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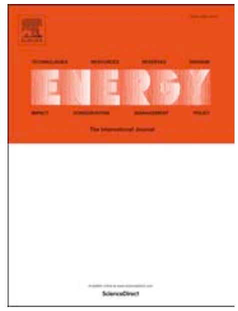

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Long-Term Simulations for Ocean Energy off the Brazilian Coast

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Abstract

Waves and ocean currents have been widely researched worldwide as possible renewable energy sources. Recent findings related to viable energy sites with high power output focus on local dynamic impacts and disregard long-term viability. This study underlines the importance of resource assessment performed through long-term simulations and attempts to improve the understanding of how spatial-temporal variability controls the dynamic patterns of feasible sites for oceanic renewable energy. Hydrodynamic and spectral wave models TELEMAC-3D and TOMAWAC were performed over a 10-year period from 2003 to 2012. Sources of high current intensity and wave height were found in five sites around the Southern Brazilian Shelf (SBS) and the Southeast Brazil Bight (SBB) and were further analyzed for frequency of high occurrence, variability over months and seasons, and spatial and temporal variability. The results indicate that renewable energy from ocean currents has more stability for conversion in the SBS, while waves present better conditions in the SBB. The weaker seasons for energy conversion were autumn and summer, with the stronger seasons varying. Wave variability demonstrates a high correlation with atmospheric dynamics regarding the passage of frontal systems as opposed to currents that are mainly forced by local wind-driven conditions.

Keywords: Renewable Energy, Variability, Waves, Currents, Telemac-3D, TOMAWAC

1. Introduction

The past decade has seen a revival of the development of marine renewable energy devices all around the world [1, 2, 3]; in addition, there is a need for cost-effective and efficient renewable power options [4, 5]. Today, the renewable energy landscape is formed by seven main categories: winds, solar power, waves, tides, ocean currents, osmotic power and ocean thermal power.

Some of the most interesting regions in the ocean with the highest kinetic energy potential are located within western boundary currents. Several studies in the literature have approached the tidal conversion concept, but few have mentioned the energy from ocean currents. Recent studies by Akimoto et al. [6], Shirasawa et al. [7] assessed the energy from the Kuroshio Current, while Finkl and Charlier [8], Yang et al. [9] supported energy conversion from the Gulf Stream.

Akimoto et al. [6] proposed that the Kuroshio Current can be exploited by floating devices with a great amount of energy viability; in addition, Shirasawa et al. [7] introduced a new prototype to harvest energy from the Kuroshio Current in a harsh environment at a depth of 500 m. Finkl and Charlier [8] studied the impact of turbines inside the Gulf Stream, while Yang et al. [9] focused on harvesting nearshore current energy in the Florida current. Regarding this matter, strong western currents provide a strong stream at their core among high depths far from the coast; this stream spreads towards the shore, promoting highly dynamic nearshore conditions in a more welcoming environment than the open ocean.

Wave energy resources are being widely studied [10, 11]. An early stage of any marine renewable energy extraction project is resource assessment. Regions with complex geometry, high variability of wind patterns and extensive areas deliver specific wave propagation properties and also give rise to high spatial and temporal variability in the wave properties. The presence of relatively shallow areas and often occurring convergent wind patterns may lead to occasional wave energy concentration in certain areas [12]. This feature requires a high spatial resolution of wave simulations and also a careful choice of wave measurement methods [13].

According to Clément et al. [14], there are difficulties facing wave power development that must be addressed, such as irregularities in wave amplitude, phase and direction that threaten the maximum efficiency of a device over the entire range of excitation frequencies. The usage of long-term simulations helps solve some of these difficulties while enhancing the knowledge of the harvest site even further [15, 16, 17, 11, 18]; thus, a short simulation is not recommended for evaluating a desirable site because it may result in a misleading assessment [19].

Concerning the prediction of the energy availability of a certain region, several authors have evaluated power potential from a small amount of observed data (from days to months) [20, 21]. In other cases, models are applied but also for a short period of time, i.e., seconds to months, to consider tidal energy [22, 23, 24, 25, 26, 27, 28, 29, 30, 31]. Although several of these authors wish to study specific processes or patterns in the flow of energy conversion, energy generation prognostics are

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