Contribution ID: **154** Type: **Oral Presentation**

Comparative Analysis of Numerical Methods for Assessing Wind Potential in Fort Beaufort, South Africa, using Two-Parameter Weibull Distribution Model.

Tuesday, 4 July 2023 14:00 (20 minutes)

The utilisation of wind energy has the potential to both alleviate South Africa's energy crisis and increase access to electricity in remote areas that lack connections to the national grid. Wind energy is a clean, abundant, and inexhaustible renewable energy source that can effectively reduce carbon dioxide emissions and mitigate the adverse effects of climate change that South Africa and its neighbouring countries are experiencing. This is usually in the form of heat waves and cyclones. South Africa has significant potential for wind energy generation, especially in coastal regions of the Eastern Cape Province. To determine the wind characteristics and wind potential of an area, an accurate wind distribution model is essential. Therefore, this study examines eight numerical methods for estimating the Weibull parameters to obtain a suitable model. Five and half years (January 2015–July 2020) hourly averaged wind data collected at an anemometer height of 10 m at Fort Beaufort weather station was used. The two-parameter Weibull distribution was used to fit with the wind data. In addition, eight distinct numerical algorithms were utilised to calculate the Weibull shape (k) and scale (c) parameters for the distribution, namely, the mean, standard deviation method (Msdm), method of multi-objective moment (MofMoM), probability-weighted moments based on power density method (PwmbpdM), WAsP method (WM), method of mabchour (momab), openwind method (Owm), energy pattern factor method (Epfm), novel energy pattern factor method (Nepfm). A goodness of fit test was carried out to evaluate the performance of each algorithm, and their results were analysed based on six statistical error indicators: mean absolute bias error (MaBE), root mean square error (RMSE), wind power density error (WPDE), Kolmogorov-Smirnov (KS) test, Anderson-Darling (AD) test, and chi-squared statistical test. The results showed that the openwind method was the best algorithm and gave Weibull shape (k) and scale (c) values of 1.67905 and 3.35800, respectively. The value of the predicted wind power density of the Fort Beaufort area was 38.45 W/m2. This value revealed that only small-scale wind power generation projects should be utilised in this area for lightning, battery charging, or water pumping using small-scale wind turbines. It is recommended to use augmentation systems such as concentrators, diffusers, and invelox to shroud the wind turbines and lower the cut-in wind speeds, as most turbines available on the market require wind speeds above 5 m/s to start operating in this area. The findings also revealed that the prevailing wind direction in the Fort Beaufort area is mainly from the southeast (SE).

Keywords: Weibull distribution; wind power density,South Africa, renewable energy, Wind energy, wind speed

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Yes

Level for award;(Hons, MSc, PhD, N/A)?

PhD

Consent on use of personal information: Abstract Submission

Primary author: Mr SHAMBIRA, Ngwarai (University of Fort Hare)

Co-authors: Prof. MAKAKA, Golden (Univeristy of Fort Hare); Dr MUKUMBA, Patrick (University of Fort Hare); Dr SHONHIWA, Chipo (Univeristy of Fort Hare)

Presenter: Mr SHAMBIRA, Ngwarai (University of Fort Hare)

Session Classification: Applied Physics

Track Classification: Track F - Applied Physics