Financing for wind farms: making consistent use of empirical values

Words: Thomas Arnold and Thomas Zirngibl, TÜV SÜD Industrie Service GmbH

The recently revised TR6 Technical Guideline of the German Public Association of the Renewable Energy Sector (Fördergesellschaft Windenergie (FGW)) is designed to ensure the provision of reliable yield forecasts. Wind reports based on the Guideline play a critical role for producing reliable estimates of the profitability of a wind-farm project. In the past, turbines have often been shown to deliver lower energy levels than their reported estimates. The ninth revision of TR 6 now specifies methods that will help to produce realistic forecasts of actual on-site wind conditions.

Wind speed and direction at the proposed site of a wind farm are critical factors in determining whether wind farm operation will be cost-effective over the long term. Previous practice has shown that measurements and evaluations of wind and weather data may be over-optimistic, favouring the stakeholders' own interests. At least two wind reports issued by third-party organisations are therefore necessary to convince banks and investors of the profitability of a wind-farm project in order to secure financing.

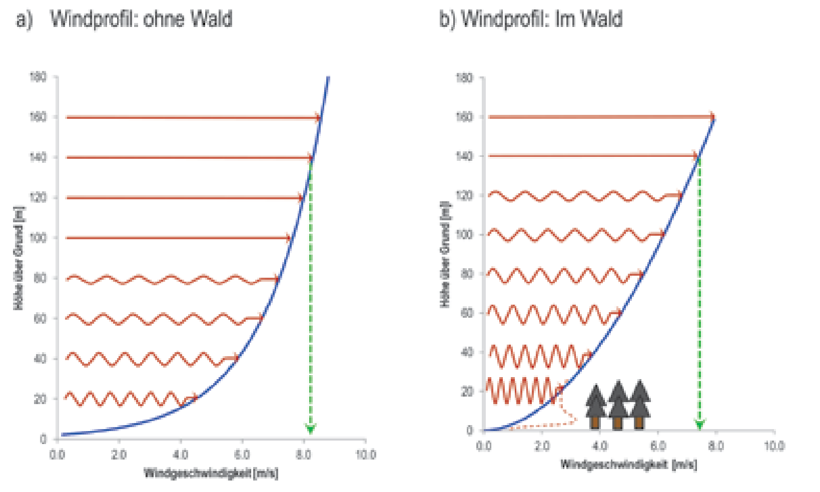
Independent accredited assessors are therefore commissioned to verify the yield forecast of a planned project. As these forecasts are always based on varying project-specific facts, figures and data, their evaluation involves some key questions: What is the quality of the available input data? What measurements were performed at the site, and over what period? Is that period representative, allowing conclusions to be drawn regarding annual yields and forecasts to be prepared for twenty years of operation? Are wind energy turbines already in operation there, and can they be used to validate the model? What methods of analysis were used in evaluation? All in all, assessors must establish whether the information about the project, the future site and its environs is sufficient to allow a realistic yield forecast to be drawn up.

New regulations provide for higher planning certainty

The Technical Guideline has addressed these issues, specifying normative requirements and establishing methodological approaches. However, experience from earlier projects

Figure 1 Generally wind speed increases with height above ground. However, the degree of this increase varies from site to site and depends on a host of factors, including topography (e.g. forested areas).

Figure 1



Windprofil: ohne Wald	Wind profile, unforested area
Windprofil: Im Wald	Wind profile, forested area
Höhe über Grund	Height above ground level
Windgeschwindigkeit	Wind speed

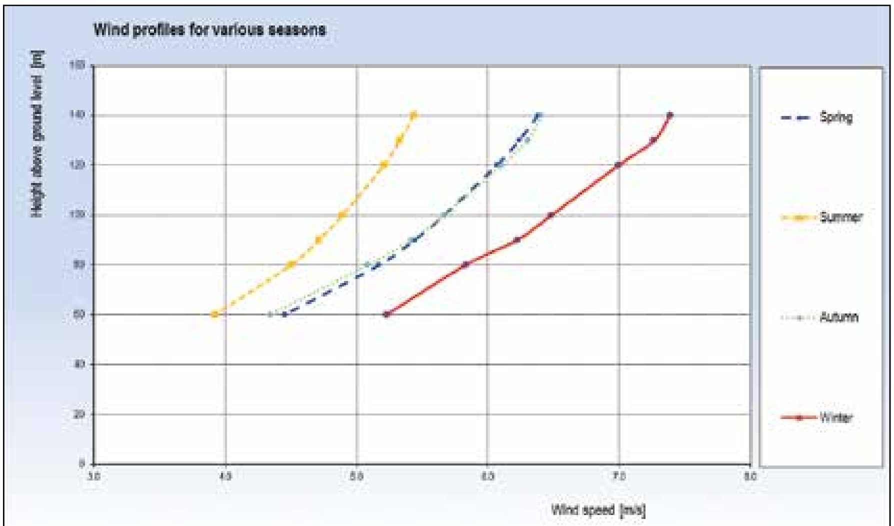


Figure 2 shows the wind profiles of a site at different seasons. The figure clearly shows several effects, including that wind blows more strongly in winter. The increase in wind speed at higher layers of the atmosphere is likewise more pronounced in winter.

and the operating practices of many wind farms have shown that in the past, excessively broad scope for interpretation and individual judgement was left open in many cases – extending to the assessors examining and verifying the yield forecasts. For example, in some cases various interpretations of specifications were possible. The Federation of German Wind Power and Other Renewable Energies (FGW) corrected and eliminated this problem by issuing a revised version of the Technical Guideline, Part 6, last September, which included important empirical information from previously realised projects.

The Technical Guideline TR 6 has normative status for wind reports. The 9th Revision now contains more clearly worded specifications governing input data as well as new, stricter criteria. For example, the designation of “Wind Report” may only be applied to documents that use the yield data of other wind-energy turbines (“validation turbines”) or wind measurements that are no more than ten kilometres from the planned site. The more complex the topography of the territory, the stricter the requirements. For example, this maximum distance is reduced to only two kilometres in cases where gradients exceed ten per cent or where the altitude between the turbines used for the database and the planned turbine site differs by more than 50 metres.

The Technical Guideline revision also clarified the ratio between the hub height applied in actual measurements and the hub height of the planned turbine. Measured data and yield data can now no longer be simply extrapolated and applied to a different height level; instead, valid and scientifically sound methods are required. In the past, the Guideline’s broad scope for individual judgement allowed validation turbines at large distances from the site under examination to be used for calculations. Distances of up to twenty kilometres, or even more in exceptional cases, were common – even though the sites were by no means comparable in terms of topography and wind conditions. This frequently resulted in excessively high yield forecasts. The revisions now introduced to TR 6 have solved this problem and thus provide investors with a significantly higher degree of planning certainty.

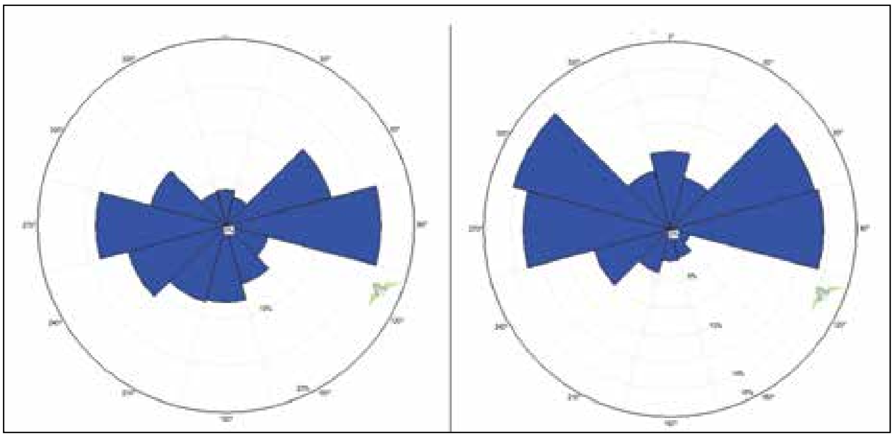


Figure 3 shows an example of the frequency distribution of wind directions for an entire year (left) and a three-month measurement (right), given in per cent per 30° sector. Where large variations in distribution occur as here, corrective actions are permitted according to FGW TR6 provided the data are filtered primarily from the sectors of the secondary directions of wind while the data from the main directions of wind remain unchanged. Following the corrections, as a minimum requirement the data set must correspond to an effective measurement period of at least three months to ensure the results are in conformity with the FGW requirements and thus valid.

Efficient generation of valid data

However, the project managers, planners and operators are now faced with new challenges. What happens if the validation turbines are located at a distance of 11 kilometres from the planned site? Under the new stricter guideline provisions, the measurement and operating data from the surrounding area previously used to calculate yield forecasts can no longer be used in analyses, as they no longer comply with distance requirements. In this case, individual wind measurements would have to be performed, potentially involving six-figure costs. If no comparable validation turbine is available within the required distance, this method certainly delivers the best and most informative data – but is also the most costly. In this case, then, an efficient and effective alternative is required that is also guaranteed to deliver high-quality and informative data.

TÜV SÜD's wind-energy experts have developed a new method that can be applied in large numbers of cases and fulfils all the criteria of the new FGW TR6 Guideline. Instead of high-cost long-term measurements using a measurement mast, the method makes use of light detection and ranging (LIDAR)-based wind measurements over shorter periods and incorporates data from the German Weather Service. Data from wind farms at greater distances – which are not sufficient in themselves to meet the requirements of FGW TR6 – are complemented by LIDAR measurements at the site, verified and underpinned with statistical information. Reliable forecasts can be drawn up on this basis.

Taking repowering as an example, in this situation the wind conditions at the site are largely known because conclusions can be drawn from the data collected over years of operation of existing wind energy turbines and their yields. However, the question is whether these conditions can be extrapolated to the higher atmospheric layers and, if so, to what extent. Those higher layers are where the wind power is generated, and as the height of the layers increases, wind speeds change in different ways depending on the terrain. The wind profile, which maps wind speed in relation to height above ground [Figure 1], is site-specific and depends on a whole series of factors, particularly including the structure of the terrain at the site (orography, topography, surface roughness and, where applicable, the trees in a forest) as well as parameters of atmospheric layering and wind direction.

Seasonal influences

The last two factors may even display strong variations at one and the same site, as climatic conditions in winter differ from those in summer and wind profiles are closely related to the seasons. Depending on the wind farm's position, wind direction may also play a major role; this applies particularly if the wind farm is located in the lee of forests, hills or mountain ranges. An evaluation of data collected from wind measurements must describe and consider all these variables and climatic parameters. If long-term measurements are not used, it is essential to compare the collected data with annual or long-term data to provide statistical confirmation.

If these aspects are consistently addressed, the required data from the upper atmospheric levels can often be generated within relatively short periods of three to six months. However, the precise duration of measurement cannot be specified in advance, as it depends on the climatic conditions prevailing during the measurement period and the various weather conditions. Meteorology differentiates between stable, neutral and unstable systems of atmospheric layers, which are created by the differences in

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temperature between near-ground and higher layers of air and have significant impacts on wind systems and wind profiles – i.e. wind speeds at various heights.

Mapping characteristic seasonal features

For wind measurements with LIDAR systems, this means that the measurement period must include all possible types of atmospheric layering in the proportions that are characteristic for the course of a year. To ensure that results are representative of conditions throughout the year and are analysable and informative, representative minimum periods must be established for each layering system. As layering systems and wind directions are not a local phenomenon, and thus not restricted to the site of measurement, data from the German Weather Service for the larger region can also be used.

		12 months Sep '12 - Aug '13	3 months Mar '13 - May '13	Difference	Evaluation
Class	Layering system	Frequency [%]	Frequency [%]	Frequency [%]	Sum Difference
1	Very stable	16,91	14,84	-2,07	∑=3.69
2	Stable	28,91	26,67	-2,23	
3	Neutral-stable	23,62	24,72	1,10	
4	Neutral-unstable	18,55	25,44	6,89	
5	Unstable	7,65	7,24	-0,41	∑=-3.69
6	Very unstable	4,37	1,09	-3,27	

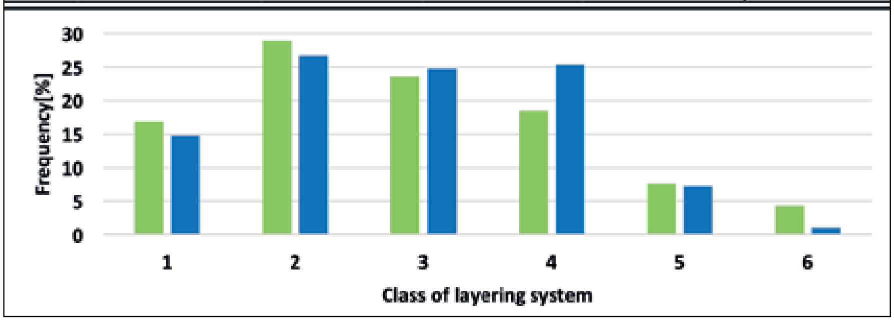

Figure 4 shows the frequency distributions of the various atmospheric layering systems for measurement periods of one entire year (green) and three months (blue) based on the data in the table. The deviation from the annual average is given in the "Difference" column. As stable and neutral layering systems result in similar wind profiles, the values in the "Difference" column in classes 1 to 4 and 5 to 6 can be added (last column "Evaluation"). The maximum limit for this total is set at 5%, ensuring that unstable layers are adequately considered.

Long-term measurement series including measurement periods provide information on the frequency and seasonal distribution of different climatic conditions, and can be put in relation with the LIDAR measurement period and continuously compared. When comparison of the data shows that these data map a representative period, measurement can be terminated. This method enables a reliable wind profile for the site to be drawn up. When added to the set of data collected from wind turbines with low hub height, this creates a data package that can be used to prepare a yield report in conformity with the FGW requirements.

This new method is still largely unknown in the industry, given the recent publication of the Ninth Revision of TR 6. For this reason, empirical values for wind data validation in line with the state of the art are still lacking. It is therefore advisable to rely on support from independent wind experts such as TÜV SÜD, who are familiar with all current requirements and methods in compliance with the Guideline, in order to establish a solid set of data for yield forecasts. ■

The authors

Thomas Arnold, Team Leader Measurements and Technical Testing for Wind Energy Turbines, TÜV SÜD Industrie Service GmbH

Thomas Zirngibl, Team Leader Site Assessment & Technical Due Diligence, TÜV SÜD Industrie Service GmbH

TÜV SÜD Industrie Service GmbH, Wind Cert Services, Ludwig-Eckert-Str. 8, 93049 Regensburg, Germany

Tel: +49 (0) 941 460212-20

Email: Thomas.Zirngibl@tuev-sued.de

www.tuev-sued.de/windenergie

[1] FGW e. V. – Fördergesellschaft Windenergie und andere erneuerbare Energien: Technische Richtlinien für Windenergie anlagen Teil 6 – Bestimmung von Windpotenzial und Energieerträgen; 9th Revised Version of 22 September 2014.