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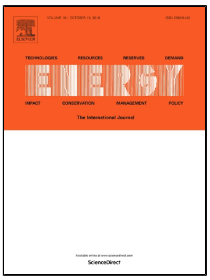

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Effect of Airfoil Profile on Aerodynamic Performance and Economic Assessment of H-rotor Vertical Axis Wind Turbines

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ABSTRACT

This research focuses on the effects of the asymmetric airfoil profiles on aerodynamic performance and economic evolution of a vertical axis wind turbine (VAWT) at different blade heights, solidities, and tip speed ratios (TSR or λ). The aerodynamic performance of six asymmetric airfoils, S809, S814, RISØ-A1-24, Du 93-W-210, FFA-W3-241, and FX66-S196-V1, was calculated using double multiple-stream tube (DMST) theory and blade element methods for determination of their performance for tip speed ratios from 1 to 12, and solidities of 0.2 to 0.6, were considered for this study. All calculations focused on the Khaf area (rural zone) in Iran and considered two heights: 10 m and 40 m. To verify the performance of the developed code, results were compared with experimental power coefficient data for NACA0012 airfoil. For FFA-W3-241 airfoil, maximum power coefficient was obtained at solidity of 0.5 and tip-speed ratio of 4.This aerodynamic excellence resulted in 22.4% and 21.9% increase in annual energy production at hub heights (h) of 10 m and 40 m, respectively, while keeping the total investment costs constant. Moreover, the ratio of wind-generated electric power sales to the total investment cost was found to be 4.33 (0.15/0.0346) for 15 years of operation.

Keywords: H-type Vertical Axis Wind Turbine; Double Multiple Stream Tube (DMST) Model; Blade Element Momentum Theory; Airfoil Selection; Power Generation; Economic Evaluation.

1. Introduction

National economic growth is highly dependent on energy consumption. Until 1973 and oil price crisis, fossil fuels were the main source of energy. In 1974, the U.S. government initiated a project with industry to develop commercial wind turbines. Introduction of the MOD-5B was one outcome of the project which was the largest single rotor wind turbine in 1987, with a rotor span of about 100 m and a power capacity of 3.2 MW. At the same time, Denmark began the development of multi-megawatt wind turbines and