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Bechtle, Philip; Schelbergen, Mark; Schmehl, Roland; Zillmann, Udo; Rueger, Maximilian; Malz, Elena; Paulus, Fiona; Birr, Michelle

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Airborne Wind Energy Resource Analysis: From Wind Potential to Power Output

Philip Bechtle[1], **Mark Schelbergen**[2], **Roland Schmehl**[2], **Udo Zillmann**[3], **Maximilian Rueger**[1], **Elena Malz**[4], **Fiona Paulus**[1], **Michelle Birr**[5]
[1]Universität Bonn, [2]Delft University of Technology, [3]Airborne Wind Europe, [4]Chalmers University of Technology, [5]Hochschule Heilbronn

Philip Bechtle
Senior Scientist
Universität Bonn
Physikalisches Institut

Nussallee 12
53115 Bonn
Germany

bechtle@physik.uni-bonn.de
www.pi.uni-bonn.de

Airborne Wind Energy Systems (AWES) have different power generation characteristics than conventional wind turbines, which can not be accurately captured in the traditional power curve. One important aspect is that it can harvest wind energy in a much wider range of altitudes than conventional wind turbines. Theoretically also High Altitude Winds (HAW) can be harnessed and the systems can be placed at a larger variety of sites.

Project developers lack technical knowledge for assessing the potential of AWES. It is up to the AWE community to fill this gap. A first step towards this goal is taken by performing a new wind resource study for AWE using the ERA5 re-analysis data, a world-wide, historical wind data set. In the "Airborne Wind Energy Resource Analysis" [1] we study the wind resource in Europe from 2010 to 2017, using a fine spatial and temporal grid, and for maximal operating altitudes of AWES between 300m and 1500m. For most of Europe we find that the wind power density which is available for 95 % of the time increases by a factor of two when continuously adjusting the harvesting height compared to a fixed harvesting height at 100m. The data and source code used for this analysis is available from [2] Following-up on the wind resource study, the ERA5 data is also compared to LiDAR data to assess the uncertainty of the AWE resource analysis.

An important future step for the AWE community would be reaching a consensus on how to characterize the power output of an AWES. These characterizations could be used together with the ERA5 wind data to make projections of the energy production of AWES farms. This requires that the power output is specified for each AWES concept and for a large spectrum of wind conditions. An example for a simplified version of such an interface will be discussed. We then interface the power output with time-dependent current exchange energy prices, in order to allow project developers to compare the economic performance of different AWES designs at different sites and energy markets of interest.

Additionally, a new possibility on characterizing AWES power output is explored as part of this project. An ERA5 data driven methodology of characterizing the wind resources is developed, covering a wider range of altitudes relevant for AWES. The wind resource is represented by a set of wind profile shapes and their probability distributions. An AWES power output specification as a function of the wind profile shape and wind speed at 100m, together with the wind profile shapes and probability distributions, is used for performing AEP estimations.

References:

[1] P. Bechtle et al., "Airborne wind energy resource analysis", Renewable Energy Volume 141, October 2019, Pages 1103-1116 https://www.sciencedirect.com/science/article/pii/S0960148119304306

[2] P. Bechtle et al., https://github.com/rschmehl/awe-era5