Hydrokinetic energy harvesting by an innovative vertical axis current turbine

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ABSTRACT

This study proposes an innovative turbine that consists of a vertical flat plate, which is allowed to rotate freely about a vertical axis of symmetry and exploits the autorotation phenomenon to harvest the energy from the current. This system is called here Vertical Axis Autorotation Current Turbine (VAACT). The VA ACT utilizes the extra mass moment of inertia to improve the rotational quality which is state of the art in this turbine. This paper covers the principle behind the VA ACT and outlines procedures and results for experiments proving the basic feasibility. Also, the operation of the turbine will be discussed by experimental results of the torque coefficient, performance and kinematic parameters. Tests were conducted in LOC (Laboratory of Wave and Current) at COPPE/Federal University of Rio de Janeiro (COPPE/UFRJ).

Utilizing the extra mass moment of inertia on the VA ACT causes to extract the energy as an efficient turbine in very low head current. The maximum VA ACT efficiency has been obtained experimentally in optimum non-dimensional moment of inertia in range of 0.5 and 0.6.

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1. Introduction

All societies require energy services to meet basic human needs and to serve productive processes. The quality of energy is important to the development process. Sustainable social and economic development requires assured and affordable access to the energy resources. This may cause the application of different strategies at different stages of economic development. For environmentally benign, energy services shall be provided with low environmental impacts and low greenhouse gas (GHG) emissions. In recent decades, 85% of present primary energy driving the global economies comes from the combustion of fossil fuels. However consumption of fossil fuels accounts for 56.6% of all anthropogenic GHG emissions [1]. Renewable energy sources play an important role to providing energy services in a sustainable manner and, in particular, in mitigating climate change.

While, the Renewable Energy (RE) share of global energy consumption is still relatively small, deployment of Renewable Energy has been increasing rapidly in recent years. Although on a global basis, it is estimated that RE accounted for 12.9% of the total 513.6 EJ of primary energy supply in 2008 [2], but its share has increased to 13.5% of the total 559.6 EJ in 2012 [3]. Fig. 1 shows the share of each type of energy sources in global energy generation. The theoretical potential for Renewable Energy greatly exceeds all the energy that is used by all economies on Earth [1]. Table 1 summarizes the ranges of technical potential for the different RE technologies until 2050.

The theoretical potential for ocean energy technologies has been estimated at 7400 EJ/yr, well exceeding current and future human energy requirements [4]. River current energy is a clean and renewable source of energy and has the advantage of predictability over other renewable energy sources. A study from 2007 in the USA concluded that the current generating capacity of hydrokinetic in rivers and constructed waterways is 12,800 MW [5].

Generally, projects with a head fewer than 2 m are not viable with traditional technology [6]. New technologies are being developed to take advantage of these small water elevation changes, but they generally rely on the kinetic energy in the stream as opposed to the potential energy due to hydraulic head. These technologies are often referred to kinetic hydropower or hydrokinetic [6]. The process of the hydrokinetic energy conversion implies utilization of the kinetic energy contained in the river streams, tidal currents, or other man-made waterways for generation of electricity or mechanical motion.