Title: DESIGN AND OPTIMIZATION STUDY OF A WIND VERTICAL SYSTEM

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2nd Semester 2021/2022

Abstract

The world's population is quickly increasing, where also the negative impact on the environment increased, it is important to use clean energy in place of old sources, one of the most important solutions is the use of renewable wind energy. The aim of this project is design and optimization study of the H-darrieus vertical axis wind turbine. Where the project involved analysis, design, and optimization study. Which this study done in PSAU at Al-Kharj location. There are several benefits to the VAWT, such as cheap cost, minimal wind cut, and more. The wind power for our design is 1.1kW. the probability of our system to work for one year is 30%, to produce 751.68 kWh, where the blades dimensions designed at optimal parameters based on particle swarm optimization method to reduce the frequency. The output of the total cost of the proposed system is about 16782 SAR. Finally, the prototype was made scale down 85% of design.

Objectives

- Choose the optimal of some parameters in design for vertical axis wind turbine systems
- Wind power analysis and optimization of wind
- Made a prototype scale down by 85% from original design with measurement system to prove quality

Constraints

Our study take in consideration the following constraints:

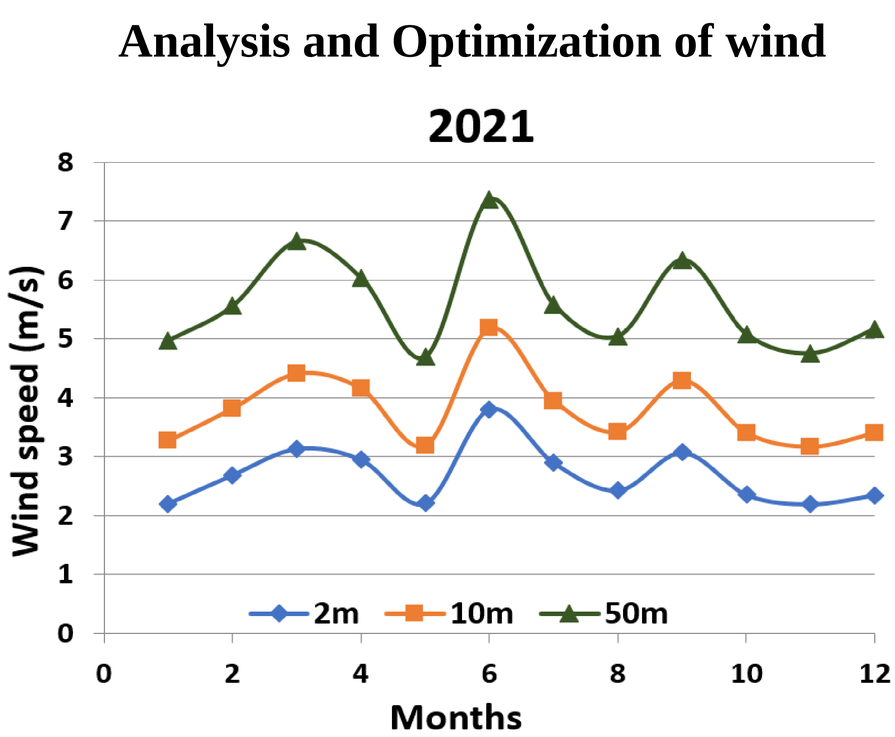
- Health and safety
- Environment
- Sustainability
- Economic
- Ethical

Basic Design Parameters

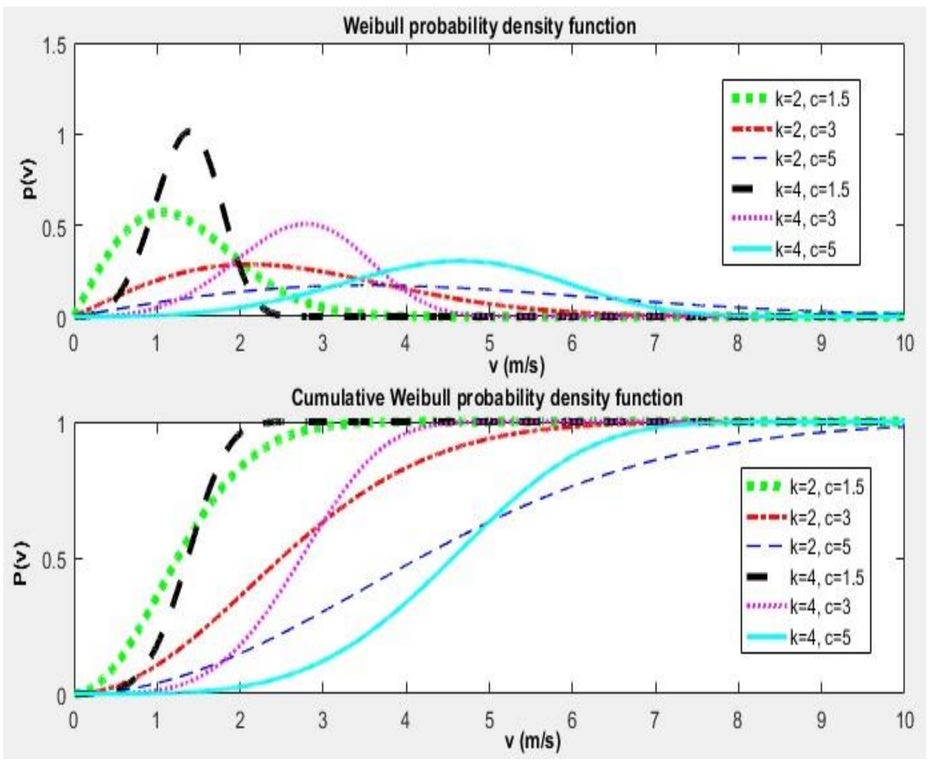
- Average wind speed
- Wind power fixed
- Swept area
- NACA-0018 air foil of blade section
- Probability of the observed wind speed
- Optimal chord length
- The solidity

Parameters	Result
Average wind speed at 27m height in Al-Kharj, V_o	4.94 m/s
Wind power, P_w	1.1 kW
Swept area, A	15.71 m^2
Tip speed ratio, TSR	2.63
Power coefficient of wind, C_p	0.26
Mechanical power on shaft, P_{mec-sh}	286 W
Average revolution speed of rotor, N_{avr}	99.21 rpm
Max torque applied, M_{t-Max}	12.14 N.m
Probability of the observed wind speed, P(v)	30%
Chord length, C_h	0.68 m
Solidity, σ	0.26
Twisting moment,T_e	2031.21 N
The shear stress on shaft , τ_{sh}	55 MPa
Diameter of the shaft, D_{SH}	70 mm
Rotor mass, $M_{total-r}$	88.26 kg
Life of the bearing, L_{Life}	4 years
Annual electrical energy	751.68 kWh

The summary of Design and Optimization study of VAWT

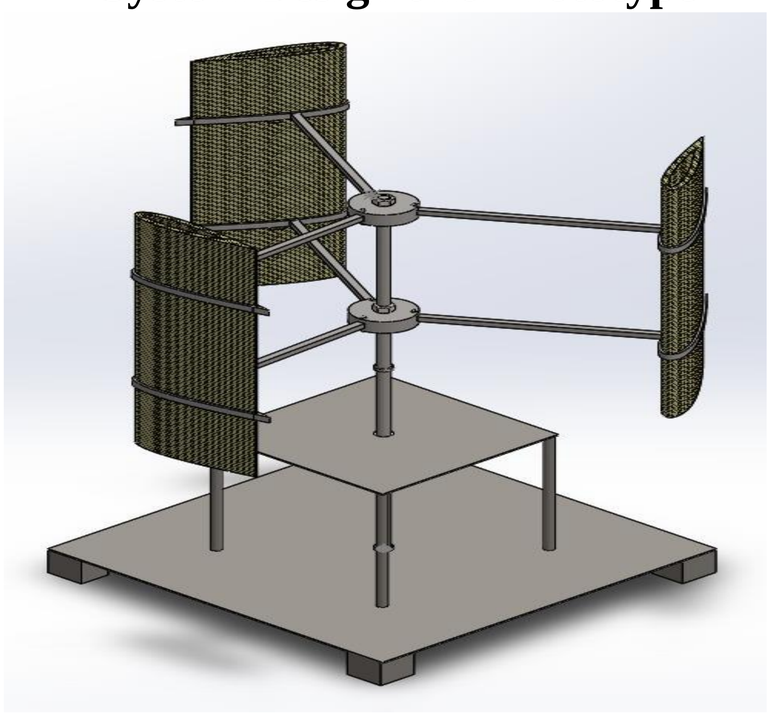


Average annual wind speed statistics in Al-Kharj of 2021



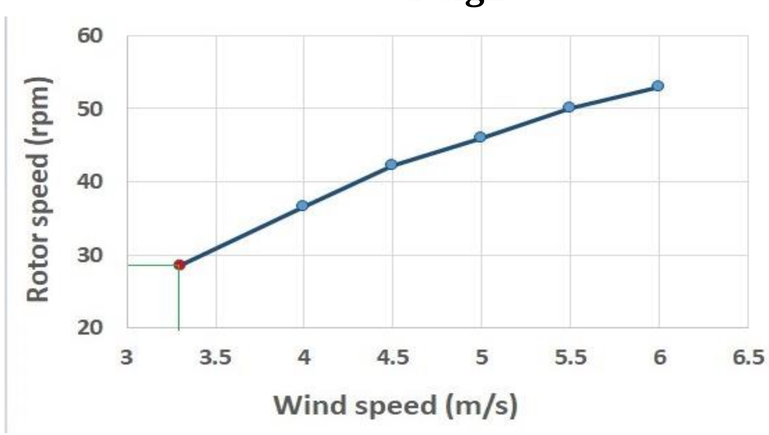
The Weibull and the Weibull cumulative probability density function from MATLAB

System Design and Prototype



Design of VAWT system

The prototype 85% scale down of original design



The rotor speed (rpm) and wind speed (m/s) of prototype

Conclusion

- The optimization of VAWT system proved that the probability of the system to work annually is four months to produce 751.68 kWh, which is for the rest of the months can rest to save money of operation
- The total cost analysis of the design is about 16500 SAR

Recommendations

- To optimize more parameters design like Swept area and Blade thickness
- To increase the output power by using epicyclic gear

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