Towards a common understanding of 3D wind modelling for safe operation of Airborne Wind Energy Systems (AWES)

Airborne wind energy systems (AWES) can access stronger and more persistent high-altitude wind resources in comparison to tower based wind turbines. At this early stage of technological AWE development different system concepts exist. As AWES are progressing towards commercial demonstration, there is a demand for operational safety guidelines that apply for all system architectures and follows from reaching a common ground between the stakeholders. This includes understanding load cases and characteristic wind conditions in high altitudes. The IEC 61400-1:2019 models are neither developed for AWES operating altitudes nor for fast changes in wind speeds (like changes in wind direction or lulls) nor do they implement appropriate turbulence intensity modelling.

A working group of AWES OEMs, project planners, and associated universities within FGW discusses best practices for the assessment of relevant wind conditions. The goal is to integrate this knowledge into a Technical Guideline. The addressed topics cover (i) a general approach to determine wind speeds at operating altitudes as well as close to the ground at parking altitudes, and (ii) common requirements for measurement campaigns.

A LIDAR data set with a time resolution of 1 s provided by GWU Umwelttechnik GmbH serves as a basis for studying characteristic wind events for AWES. In the first step, we compared the wind data with the turbulence models from IEC 61400-1:2019[1] to identify discrepancies. In general, the wind models of IEC 61400-1:2019 agree well with the LIDAR data. In the second step, different re-occurring wind profile shapes are identified, the raw wind data is clustered accordingly, and the probability of occurrence of each profile shape is determined.[2] The resulting set of profile shapes is location dependent.

In the next steps, we want to define characteristic frequencies of relevant wind events by analyzing the effect of different time bases on turbulence intensity and standard deviations. This will allow us to understand the effect between time resolution and system reaction time.

In the future, we aim to develop an AWES wind model based on different LIDAR data sets as well as using AWES operating data.

FGW welcomes any contributions from interested third parties, in particular additional measurement data.

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[1] IEC 61400-1:2019. Wind energy generation systems - Part 1: Design requirements. 2019-02, Edition: 4.0

[2] Schelbergen, M., Kalverla, P. C., Schmehl, R., and Watson, S. J.: Clustering wind profile shapes to estimate airborne wind energy production, Wind Energ. Sci., 5, 1097–1120, https://doi.org/10.5194/wes-5-1097-2020, 2020. https://wes.copernicus.org/articles/5/1097/2020/