Faculty and Postdoc; Energy, Environment & Resource Sustainability

Wind energy potential along the onshore and offshore Qatar

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Abstract

Wind energy is one among the clean and renewable energy resources. The utilization of non-conventional energies over the conventional sources helps to reduce the carbon emissions significantly. The present study aims at investigating the wind energy potential at select coastal locations of Qatar using ERA5 winds. ERA5 is the updated reanalysis product of the European Centre for Medium-range Weather Forecasts (ECMWF), in which the scatterometer and in situ wind data are assimilated to improve the accuracy of predictions, thus the long-term and short-term variabilities are reasonably well captured. Compared to the earlier studies, in this work, we have assessed the wind power at inland and offshore areas of Qatar, considering 40-year long (1979-2018) time series data with hourly ERA5 winds at 10-m height. The results show that there is no significant increase or decrease of wind power around Qatar in the last 40 years in most of the locations, while there is a slight decreasing trend in the offshore areas of Ruwais. This indicates that the average wind power is consistently available throughout the years. The links of climatic indices, especially the ENSO events with the wind climate of Qatar, are clearly evident in the long-term data. As obvious, the offshore regions of Qatar have relatively high wind power compared to the land areas. Among the select locations, the highest annual mean wind power density is obtained in the offshore Ruwais (152 W/m^2), followed by offshore Ras Laffan (134 W/m^2) and land area of Al Khor (120 W/m^2). The maximum wind power density varies between 1830 and 2120 W/m^2 in the land areas, while it is between 1850 and 2410 W/m^2 in the offshore areas of Qatar. The highest wind power is consistently available during the prevalence of shamal winds in winter (January-March) as well as summer (June).

Introduction

Qatar is situated along the Arabian Gulf (Fig.1), which experiences variable climate in different seasons. In winter, shamal winds are dominant, which are considered as one among the extremes in the region. In summer, the wind conditions are controlled by the prevailing regional and local climates. Summer shamal winds blow quite frequently, which brings dust from the northern parts of the Arabian Peninsula. The conventional energy resources have been largely exploited; that not only reduce the resources, but also impacts the envrionment due to carbon emissions. The emerging trends are the utilization of non-conventional energies such as solar radiation, winds, tides and waves, which are clean and renewable. However, the potential of such sources varies in different regions. In this study, we focussed on the assessment of wind power along the onshore and offshore reigons of Qatar. A long-term assessment would benefit in understanding the available potential as well as the variability due to climate change. Based on the wind power assessment, probable wind turbines can be optimised.

Materials and methods

ERA5 winds

- ERA5 is the updated reanalysis product of the European Centre for Medium-range Weather Forecasts (ECMWF)
- Scatterometer and in situ wind data area assimilated in ERA5 to improve the accuracy of predictions; thus, the long-term and short-term variabilities are reasonably captured.
- The wind data is available for every 1 hour in 0.25 deg x 0.25 degree grid intervals.
- It has been validated at a few loations in the Arabian Gulf (Mahmoodi et al., 2018; Senafi et al., 2019).

Wind power estimation

The wind power density,

$$P_A = \frac{1}{2}\rho V^3$$

It is the energy content of the wind given in watts per square meter (W/m2)

Here ρ is the density of air and V is the wind speed.

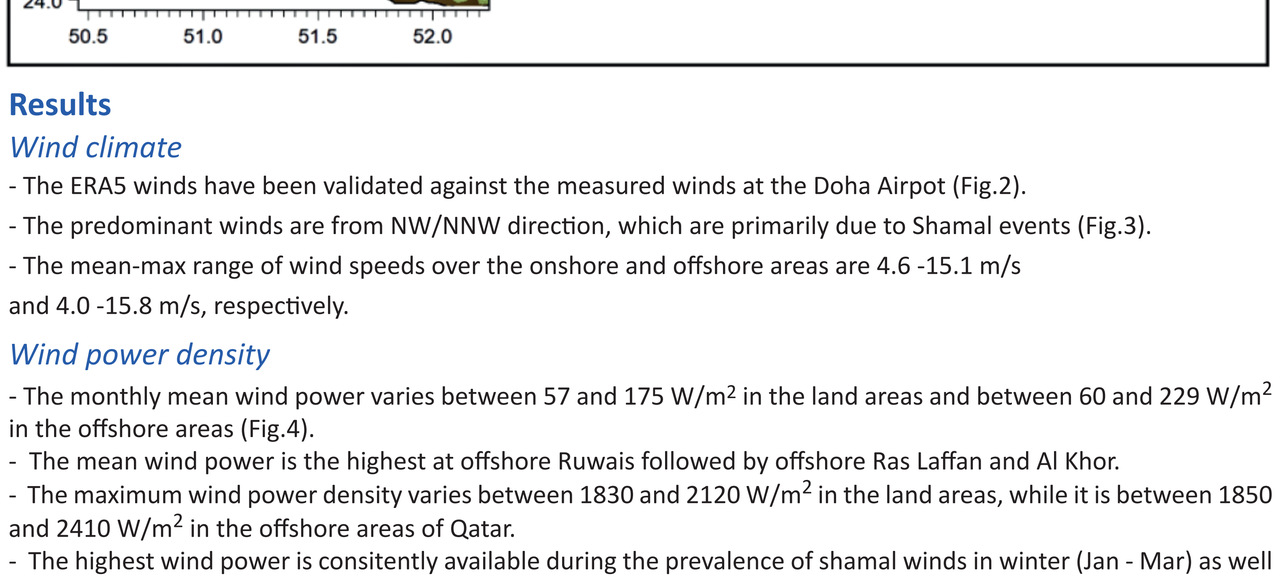


Fig.1. Bathymetry of the Arabian Gulf and Qatar EEZ (Locations of wind assessment are marked)

Results

Wind climate

- The ERA5 winds have been validated against the measured winds at the Doha Airpot (Fig.2).
- The predominant winds are from NW/NNW direction, which are primarily due to Shamal events (Fig.3).
- The mean-max range of wind speeds over the onshore and offshore areas are 4.6 -15.1 m/s and 4.0 -15.8 m/s, respectively.

Wind power density

- The monthly mean wind power varies between 57 and 175 W/m^2 in the land areas and between 60 and 229 W/m^2 in the offshore areas (Fig.4).
- The mean wind power is the highest at offshore Ruwais followed by offshore Ras Laffan and Al Khor.
- The maximum wind power density varies between 1830 and 2120 W/m^2 in the land areas, while it is between 1850 and 2410 W/m^2 in the offshore areas of Qatar.
- The highest wind power is consitently available during the prevalence of shamal winds in winter (Jan - Mar) as well as in summer (Jun).
- Inter-annual variability is evident in the wind power, especially during ENSO events (Fig.5).

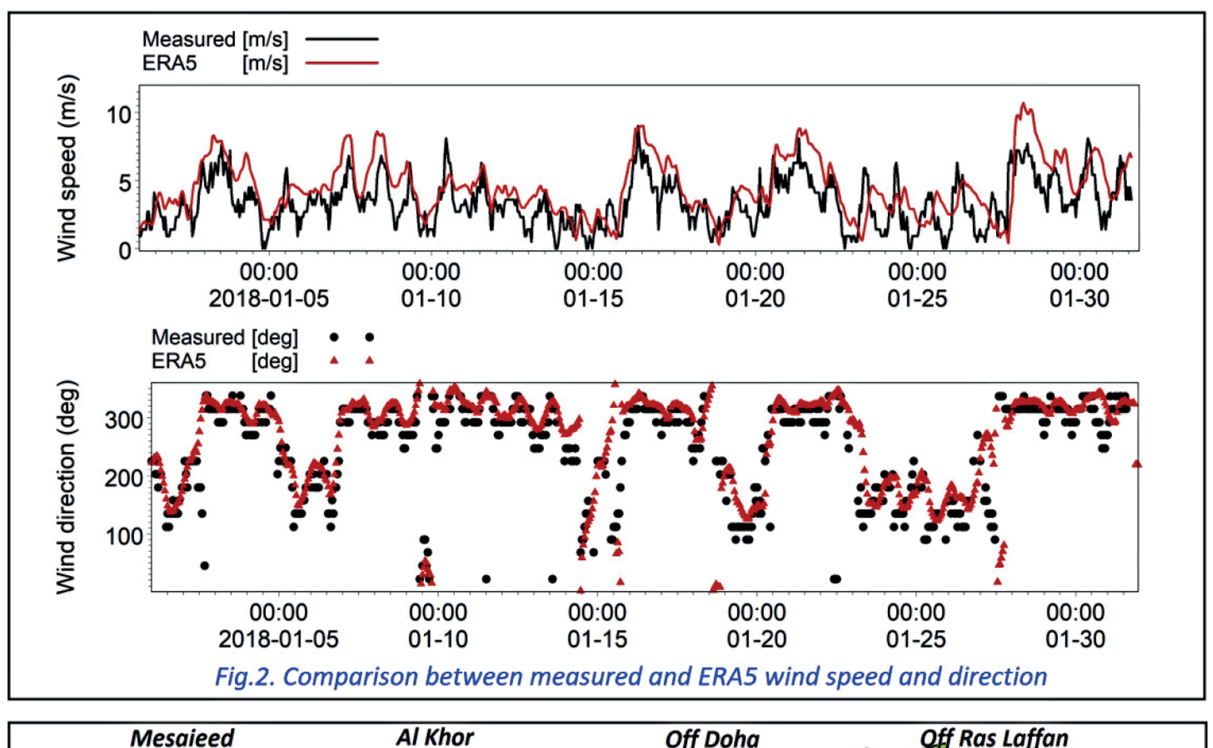
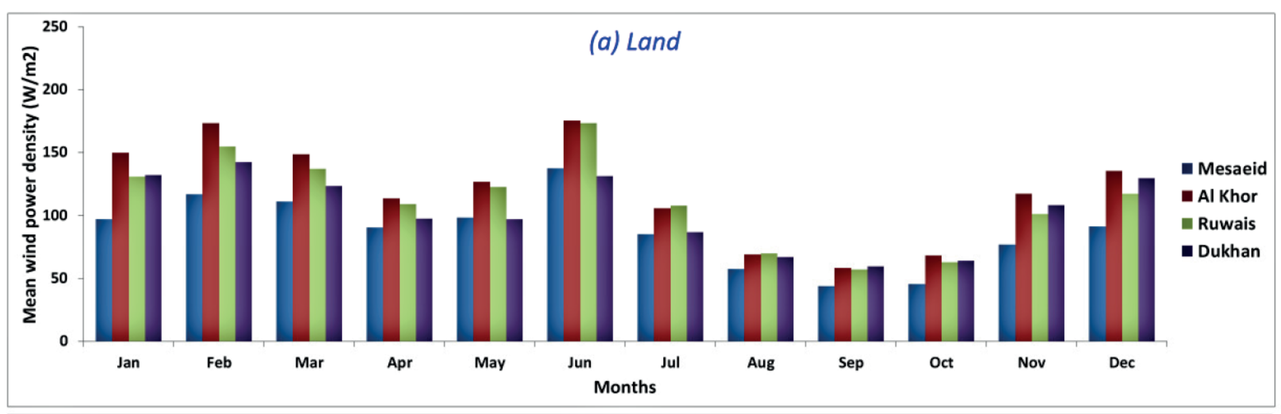


Fig.2. Comparison between measured and ERA5 wind speed and direction



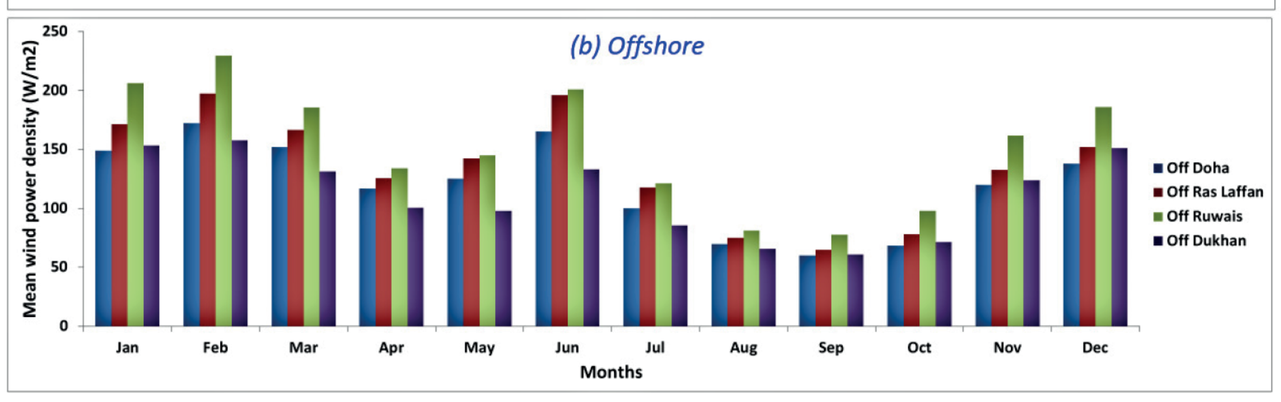


Fig. 4. Mean wind power density at select locations along the coast of Qatar

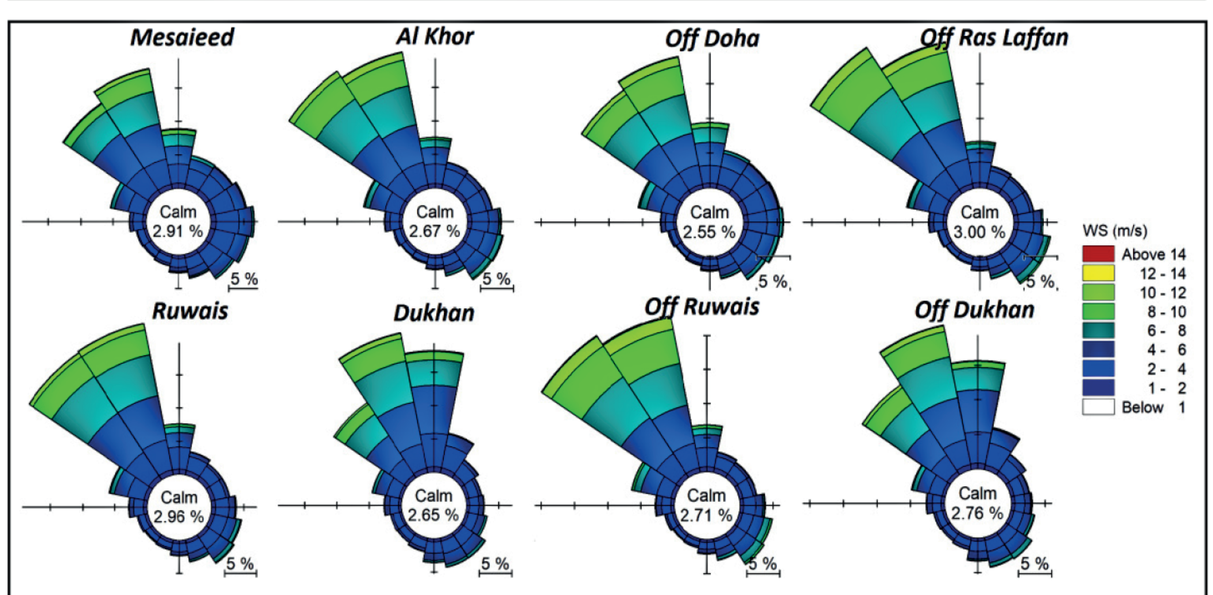


Fig. 3. Wind rose at select locations along the coast of Qatar during 1979-2018

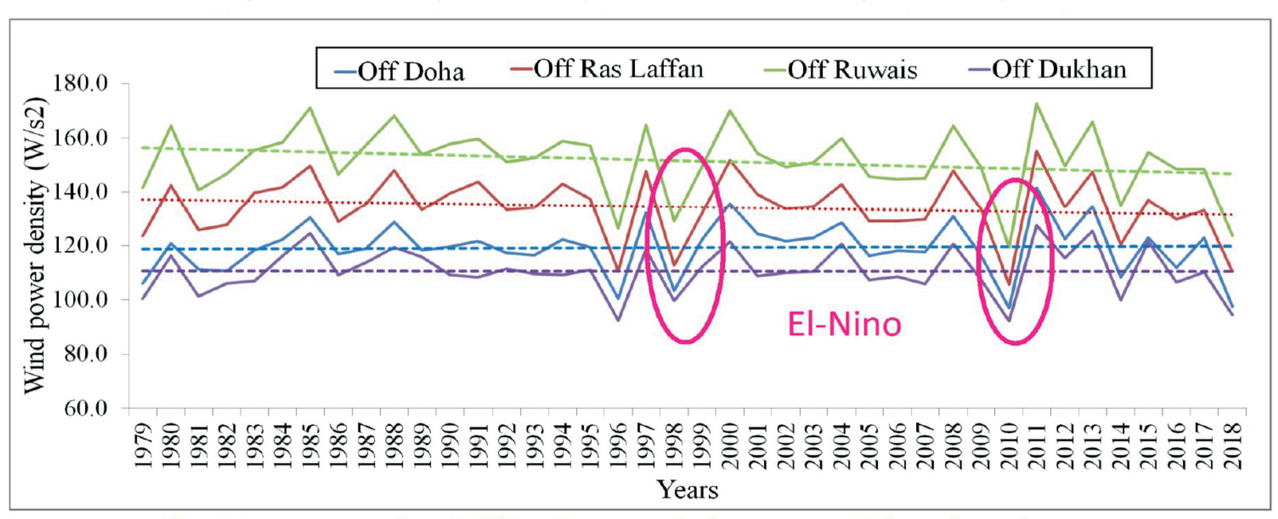


Fig. 5. Inter-annual variability of mean wind power at offshore locations

Conclusions

- The study reveals that the wind energy potential is nearly consistent across the onshore and offshore regions of Qatar during the 40 year period.
- The offshore wind power is higher than the onshore wind power.
- The wind power is higher during winter than the summer.

Acknowledgments

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