Measuring-Network of Wind Energy Institutes

Findings of Inter-laboratory Comparison of Site Calibration calculations according to IEC 61400-12-1, Edition 2

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Prepared by K. Papadopoulos, International Wind Engineering

1. INTRODUCTION

The MEASNET Expert Group on Power Performance has organised an internal exercise during 2019-2020 regarding the Site Calibration Procedure according to Annex C of IEC 61400-12-1 (Edition 2, 2017). The purpose of the exercise was the investigation of different interpretations of the new methodologies among the group members.

2. REFERENCE MEASUREMENT PROCEDURE

IEC 61400-12-1, Edition 2, 2017-03: Wind energy generation systems- Part 12-1: Power performance measurements of electricity producing wind turbines (Annex C- Site Calibration Procedure).

3. ORGANISATION OF THE EXERCISE

3.1 Scope

The scope of the exercise was to compare results for both methods of the site calibration analysis as defined in the standard:

- Method 1: Bins of wind direction and wind shear
- Method 2: Linear Regression method where shear is not a significant influence

Referring to the standard, the scope addressed the following aspects:

- Clause C.5.1.2: Assess significance of shear
- Clause C.5.2: Method 1
- Clause C.5.3: Method 2
- Clause C.5.4: Additional calculations
- Clause C.6.1: Site calibration category A uncertainty
- Clause C.7.1: Convergence check
- Clause C.7.2: Correlation check for linear regression
- Clause C.7.3: Change in correction between adjacent wind direction bins

3.2 Input Datasets

Three different datasets were analysed for the full scope of Section 3.1. The datasets correspond to differing terrain types in order to consider the special conditions that may be encountered:

- Dataset 1: Terrain of low complexity
- Dataset 2: Terrain with medium complexity
- Dataset 3: Very complex terrain

3.3 Required Analysis

The participants were asked to analyse each dataset, to provide results for both Method 1 and Method 2, to conclude if shear is significant and to decide which Method of analysis they would apply in each case.

4. PARTICIPANTS

Eleven laboratories participated in the exercise:

Barlovento	CEPRI	DNV-GL
DWG	IWE	LME-Circe
TNO	UL	Wood
Wind Consult	WindTest Grevenbroich	

5. ASSESSMENT OF RESULTS

Table 5.1 Presentation of the Inter-laboratory comparisons for Site Calibration calculations

Task	Result	Key points
Selection of valid records for the Site Calibration Database	OK	The data filtering and data binning (e.g. above/below 8 m/s, number of records > 11 m/s) shall be based on the wind speed of the TURBINE mast (not the reference mast).
Calculation of flow correction factors in Method-1 (wind speed ratio) and Method -2 (linear regression parameters)	OK	Agreement within ~0.01%.
Evaluation of temporal convergence of the flow correction parameters	Agreement ranging from 50 to 100%. Deviations with increasing terrain complexity.	The check does not affect results or uncertainties. But may affect the decision for inclusion/ exclusion of sectors.
Uncertainty due to change of flow correction factors between adjacent direction bins	OK	Increased care required when applying Eqn. C.7. Clarify when this component is applied (although the contribution should be negligible in most cases).
Application of k-fold analysis for Type-A uncertainty	OK	Generally small magnitude (<0.05 m/s) compared to Type-B. The degrees of freedom definition in the standard needs to be clarified/corrected.
Assessment of shear significance	OK	The decision rules are not clear in the standard. Participants followed a few different paths which led to similar decisions for the datasets analysed.
Selection of Method (1 or 2) for analysis	OK	The final decision is taken by the analyst with proper documentation. A method uncertainty component might be introduced to assess the effect of the Method Selection to the final PC/AEP result.

6. TARGET LIMITS

The target/acceptance limits for any comparison should be considered in terms of plausibility and in terms of their effect on the end result. The end result is not the site calibration itself but the power curve and AEP calculations. When dealing with the intermediate results of the site calibration, one has to keep in mind their effect on the end result.

The site calibration affects the wind speed. The wind speed is the dominant driver not only for the AEP value but also for the AEP uncertainty. Obviously, the effect diminishes for wind speeds higher than the rated speed (for pitch-controlled turbines). The below proposed target values for the deviations in SC calculations from different laboratories ensure that the respective target values for PC and AEP calculations are not compromised.

Table 6.1 includes the plausible pass/fail criteria for the calculations pertinent to the site calibration procedure.

Table 6.1 Plausible limits for deviations in Inter-Laboratory Comparisons assessing the Site Calibration procedure

Parameter	Max deviation limit	Comment
Data sorting-binning	±1 record	Intermediate calculation. Identifies if participants used the same records in their analysis. The range limits of any binning categorization shall be clearly defined. When calculated variables are used for the binning (e.g. wind shear) there may be adjacent cells of the matrix which might show deviations of more than 1 record. This should not be considered a limit violation; the results mainly serve the purpose of locating the source of deviations in subsequent results of the analysis.
Wind speed ratio (Method 1)	±0.001	Has to be checked in every cell of the wind sector/wind shear matrix which fulfils the completion criteria. Translates to 0.01m/s at 10 m/s.
Regression parameters (Method 2)	Slope: 0.001 Offset: 0.001 m/s	Has to be checked in every completed sector. Translates to 0.01m/s at 10 m/s.
SCP-, SCP+		Intermediate values. No limit required.
$u_{VT,coc}$	0.001	Corresponds to 1/5 of the uncertainty when the flow correction factor deviates by just above 2% between adjacent sectors. Translates to 0.01m/s at 10 m/s. Limit could be relaxed.
s_{SC}	0.01 m/s	Small effect on site calibration uncertainty. This check could be informative and could not count in the scoring scheme.
Method selection	Informative comparison	Should not be part of PTs as long as there is no consensus on the criteria to be followed. It is implied from the standard and confronted by the experts in their everyday analysis that several criteria might affect the decision.
Establishment of completed sectors	Identical sectors for Method 2. Identical cells of the matrix in Method 1.	It is important because it affects SCP calculations, $u_{VT,coc}$ and most importantly the sector to be used in the power performance test.