (average, max, min and std.dev)

- Nacelle wind speed (uncorrected, i.e.no offset, scaling or NTF applied) [1]
- Nacelle direction
- Wind direction from nacelle equipment
- Signal/status for turbine operation modes: average, max, min

Preferably the turbine signal data should be provided time stamped and synchronised to an UTC time server with a sampling rate of 1 second. In case this data is provided in binary format, the format description has to be provided to ROMO Wind. If only aggregated information is available at least time stamped 10min statistic data in CSV-format (UTC+0) has to be provided. Local time zone is also acceptable, but it is mandatory that the time is synchronized to an UTC time server with maximum ±3 seconds deviation to real time. Information whether daylight saving mode is enabled or not has to be provided to ROMO Wind.

If **no** IEC 61400-12-1 or-12-2 compliant, i.e. independent and calibrated power measurement was installed at the reference turbine, this has to be communicated to ROMO Wind. In this case the lack of IEC 61400-12-1 or -12-2 compliant power measurement will be listed as deviation from the IEC 61400-12-1 or -12-2 standard.

If **no** turbine signals from 3rd party consultants can be provided for the reference turbine, this has to be communicated to ROMO wind. In this case also for the reference turbine SCADA data will be used, which will be listed as deviation from the IEC 61400-12-1 or -12-2 standard.

1.4.3 SCADA data

iSpin is measuring wind and climate quantities independent from the SCADA system and synchronises the data collection frequently with an internet time server (pool.ntp.org).

In order to evaluate the performance of the turbine it is therefore necessary to correlate iSpin wind data with time synchronised turbine data, i.e. SCADA data. Preferably this should be achieved by use of an OPC interface. If no OPC interface is available the SCADA data shall be provided as files.

The SCADA data has to fulfil following requirements to achieve meaningful results:

- Preferably the SCADA data should be provided time stamped and synchronised to an UTC time server with a sampling rate of 1 second. In case this data is provided in binary format, the format description has to be provided to ROMO Wind. If only aggregated information is available at least time stamped 10min statistic data in CSV-format (UTC+0) has to be provided. Local time zone is also acceptable, but it is mandatory that the time is synchronized to an UTC time server with maximum ±3 seconds deviation to real time. Information whether daylight saving mode is enabled or not has to be provided to ROMO Wind.
- SCADA data of the reference turbine and the other PTP wind turbines should contain at minimum the following information
  - Date and Time stamp
  - Active power: average, max, min and std.dev.
  - Nacelle wind speed: average, max, min and std.dev.
  - Nacelle position/direction: average, max, min
  - Nacelle wind direction if available: Average, max, min, std.dev.
  - Rotor speed/generator speed: if available in their given form. Degrees per second, rpm or other.
  - Pitch angle of blades: if available, in their specific format.
  - Signal/status for turbine operation mode (including: error codes or other identifiers for normal operation, various stop conditions etc.).

[1] Costs for wind tunnel calibration of nacelle anemometry for reference turbine will be borne by PTP

1.5 Project execution

Due to the amount of wind farms, the high number of different Participants and especially due to the amount of the turbines types to be equipped and evaluated with the iSpin system it is necessary to agree and support certain key requirements for successful project execution:

1.5.1 Project Members

- Each of the involved Participants must assign and identify adequate human resources (e.g. for project management, technical support, data analysis)
- Each of the involved Participants must assign/identify a project manager as point of contact.
- Each of the involved Participants must assign/identify a point of contact for data analysis and results generation/sharing

1.6 Access to the turbines

ROMO Wind requests that the Participant enables access to ROMO Wind and/or its service companies to perform the iSpin installation / commissioning and maintenance or repair work, where needed. This work will always be coordinated with site wind conditions and other service, but the Participant will have to accept that stand-still periods of the turbine will cost modest production losses. The production losses will be carried by the Participant.

1.6.1 Installation

- For the case that iSpin will be installed in a turbine type for the first time, a visit of the turbine before final installation will be necessary. This visit will always be coordinated with site wind conditions and other service, but the Participant will have to accept that stand-still periods of the turbine will cost modest production losses. The production losses will be carried by the Participant.
- Each involved Participant must accept and support the iSpin system installation within the strict time table of the project.
- Participant must gain approval and support documentation for installation of iSpin components (like drawings, specifications, HSE release, wiring diagram for power supply) from the OEM to install iSpin components in the spinner and the compass/met unit in the nacelle roof (in case turbines are still in warranty or within an availability guaranty service contract)
- If needed for offshore sites, the Participant must accept and support the installation of a nacelle based lidar system. Participant must gain approval and support documentation for installation of the nacelle based lidar (like drawings, specifications, HSE release, wiring diagram for power supply) from the OEM.

1.6.2 Maintenance and repair

- Participant must allow access to maintain and repair the iSpin systems, where needed.
- Participant must allow access to maintain and repair the nacelle based lidar systems, where needed.

1.7 Analysis and data treatment

An important part of the Performance Transparency Project is the publication of results during and after the project. Therefore each of the Participants has to:

- Accept and support that certain raw data, data analysis and anonymised reports will be made freely available after project completion
- Accept and support that the project participation will be publically known
- Accept and support the publication of anonymised performance transparency project results during and after project execution. Preferably these publications are joint publications

2 Necessary Information per PTP Wind Turbine

The selection of the wind farm turbines to be evaluated (PTP Wind Turbines) will be made by ROMO Wind and the Participant after signing the participation agreement. After this selection below requested information shall be provided per PTP Wind Turbine to ROMO Wind.

The requested information basically follows the content of data to be provided to 3rd party consultants when it comes to power curve verifications according IEC 61400-12-1 or -12-2.
The requested information can normally be extracted from the life time folder of of each turbine and should be confirmed by the turbine manufacturer. Information which can be not extracted from the life time folder should be requested from the OEM directly.

To supply the requested information completely will help to reduce eventually neccessary site inspection work by 3rd party consultants during the PTP to a minimum.

1. General wind turbine information	**Input**	**Unit**
Manufacturer		[-]
Specific type name		[-]
Serial number of tested wind turbine		[-]
Location of tested wind turbine		[-]
Coordinates of wind turbine location		[-]
Rotor axis (horizontal/vertical)		[-]
Rated power		[kW]
Power control (stall/pitch)		[-]
Hub height above ground		[m]
Hub height above foundation flange		[m]
Rated wind speed		[m/s]
Cut-in / cut-out wind speed		[m/s]

2. Rotor	**Input**	**Unit**
Rotor diameter		m
Number of blades		[-]
Swept area		m²
Kind of hub (teetered/rigid)		[-]
Type of spinner		[-]
Position relative to tower (upwind/downwind)		[-]
Rotational speed range		[rpm]
Rotor blade pitch angle		[-]
Cone angle		[°]
Tilt angle		[°]
Distance between centre of rotor and centre of tower		m

3. Rotor blades	Input	Unit
Manufacturer		[-]
Type		[-]
Serial number of rotor blades		[-]
Blade section inside /outside		[-]
Material		[-]
Blade length		[-]
Blade section depth outside, max./end		[-]
Additional components (e.g. stall strips, vortex gen., tip strips, serrations)		[-]

4. Gear box	Input	Unit
Manufacturer		[-]
Type		[-]
Serial number of gear box		[-]
Gear ratio		[-]

5. Generator	Input	Unit
Manufacturer		[-]
Type		[-]
Serial number of generator		[-]
Rated power		[kW]
Rotational speed range		[rpm]

6. Tower	Input	Unit
Manufacturer		[-]
Type		[-]
Design (lattice/tube, cylindrical/tapered)		[-]
Material		[-]
Length		[m]
Diameter tower bottom		[m]

7. Control system	Input	Unit
Kind of power control		[-]
Actuation of power control		[-]
Manufacturer of control system		[-]
Control system type		[-]
Designation of used control setup (control software version)		[-]
Seasonal depending power control (yes/no)		[-]

8. Additional information	Input	Unit
Class of current transformers		[-]
Class of power transformer		[-]
Current transducer settings for power measurement		[-]
Voltage transformer settings for power measurement		[-]
Power transducer setting		[-]
Power measurement path (w/ or w/o consumption)		[-]
Offset value of nacelle wind speed		[m/s]
Gain value of nacelle wind speed		[-]