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Self-Start Performance Evaluation in Darrieus-Type Vertical Axis Wind Turbines: Methodology and Computational Tool Applied to Symmetrical Airfoils

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Abstract. An increased interest in vertical axis wind turbines has been stimulated by the rapid growth of wind power generation and by the need for a smarter electrical grid with a decentralized energy generation, especially in the urban areas. The lift type vertical axis wind turbines (Darrieus wind turbine) performance prediction is a very complex task, since its blades move around the rotor axis in a three dimensional aerodynamic environment that lead to several flow phenomena, such as, dynamic stall, flow separation, flow wake deformations and their natural inability to self-start. These issues can be overcome with the use of several more or less complex solutions, being one of them the development of a blade profile capable of making the wind turbines self-start. This paper focuses on presenting a new methodology for fast development of new blade profiles, for self-start capable Darrieus wind turbines, which is a complex and time-consuming task.

Key words

Vertical axis wind turbine, blade profile, self-start, pressure coefficient.

1. Introduction

The increasing cost of fossil fuels and the different agreements among the industrialized countries with the aim of reducing CO_2 emissions has driven the renewable sources in an increased acceptance for energy production.

The wind energy systems have been considered as one of the most cost effective of all the currently exploited renewable sources, so the demand and investment in wind energy systems has increased in the last decade.

Several studies have been conducted to model, simulate [1] and characterize [2] the wind behaviour to stimulate the acceptance of the wind energy in the market, by offering tools to help and ease the enterprise I&D.

The investment in wind energy for the 27 EU Member States is expected to grow in the next 20 years reaching almost €20 billion in 2030, with 60% of that investment in offshore systems [3]. In the past for Portugal alone, the wind power goal foreseen for 2010 was established by the government as 3750 MW.

The value of 3750 MW already represented about 25% of the total installed capacity [4]. Nevertheless, this value has recently been raised to 5100 MW, by the most recent governmental goals for the wind sector.

As the penetration level of wind power increases into the power systems, the overall performance of the electric grid will increasingly be affected by the characteristics of wind turbines. One of the major concerns related to the high penetration level of the wind turbines is the impact on power system stability and power quality [5].

The decentralized energy generation is an important solution in a smarter electrical grid with a growing acceptance for the urban areas. Also, the increasing need for more environmentally sustainable housing and the new European norms regulating this issue, have contributed for the promotion of wind energy systems in buildings.

In urban areas the wind is very turbulent and unstable with fast changes in direction and velocity. In these environments the vertical axis wind turbines (VAWT) have several advantages over horizontal axis wind turbines (HAWT). Several solutions have been presented to overcome the Darrieus type VAWT inability to self-start: use of a guide-vane [6], using a hybrid configuration of a Savonius VAWT (drag type wind turbine) and a Darrieus VAWT (lift type wind turbine) [7]-[9], use of mechanical system to optimize the blade pitch [10], [11], use of blades that change their form during operation [12], [13], or a specific blade profile capable of offering self-start capabilities to the wind turbine without extra components [14], [15].

Our paper presents a methodology and computational tool for fast development of a specific blade profile capable of offering self-start capabilities to the VAWT without extra components.

The VAWT in order to self-start relying only on the blades profile, without the help of extra components and external power, must take advantage of the drag forces caused by the wind on the blades when the turbine is in a stopped position, without compromising the wind turbine performance at high tip speed ratio (TSR).