Measuring-Network of Wind Energy Institutes

16pp01

Power Performance Proficiency Test

External Report for IECRE

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Abstract

This document presents the results of the 16pp01 proficiency test organized by Measnet in collaboration with IECRE. This proficiency test is organized according to the (already expired) standard IEC 61400-12-1:2005.

The results have been analyzed by Deutsche WindGuard Consulting GmbH acting as the conductor of the proficiency test. Measures have been taken in order to prevent the conductor from getting the results of the other institutions before having presented to the Measnet secretariat its own results.

Detailed intermediate and final results of the proficiency test have been reported in several reports issued while and after the proficiency test.

Contents

1. Introduction & Methodology

Within the framework of the MEASNET network internal quality evaluation program, the collaboration with the IECRE organization and the consideration of proficiency testing as a service offered to its customers, an power performance Round Robin exercise was organized and performed.

The following IECRE approved laboratories for power performance tests participating in this proficiency test are:

- Barlovento Recursos Naturales S.L.
- Beijing CGC Certification Center Co., Ltd.
- CEPRI – China Electric Power Research Institute
- COWI A/S
- Deutsche WindGuard Consulting GmbH
- ECN part of TNO
- GL Garrad Hassan Deutschland GmbH
- GL Garrad Hassan Iberica SL
- Moeller Operating Engineering GmbH
- SERCAL- Shanghai SERCAL New Energy Technology Co Ltd
- UL International GmbH (DEWI)
- Wind Turbine Test, Test and Measurements, DTU Wind Energy
- WIND-consult Ingenieurgesellschaft für umweltschonende Energiewandlung mbH
- Windtest Grevenbroich GmbH
- Wood (Clean Energy, “Sgurr Energy”)

Ten other non-IECRE approved laboratories and organizations have participated in some or all phases of the proficiency test.

The results have been analyzed by Deutsche WindGuard Consulting GmbH (DWG) according to the standard IEC 61400-12-1:2005 [1].

The proficiency test was performed in two Phases. Phase 1 was a preparation phase to clarify the tasks of the test and to determine pass and fail criteria to be applied in Phase 2 of the test. Phase 1 was extended by a Phase 1B and Phase 1C to check clarifications and agreements and to achieve intercomparability for the results of the topics of the proficiency test.

The applicability of pass/fail criteria given in the OD for power performance assessments [2] was checked and partially replaced by suggestions of DWG derived from the experience of Phase1B of the test. These suggestions have been derived from what DWG expects to be a conservative approach for the importance of a result and the possible degree of its determination. This was discussed in detail by DWG in [9].

1.1. Topics and Database.

The different tasks of the proficiency test require different data bases. Two comparable data bases were used for Phase 1 and Phase 2 of the test.

These data bases were provided by Deutsche WindGuard Consulting GmbH. They were a mixture of constructed and real data. In case of real data, the data was anonymised by manipulating the individual channels.

The different tasks are defined according to the requirements of the OD for power performance assessments [2].

The instructions of the several phases of the proficiency test were given in detail in the instructions documents of the particular phases [3], [5], [7] and [10].

1.2. Pass / Fail criteria.

The following aspects of the power performance testing have been covered by the proficiency test and the results from multiple test laboratories have been compared. Below there is a summary of the aspects and the pass/fail criteria applied in the last phase:

1) Site calibration factor for each end of each wind speed sector
    - Maximum allowed difference is 0.001 from median value
2) Site calibration uncertainty for each wind speed sector
    - Maximum allowed difference is 10% from median value at 6 m/s, 10 m/s and 14 m/s.
3) Filtering of data
    - Maximum allowed difference is 3 datasets from median value
4) Average power per bin, for each bin, Database A
    - Maximum allowed difference from median value is 0.2% over 3 m/s and 0.5% below 3 m/s
5) Average power per bin, for each bin, Database B
    - Maximum allowed difference from median value is 0.2% over 3 m/s and 0.5% below 3 m/s
6) AEP measured, for each Annual Average Wind Speed
    - Maximum allowed difference is 0.2% from median value
7) AEP extrapolated, for each Annual Average Wind Speed
    - Maximum allowed difference is 0.2% from median value
8) Terrain assessment on each criterion of Annex B (max slope and max terrain deviation evaluated for 4 distances)
    - Maximum absolute deviation to the median allowed is 0.2 degrees for slope and 2 % or 0.2 m (whatever is greater) for the variation
9) Determination of each end of the measurement sector by evaluation of obstacles according to Annex A
    - Maximum allowed difference is 0.2 degrees from median value
10) Determination of each end of the final measurement sector (possibly reduced measurement sector including site calibration influence)
    - Maximum allowed difference is 0.2 degrees from median value

11) Power curve uncertainty per bin as per Annex D and E

- Maximum allowed difference from median value is 10% over 4 m/s and 20% below 4 m/s

12) AEP uncertainty per Annual Average Wind Speed

- Maximum allowed difference is 10% from median value

13) In situ calibration according to Annex K, for each bin to be evaluated

- Maximum allowed difference is 0.025 m/s difference (of square sum) from median

1.3. Calendar.

Different issues have delayed the proficiency test. Being the first IECRE Proficiency test on Power Performance as well as some indefinition relating the Pass / Fail criteria have led to the necessity of three stages in Phase 1.

Phase 1:

Data Base 1A sent to participants	16.06.2016
Phase 1A results discussion	24.09.2016
Data Base 1B sent to participants	15.11.2016
Phase 1B results discussion	March 2017
Data Base 1C sent to participants	10.08.2017
Phase 1C results discussion	August 2017

Phase 2:

Data Base Phase 2 sent to participants	23.08.2018
Phase 2 results discussion	06.03.2019
Final report Issued	20.05.2019

Please note that the final report date corresponds to the date in which the conductor issued its report. Further discussions in IECRE on the content of public and restricted reports have led to delays in the release of a public report.

2. Results provided by the institutions

The participants provided their results in numerical format in designated excel tables for the particular phases.

The Measnet organization took care of the data and guaranteed that the data were treated anonymously, so the PT conductor did not know the results of the other participants in advance nor the author of each result sheet.

These results were analysed by DWG and presented in detaile in the reports of the different phases. These reports show plots and tables of statistics of the provided results for all topics and aspects [4], [5], [8] and [14].

DWG also prepared and provided excel-files to MEASNET which contain all numerical results of the institutions. These include the statistics of the participants results.

3. Evaluation of the results for IECRE Laboratories

3.1. Results of the particular topics of the PT

Twenty-one organizations participated in Phase 2 of the MEASNET IEC-RE Proficiency Test 2016. 13 of these participants were IECRE approved testing labs for power performance tests.

As stated in 1.2. Thirteen aspects and corresponding limits for the proficiency test have been defined in former IECRE OD for the assessment of testing laboratories. As a result of Phase 1 of the proficiency test these limits have been checked and adjusted. A detailed analysis about this is given in [9].

The results of each participant in terms of pass/fail criteria are shown in the following table. The table shows whether the results determined and provided by the participants are within the limits defined in [9].

86 % of the tasks assigned to all the Technical laboratories were fulfilled producing results within the given limits. A weighting regarding the relevance of the different aspects is not defined. Hence, a ranking of the participants is not evident or at least difficult by the number of passed tasks.

Three laboratories completed all the tasks without any deviation and four other had only one or two deviations.

An assessment of aspect 5 was not possible because the data to be analysed did not contain data for database B.

Table 1, below, summarizes the results of those participants that belong to the Technical Laboratories group.

Participant			a	b	c	e	f	g	h	j	m	n	r	s	t	
A 1	SC factor		x	x	x	x	x	x	x	x	x	x	x	x	x	100%
	remark	Valid Secto	x	x	x	x	x	x		x	x	x	x	x	x	92%
A 2	SC uncert	6 m/s	x	x	x	x	x	x	x	x	x	x		x	x	92%
	SC uncert	10 m/s	x	x	x	x	x	x	x	x	x	x		x	x	92%
	SC uncert	14 m/s	x	x	x	x	x	x		x	x	x		x	x	85%
A 3	Filtering		x	x	x	x	x		x	x	x	x	x	x	x	92%
A 4	Power bin, DB A	Ref. dens.	x	x	x		x	x	x	x	x	o	o	o	x	92%
		Site dens.	x	o	x		x	x	x	x	x	o	o	o	x	92%
												x	x	x		
				x								x				
A 5	Power bin, DB B	Ref. dens.	na	na	na	na	na	na	na	na	na	na	na	na	na	
		Site dens.	na	na	na	na	na	na	na	na	na	na	na	na	na	
A 6	AEP measured		x			x	x	x		x	x	x		x		62%
A 7	AEP extrapol		x			x	x		x	x	x	x		x		62%
A 8	Terrain, slope		x	x	x	x	x	x	x		x	x	x	x	x	92%
	Terrain, variation		x	x	x	x	x	x	x		x	x	x	x		85%
A 9	Obstacles		x	x	x	x	x	x	x	x	x	x	x	x	x	100%
A 10	Obst, final sect		x	x	x	x	x	x	x	x	x	x	x	x	x	100%
A 11	PC uncert	Ref. dens.	x	x			x	x	x		x	x	x	x		69%
		Site dens.	x	x			x	x	x		x	x	x	x	x	77%
A 12	AEP uncert		x	x		x	x	x	x	x		x	x		x	77%
A 13	In situ test		x		x	x	x	x	x	x	x	x	x	x	x	92%
		Sum	17	14	12	13	17	15	15	13	16	17	12	16	13	
		Rate	100%	82%	71%	76%	100%	88%	88%	76%	94%	100%	71%	94%	76%	86%

Table 1: Summary of the assessment. “x” represents that a participant passed an aspect. Empty fields indicate that results are out of limits. “o” is for passing an aspect with a remark. Sum shows the number of passed aspects. The right column shows the percentage of the passed participants of the aspects.

3.2. Results of the merged topics of the PT

No pass/failed criteria for the whole proficiency test had been defined before the issuing of these results presented in the table above and report [11]. Therefore a continuative procedure was initiated and conducted by MEASNET. This procedure and the corresponding results are summarized and shown in the following.

MEASNET asked the participants to send information (on optional basis) regarding their outliers as specified in previous chapters of this report.

The participants were asked to

- explain their outliers
- categorize them by
  - different interpretation of the standard/task
  - unclear description of task
  - unthougtful-ness (e.g. copy paste error, typo...)
  - wrong methods of calculation
- and to provide a correction plan

The answers of the participants were collected and provided in the Outliers Explanations Report for Power Performance PT 2016 [12].

At a telephone conference with all participants a summary and evaluation document of these outlier explanations was discussed [13]. This summary and evaluation document contained common aspects from A to E and detailed aspects 0 to 20. An error point system was designed in this regard. For each of these aspects certain error points were specified for mistakes done by the participants. This error point system was discussed in detail during the telephone conference (2019-06-03). In a few regards the error points were changed in consensus.

As its result a table was prepared which shows the error points of the participants (see Table 2, which was provided by MEASNET). The columns are according the common and detailed aspects listed in [13].

All IECRE laboratories took the chance to resolve their errors. It was agreed with consensus, during the telephone conference, that all participants who provided reasonable correction plans for all their error points would be considered as passed the IEC-RE Power Performance Testing Proficiency Test 2016. If correction plans were not presented, the participant would be considered as to have failed the Proficiency Test.

After the correction plans were presented all IECRE laboratories passed the Proficiency Test.

Item code	Evaluated aspect
A	AEP measured, AEP extrapolated and AEP uncertainty: Binning issues
B	Power curve uncertainty and AEP uncertainty: Power transducer issues.
C	Site calibration uncertainty: Use of K factor
D	Site calibration uncertainty: Data logger uncertainty
E	Air density calculation: Humidity not considered
1	*In situ* Test: incorrect application of sector
2	Incorrections in obstacle assessment
3	Data filtering: consideration of certain data as corrupted
4	Transcription error
5	Terrain deviation evaluation error
6	Wrong methods of calculation in terrain evaluation
7	Use of wrong reference for the wind speed sensitivity calculation
8	AEP uncertainty calculation: Power Transducer component issues
9	AEP uncertainty calculation: Anemometer component issues
10	Transcription error related to wind direction filtering
11	Problems in the consideration of obstacles
12	Script not used correctly
13	*In situ* test values application issues
14	AEP uncertainty calculation use of different formula issues
15	Reference air density input in the uncertainty issues
16	Transcription errors in the results presented
17	Use of wind speeds outside measured range in the AEP calculation
18	Normalization of data issues (PT task interpretation)
19	Final results transcription error
20	Undescribed errors

Table 2: Deviations found during the evaluation of participant's results. A through E are issues found in more than one participant. 1 to 20 are issues that affect only one participant.

RETL	Evaluated items																								Total
	Common aspects					Detailed aspects																			
	A	B	C	D	E	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
a																									*	*
b	0.5					1																				1.5
c	0.5	*																								0.5+*
e		*			1																					1+*
f																									*	0+*
g								*	0.5																	0.5+*
h			1																			*				1+*
j										0.5	1	1														2.5
m													1													1
n																									*	0+*
r	0.5			0.5																						1
s																			1							1
t	0.5																			0.5	0.5					1.5

Note: * Indicates an item passed with a remark involved.

Table 3: Number of resolved error points of the RETL participants. All the RETLs provided correction plans for the listed errors.

3.3. Statistics regarding the AEP values.

Focusing on topic 6, AEP measured, for each Annual Average Wind Speed, it is interesting to present the following numerical values:

v-average [m/s]	Median [MWh]	Average [MWh]	Std [MWh]	Max [MWh]	Min [MWh]	Range [MWh]
4	311,07	311,32	0,42	311,99	311,07	0,92
5	797,23	797,40	0,29	797,86	797,20	0,66
6	1458,28	1458,41	0,20	1458,73	1458,28	0,45
7	2193,43	2193,58	0,25	2194,29	2193,40	0,89
8	2904,84	2905,16	0,98	2908,68	2904,80	3,88
9	3519,32	3520,05	2,63	3529,55	3519,30	10,25
10	3996,01	3997,37	5,10	4015,79	3996,00	19,79
11	4324,61	4326,72	8,02	4355,72	4324,60	31,12

Table 4: Calculation of AEP measured without removing the ouliers.

It is important to note that the differences above 4 m/s are caused by the result of a single laboratory. Taking this oulier out the result is as follows:

v-average [m/s]	Median [MWh]	Average [MWh]	Std [MWh]	Max [MWh]	Min [MWh]	Range [MWh]
4	311,07	311,34	0,43	311,99	311,07	0,92
5	797,23	797,41	0,30	797,86	797,20	0,66
6	1458,28	1458,41	0,21	1458,73	1458,28	0,45
7	2193,43	2193,53	0,16	2193,77	2193,40	0,37
8	2904,84	2904,91	0,12	2905,10	2904,80	0,30
9	3519,32	3519,38	0,10	3519,52	3519,30	0,22
10	3996,01	3996,06	0,08	3996,18	3996,00	0,18
11	4324,61	4324,65	0,07	4324,75	4324,60	0,15

Table 5: Calculation of AEP measured removing the single oulier laboratory above 4 m/s.

4. Clarification Sheets

During this Proficiency one Clarification Sheet has been issued:

- "Determination of uncertainty in wind speed bins of Power Curve" referring to Annex E and Formula E.20

5. References

[1] IEC 61400-12-1, WIND TURBINE GENERATOR SYSTEMS, Power performance measurements of electricity producing wind turbines, 2005

[2] IECRE OD-551-12, Edition 1.0, IECRE, 2016-02-26

[3] MEASNET IEC-RE Proficiency Test 2016, Phase 1, Power Performance Testing, Instructions, Deutsche WindGuard Consulting GmbH, 2016-06-16

[4] MEASNET IEC-RE Proficiency Test 2016, Phase 1: Results Power Performance Testing, Deutsche WindGuard Consulting GmbH, PP16072.B0, 2016-09-12

[5] MEASNET IEC-RE Proficiency Test 2016, Power Performance Testing, Phase 1B: Effectivity of Clarifications and Determination of Limits, Deutsche WindGuard Consulting GmbH, 2016-11-15

[6] MEASNET IEC-RE Proficiency Test 2016, Phase 1B: Results Power Performance Testing, Deutsche WindGuard Consulting GmbH, PP16112.A0, 2017-01-17

[7] MEASNET IEC-RE Proficiency Test 2016, Phase 1C, Power Performance Testing, Instructions, Deutsche WindGuard Consulting GmbH, 2017-08-10

[8] MEASNET IEC-RE Proficiency Test 2016, Phase 1C: Results Power Performance Testing, Deutsche WindGuard Consulting GmbH, PP17057.A0, 2017-11-23

[9] Comments to Aspects and Limits for MEASNET IEC-RE Proficiency Test 2016 Power Performance (PTPP-Phase1-AspectsAndLimits-V2.pdf), Deutsche WindGuard Consulting GmbH, 2018-10-01

[10] MEASNET IEC-RE Proficiency Test 2016, Phase 2, Power Performance Testing, Instructions, revised Version v2, Deutsche WindGuard Consulting GmbH, 2018-10-17

[11] MEASNET IEC-RE Proficiency Test 2016, Phase 2: Results Power Performance Testing, Deutsche WindGuard Consulting GmbH, PP18104.A2, 2019-01-24

[12] IEC-RE, Outliers Explanations Report, Competence Area Power Performance, Proficiency Test 2016, “16PP01 outliers explanations report_19.03.04.pdf”, MEASNET, 2019-03-04

[13] IEC-RE, Outliers Explanations Report, Competence Area Power Performance, Proficiency Test 2016, “Findings from 16PP01 outliers explanations report_19.03.04_vAV.odt”, MEASNET

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