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Case Study Regarding the Conversion Efficiency of Small Horizontal Axis Turbines

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Abstract

Wind energy is an alternative energy source, in the category of renewable energy, which converts wind power into another useful form of energy. In this paper, the authors propose a study concerning the use of small turbines for electricity production, which are feasible at speeds around 3 m/s. It consists in a comparative analysis between experimental results obtained on site for a horizontal axis wind turbine (HAWT) and simulations obtained through the iHOGA program (Hybrid Optimization by Genetic Algorithms).

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1. Introduction

The potential of using the kinetic energy of the wind was noticed and exploited since antiquity. The first historic records of the existence of windmills used for grinding grain refers to Persia (IXth-Vth centuries BC), and then the idea was taken over by the Romans around the second century BC, which extended the use of this energy to water pumping. But the country that identifies with the use of windmills is medieval Netherlands (starting with the XIVth century AD) who use this energy for draining the land areas situated under sea level.

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Another stage in the use of wind energy that had an important role was the prior period to the industrial revolution in Europe, before the discovery of the steam engine, respectively in the USA, XIXth century, during which the economic foundations of the relatively new founded state were laid.

The following period, of industrial development, was focused mostly on the use of fossil resources.

But with the energy crisis of the '70s, and later in the '80s, the attention of professionals and politicians was directed on alternative energy sources, including wind energy, which is a clean and renewable resource.

Worldwide, wind energy is currently used in many countries in Europe, USA and Asia. To highlight the interest in using wind energy in the following was presented comparative chart between the years 2007 and 2015- see Fig. 1 [1]. It is known there is a direct connection between economy and energy. In this regard, we note that countries that are characterized by a recognized worldwide economic growth, such as China, took a keen interest in exploiting wind energy resource. But we must remember the important role that it played Denmark in the implementation and operation of wind energy in the modern era, even if currently installed capacity hasn't increased considerably.

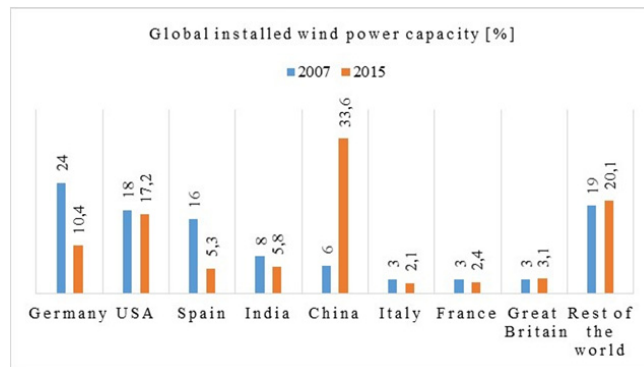


Fig. 1. Distribution of installed wind power capacity in the world

Although Romania has a significant wind potential in certain areas of the country, it has been exploited on a limited scale until few years ago [2]. But following an open policy toward the EU recommendations, there are several large projects still ongoing, such as those in the Dobrogea region, Black Sea continental area, southern Moldavia and Banat, which align Romania with other countries that exploit wind energy.

We still need to specify that most areas of the country are characterized by wind speeds under 8-10 m/s, implying the unprofitability of the usual high-power turbines. Therefore, the orientation of specialists for these disadvantaged areas in terms of wind potential, must follow two directions:

- the use of medium or small turbines that convert wind speeds with values of 2-5 m/s;
- using wind energy concentrator as casing turbines, having as result the increasing of the wind speed in the rotor section [3].

For low wind speeds would be recommended the use of vertical axis turbines that are feasible for speeds around 3 m/s. However, both due to the disadvantages about a much lower efficiency compared to the horizontal axis turbines and also because it requires an additional source for the start, they were not generalized on the market.

In this paper the authors are proposing a study regarding the first direction, which consists of a comparative analysis between the experimental results obtained in situ for a small power turbine with horizontal axis and simulations obtained through the iHoga program.

2. Aspects regarding the efficiency of wind energy conversion into electricity

The turbines are devices that extract energy from a stream of air and are designed to generate torque to drive the generator. In fact, the principle of obtaining electric energy is based on two processes of conversion [2] carried out by:

- the conversion of the kinetic energy of the wind into mechanical torque for driving the rotor of the generator;

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