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FGW TC WP- resolution for
technical guideline TG 6 Rev. 9

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FGW Technical Committee for Wind Potential (TC WP) – resolution of 21th of September 2016:

The TC WP votes for the following supplement to revision 9 of the technical guideline part 6 (TG 6).

Appendix D "Long-Term Correction (Informative)" is added to the revision 9 of the TG 6.

On behalf of FGW TC

Bente Klose

Appendix D Long-Term Correction (Informative)

D.1 REQUIREMENTS FOR METHODS FOR LONG-TERM CORRECTION

When assessing the wind potential historical wind data is generally adopted to determine the anticipated mean wind and yield conditions during the future operational lifetime of the planned wind turbine. The fundamental assumption is made that historical wind conditions will also exist in the future (persistence assumption[3]). Because wind conditions vary from year to year, it is necessary to adopt sufficiently long periods for both the measurement data and in terms of the project duration. It generally makes sense to adopt periods of more than ten years. However, even mean values over extended intervals are not constant, although the fluctuations become substantially smaller with longer averaging intervals. For this reason, and because the operational lifetime of the planned wind turbine is limited, a relevant forecast in a climatological sense can only be made if the anticipated fluctuation range of the identified long-term wind conditions is also determined and is introduced into the uncertainty assessment as the standard deviation for the long-term value.

Because a project-specific wind measurement for assessing the wind potential is generally limited to a short period, it is vital that it is adapted using long-term climatological data in terms of seasonal and interannual variability. In the same manner, yield data from reference wind turbines used as short-term data shall be corrected to the long-term using a suitable method, i.e. the long-term energy yield of the reference wind turbine shall be determined. Such an adaptation can be performed with the aid of suitable reference data, which are representative of the same wind climate and which cover both a very long period and the measurement or operating period on the site.

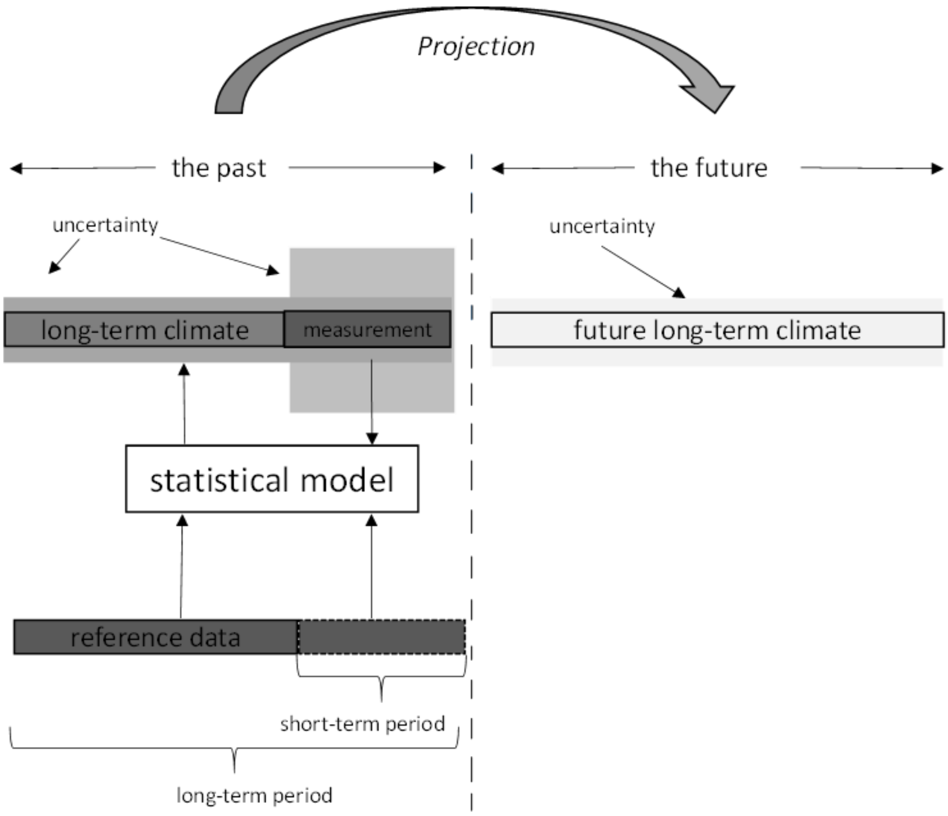

Figure D–1: schematic procedure for long-term adaption

[3] The assumption of persistence does not take into consideration any long-term climatic changes (e.g. increased CO_2). However, climate simulations only reveal minor impacts in terms of energy yield for the wind potential.

A statistical relationship between the measurement and the reference data is derived for the overlapping period for the purpose of long-term correction (Figure D–1). Applying this statistical relationship to the long-term period covered by the reference dataset returns the anticipated long-term wind climate at the measurement location. It should be noted that applying the statistical relationship to the reference dataset shall be limited to a long-term period for which the consistency of the reference dataset can be sufficiently tested. The consistency test shall be performed and presented with the aid of at least one, independent of the first, additional suitable reference dataset. The data from site-specific wind measurements or reference wind turbines are referred to here as short-term data. The additional data adopted and covering a long-term period is known as long-term or reference data.

D.1.1 SHORT-TERM DATA

Currently, short-term data includes:

1. Site-specific wind measurements with wind speed and direction, also temperature and air pressure
2. Yield data from reference wind turbines (incl. availability data and information on operating modes)

The short-term data shall fulfil the requirements described in Section 2.2.

D.1.2 LONG-TERM DATA / REFERENCE DATA

The following data types may be considered as long-term data:

1. Long-term wind measurement data (e.g. from weather services)
2. Reanalysis data
3. Mesoscale analyses (spatial refinement of the above reanalyses by means of higher resolution flow simulations)
4. Long-term yield data from wind turbines
5. Yield or wind indexes derived from wind turbine yield data or wind data

The long-term data shall fulfil the following requirements:

1. The long-term data must be representative of the wind climate on the site. This means that the long- and short-term data must display a physical and quantifiable relationship. The representativeness of the long-term data shall be verified using statistical methods, for example by the correlation coefficient r or the coefficient of determination r^2.
2. The long-term data shall be temporally consistent. In this context, ‘consistent’ means that the long-term fluctuations in the wind energy supply must be realistically modelled by the adopted data and not be distorted by data errors (e.g. by changes in the measurement environment or equipment) or display unrealistic trends or leaps. In particular, the long-term data must reflect the differences between the short- and the long-term as exactly as possible. If data sources with these types of data errors are used for long-term correction, this may lead to substantial errors when determining the wind energy supply.

   The consistency of the long-term data shall therefore be examined quantitatively and tested for plausibility and be verifiably described in the report. Such testing is only possible by comparing two or more independent, long-term datasets. Only if the long-term correction results achieved using the individual datasets are mutually confirmed with as few deviations as possible can any falsifying effects due to data errors, such as incorrect leaps or trends, for example, be minimised. The deviations in the results achieved using the individual datasets provide an indication of the uncertainties associated with the long-term data. The results of consistency testing must be quantitatively documented in the report. Such comparisons can only verify the consistency of the long-term data for the period jointly covered by this data. If one dataset comprises a longer period, consistency testing is not possible for this period. Additional information such as station inspections or measurement logs helps to investigate the consistency and stability of the long-term data, but on its own is insufficient to ensure long-term consistency.

The final dataset used for the long-term correction must be verified by at least one additional, independent dataset[4]. If a mean value from several independent datasets is used for the long-term correction, it is sufficient for these datasets to be used for mutual verification. Reliable testing of long-term consistency is not possible using one single long-term dataset alone. This also applies to the case that during testing, datasets must be excluded as being obviously erroneous and only a single dataset could be used for long-term correction. This dataset may also contain errors, which cannot be recognised because of the lack of comparison with independent data. If only one dataset is actually available for long-term correction, the result of the long-term correction must be regarded as highly unreliable and be taken into consideration in the long-term correction by a suitably high uncertainty.

3. Depending on the methodology used, a high temporal (hourly) resolution range often makes sense when using wind data for long-term correction. Due to the non-linearity of the wind turbine power curves, long-term harmonised wind speed and wind direction frequency distributions are required to calculate energy yield, which realistically model the variability of the wind, including daily and annual trends.
4. When using yield data for long-term correction, the influence of wind variability is already modelled by the yield data. Mean monthly operating data and yield indexes can therefore be regarded as sufficient. However, wind turbine availability must be taken into consideration here. Monthly data with (temporal) availabilities below 90 % shall be excluded from the analysis.
5. If measured air pressure and air temperature data are adopted to determine a representative long-term air density, a long-term correction with suitable long-term data is recommended.

The quality, consistency and suitability of the long-term data for the case at hand is crucial to the result of the long-term correction.

D.1.3 COMPARISON PERIOD

The overlapping period between short- and long-term data is known as the comparison period. The comparison period must encompass all relevant weather conditions and the prevalent ranges of wind speed and wind direction. In order to remain independent of seasonal fluctuations, data covering at least one year, measured at the site, is generally required. Long-term corrections in the context of this section, with comparison periods of less than 12 months are associated with high uncertainties, such that wind potential and energy yield estimates made solely on this basis are only preliminary estimates. This is particularly the case if no high-resolution temporal data is available and/or large deviations occur in the long- and short-term data wind climate. Where highly detailed MCP methods (e.g. direction-dependent, non-linear) and high-quality reference data is used, i.e. high-resolution time series highly representative of the site, shorter comparison periods may also be sufficient. This must be demonstrated in the analysis and taken into account in the uncertainty assessment.

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[4] For example, data acquired from dynamic downscaling methods, driven by reanalysis data, cannot be regarded as being independent of the underlying reanalysis data.

D.1.4 REFERENCE PERIOD

The reference period is the period of time to which the short-term data refers, with the help of long-term correction. The reference period should show a long-term representative wind regime. Periods of at least 10 years should be aimed for. However, with the increasing length of the reference period, the danger of impaired reference data as a result of unrealistic trends and data leaps increases. It may be necessary to deal with the affected periods separately or to reduce the length of the reference period. The use of long-term data shall be limited to the period verified as being consistent. A compromise between the stability of the long-term climate and the reliability of the data is required, which must be decided on a case-by-case basis. In special cases it may make sense to shorten the reference period to less than 10 years. The length of the reference period must be taken into consideration in the uncertainty assessment, taking temporal variability into account.

D.1.5 PROCEDURES FOR PERFORMING LONG-TERM CORRECTION

A procedure for performing a long-term correction shall fulfil the following requirements:

1. The modelling algorithm, i.e. the relationship between short- and long-term data for long-term correction, must be clearly defined and validated. Validation shall be performed using long-term measurement series'.
2. The method must deliver a clear statistical relationship between long- and short-term data for the comparison period. The modelling algorithm must reflect the distribution characteristics of the short-term data.
3. The uncertainties due to the applied method shall be estimated.

Two groups of procedures for producing the long-term correction are to be distinguished.

1) MCP methods (Measure-Correlate-Predict):

Using these methods, a statistical relationship is derived by comparing measurement and reference within the comparison period. Its application to the long-term reference returns the required long-term climate for the measurement (including time series', frequencies, etc.). Among others, MCP methods include:

- Regression analyses based on time series. These may also be direction-dependent or non-linear.
- Matrix methods are based on the comparison of wind direction and speed frequency distributions to derive the statistical relationship between measurement data and reference. A realistic estimate of the distribution functions is important even for low data coverage. It should be noted that not every matrix method possesses sufficient conservation properties in terms of the statistical moments of the frequency distribution.
- Non-linear methods such as neuronal networks, for example.

Generally, MCP methods require high temporal data resolution and sufficient data coverage for all energy relevant wind statistics components. The adopted MCP method should be capable of reproducing the original measurement data without substantial errors, for example the mean, variance and direction distribution. Energy conservation must be ensured by the method used. A simple linear regression of the wind speed is not initially energy conserving. Any formation of a temporal mean value also reduces the kinetic energy contained in the wind data compared to the ten-minute means usual when determining the wind yield. If this method is adopted, additional measures for guaranteeing energy conservation are needed. The quality of the correlation often does not allow the use of complex MCP methods or high-resolution data.

2) Scaling methods based on integral values:

A simple statistical relationship is derived by comparing the mean values of the short- and long-term reference periods, e.g. their ratio. Its application to mean short-term measurement data returns the required mean values of the long-term measurement data. This method is limited to its application on integral parameters such as mean values. Among others, scaling methods include:

- The application of a yield index, such as the BDB index of the operator's data [7]. Such an index can be derived from real operating results or other reference data via empirical relationships (e.g. the correlation of wind and yield) or physical models (conversion of wind into yield). The application of yield indexes requires data with at least a monthly resolution.
- The scaling of measured mean wind speeds, the Weibull parameters A and k, or of frequency distributions.

Even when using scaling methods it must be ensured that a relevant statistical relationship exists between the measurement and the long-term data. The quality of the relationship can be measured using correlations, for example, such as between the yield index and the yield data. When using scaling methods, in particular, the comparison period should be at least one year, because differences in the distributions between short- and long-term periods, for example different direction distributions, are otherwise not incorporated. Energy conservation and correct direction distributions may otherwise not be guaranteed by scaling methods and contribute to an increase in uncertainties.