UNIVERSITY OF THE PHILIPPINES

Master of Science in Meteorology

Alex C. Garibay, Jr.

WIND ENERGY PRODUCTION VARIABILITY OF BANGUI WIND FARM

Thesis Adviser:

Gerry Bagtasa, Ph.D.

Institute of Environmental Science and Meteorology

University of the Philippines, Diliman

Date of Submission

June 2021

Thesis Classification:

P

WIND ENERGY PRODUCTION VARIABILITY OF BANGUI WIND FARM

Alex C. Garibay, Jr. Dr. Gerry Bagtasa

University of the Philippines – Diliman Thesis Adviser

Abstract

The energy production of a wind farm depends solely on the intensity of the wind. It is the driving force of their over-all power generation and also the source of its variability. The Bangui Wind Farm which is considered to be the first wind farm in the country is located on the northwest-most part of the Philippines on the seashore of the Bangui Bay, Ilocos Norte. This location is characterized by strong seasonal winds depending on the monsoon season. This study aims to investigate the drivers of wind speed variations in the location of the Bangui wind farm. This is done by determining the patterns of its variation. Specifically, gain insights on how large-scale climate drivers such as El Nino Southern Oscillation (ENSO), western North Pacific Summer Monsoon (WNPSM), East Asian Summer Monsoon (EASM), and East Asian Winter Monsoon (EAWM) affect wind variability at different temporal scales using reanalysis and in-situ data.

The observed data from Northwind Power Development (NWPD) and reanalysis data (WRF-ERA-I, JRA-55, NCEP) were used in this multi-scale study. Reanalysis data were compared to observations to determine which dataset that can serve as a proxy for a longer temporal-scale analysis. The wind data were then tested for correlation with the different climate driver indices using the Pearson-Product. Moreover, the Fast-Fourier Transform (FFT) was used to determine the cyclical patterns of the wind speed at the site.

The energy production in Bangui Wind Farm exhibits monthly (σ = 1.91 GWH), seasonal (σ =2.67 GWH), annual (σ =3.35 GWH), and interannual variations. The JRA-55 reanalysis exhibits the best model wind correspondence to in-situ data as far as this study is concerned and is used throughout the long temporal-scale analysis. FFT results of the reanalysis data show that wind speed demonstrates diurnal ($\sigma^2 = 1.62$), seasonal ($\sigma^2 = 1.82$), semi-annual and annual ($\sigma^2 = 0.19$) cycles which explains majority of the wind variance. This coincides with the results obtained from the Principal Component Analysis (PCA) of the Empirical Orthogonal Function (EOF). PC1 is attributed to annual cycle, PC2 to semi-annual cycle and PC3 to seasonal cycle. The wind speed in the Bangui Wind Farm demonstrates significant correlation with climate driver indices such as ENSO (r=-0.42), WNPSM (r=0.29), EAWM (r=0.19), and EASM (r=0.32). In ENSO years, wind anomalies are observed from SON of the ENSO developing year until MAM of the following year, with peak in DJF. Consequently, the ENSO3.4 index had highest correlation to wind speeds during DJF (r=-0.48), then MAM (r=-0.40) and SON (r=-0.38) seasons. Results also show that during warm (cold) phase of ENSO from SON to MAM the following year, mean wind anomaly is -0.37 mps (0.36 mps) from mean of 6.19 mps and energy production anomaly is -0.38 GWH (0.81 GWH) from mean of 6.25 GWH. This is equivalent to a energy production decrease of 6.14% in El Nino and an increase of 12.95% in La Nina. The results obtained in the study can serve as a guide in managing and forecasting of future energy production of the Bangui Wind Farm and in mitigating the effect of different climate drivers.

keywords: wind speed, energy production, Bangui Wind Farm, EASM, EAWM, WNPSM, ENSO