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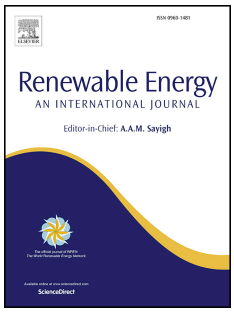

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Drag Power Kite with Very High Lift Coefficient

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Abstract

As an alternative to conventional wind turbines, this study considered kites with onboard wind turbines driven by a high airspeed due to crosswind flight ("drag power"). The hypothesis of this study was, that if the kite's lift coefficient is maximized, then the power, energy yield, allowed costs and profit margin are also maximized. This hypothesis was confirmed based on a kite power system model extended from Loyd's model. The performance of small-scale and utility-scale kites in monoplane and biplane configurations were examined for increasing lift coefficients. Moreover, several parameters of the utility-scale system were optimized with a genetic algorithm. With an optimal lift coefficient of 4.5, the biplane outperformed the monoplane. A 40 m wing span kite was expected to achieve a rated power of about 4.1 MW with a power density of about 52 kW/m^2. A parameter sensitivity analysis of the optimized design was performed. Moreover, to demonstrate the feasibility of very high lift coefficients and the validity of a utilized simplified airfoil polar model, CFDs of a proposed high-lift multi-element airfoil were performed and the airfoil polars were recorded. Finally, a planform design of a biplane kite was proposed.

Keywords: Crosswind kite power, drag power, airborne wind turbine, high-lift airfoil, biplane, genetic algorithm
2010 MSC: 65Z05

1. Motivation

Kites are tethered wings and promising alternatives to harvest wind energy (cf. e.g. [1, 2, 3, 4]). As shown in Fig. 1, a kite is flown in crosswind trajectories like figure eights or circles. The considered kite has onboard turbines and generators to generate electrical power which is transmitted to the ground via electrical cables integrated in the tether [5]. Due to the high speed of the kite, the (true) airspeed at the kite is about a magnitude higher than the actual wind speed, so that the onboard turbines are small. For vertical take-off and subsequent transition into crosswind flight, the generators and wind turbines are used as motors and propellers. The reverse procedure is used for the landing when the wind calms down or for maintenance. This airborne wind energy concept is called "crosswind kite power/drag power" [1], or sometimes also "onboard-", "continuous power generation", "fly-gen" or "airborne wind turbine".

Compared to conventional wind turbines, crosswind kite power promises to harvest wind energy at higher altitudes with stronger and steadier winds, but by requiring only a fraction of the material. Hence, it promises

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