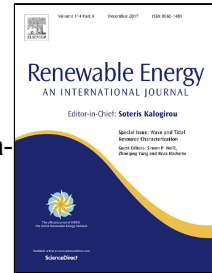


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Performance Evaluation of a Novel Vertical Axis Wind Turbine with Coaxial Contra-Rotating Concept

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ABSTRACT

In the present work, development and aerodynamic performance prediction of a unique contra-rotating vertical axis wind turbine (VAWT) have been studied. The purpose of this paper is to investigate the effectiveness of employing the contra-rotating concept to a VAWT system while enhancing its conversion efficiency. The performance evaluations of the current model were established in terms of key aerodynamic performance parameters such as power, torque, power coefficient and torque coefficient. The systematic analysis of these quantities showed the effectiveness of the contra-rotating technique on VAWT system and the ability to extract additional almost threefold power over the entire operating wind speed ranges covered. The system has also improved the inherent difficulties of the Darrieus rotor to self-start. Moreover, the results of the new concept also demonstrated a significant increase in terms of conversion efficiency for both power and torque compared to a single-rotor system of a similar type. It is anticipated that this current approach will revolutionize wind energy harvesting strategies and will find application in a wide range of wind turbine sites that are characterized by relatively low and moderate wind speed regimes and particularly be useful in the urban environment where turbulence intensity is high.

Keywords: Aerodynamic performance; Contra-rotating technique; Vertical axis wind turbine (VAWT)

Nomenclature

CFD	computational fluid dynamic	P_{ext}	extractable power [W]
CRWT	contra-rotating wind turbine	P_w	actual power [W]
HAWT	horizontal axis wind turbine	P_T	theoretical wind power [W]
RPM	revolution per minute [N]	R	rotor radius [m]
SRWT	single rotor wind turbine	ρ	fluid density [kg/m ³]
TSR	tip-speed ratio [λ]	r_{shaft}	radius of the shaft [m]
VAWT	vertical axis wind turbine	r_{rope}	radius of nylon string [m]
A	projected area of rotor [m ²]	S	spring balance reading [Kg/m ²]
c	blade chord [mm]	T_m	blade torque [Nm]
C_t	torque coefficient	T_T	theoretical torque [Nm]
C_p	power coefficient	U	tip speed [m/s]
D	rotor diameter [m]	V	free stream velocity [m/s]
g	gravity [m/s ²]	W	weight of the load [Kg/m ²]
H	blade height [m]	ω	rotor angular speed [rad/s]

1. Introduction

The generation of electricity has commonly been accomplished through the combustion of fossil fuels. However, fossil fuel power plants to some extent pollute the environment by producing contaminating emissions and the supplies of these energies have been predicted to finish in a few decades of time. Thus, the use of fossil fuels has to be limited and the use of renewable energies should be encouraged. Renewable energies such as the wind, solar, wave and

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