Natural Energy Resources in the Coastal Region: A Utilization Concept

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ABSTRACT

Forecasts of wind and wave power incident to the coastal region of Santa Cruz, California, USA, compare well with similar buoy data for the west coast of Canada. The degree of steadiness of the coastal energy resource is defined with strong indications of the influence of earth-lunar dynamics. Utilization of tidal energy to fill in for the high degree of unsteadiness in the wave energy resource is outlined.

KEY WORDS: Waves; tides; energy; resources; ocean; California.

INTRODUCTION

The objective of this work is to develop an understanding of the nature of the natural energy resources that are present in the coastal region of the world using the example of Santa Cruz, California, USA. This work is an extension of the study of multidirectional wave energy started in 2007 and reported in Waid (2008). At that time, a good assessment of the global wave energy resource was provided by Cornett (2008). He had used a ten-year (1997-2006) collection of global wave climatology data as the basis for his computations and a series of related studies. He substantiates his work by a good correlation with buoy data from the east and west coasts of Canada as well as numerous other sites. He includes a presentation of the extreme wave heights as well as several forms for representing temporal variability. My studies indicate that wave energy unsteadiness is very regular and is dependent on earth-lunar dynamics. These observations should allow a rigorous view of the temporal variability of wave energy, and provide guidance to deal with the significant unsteadiness that occurs with natural wave power.

One aspect of the extreme wave heights that occur occasionally in the winter season in the deep water region west of Southern California is the extreme wave episodes which last for at least nine hours and sometimes for weeks. These events have been correlated (Seymour, 1996) with the occurrences of the year-long heating of the eastern central Pacific Ocean by an event of ENSO (an El Nino-Southern Oscillation effect). Since the direction from which these extreme episodes come is from the West to NorthWest, they should also be incident to the coastal region in the vicinity of Santa Cruz within a degree or two of heading. This should help explain the current events observed for the forecasted wave conditions for Santa Cruz for the winter of 2009-2010. The Cornett (2008) ten-year climatology data set encompasses two periods of ENSO events (1997-8 and 2004-5) that by inclusion may have influenced these 10-year average values. These ENSO event dates are based on information from the Los Angeles Times newspaper, March 15, 2005.

Understanding the wave energy resource variability is the first step in adapting an energy utilization system to the resource. Effective utilization of natural wave energy may be accomplished by using the tidal current energy to complement the unsteadiness of the wave energy. This tidal current resource will have a much more steady level of available energy to utilize, and the shorter underpowered time should be able to be handled by a smart power grid or a smaller capacity energy storage system. The application of natural tidal current energy could become the solution to the extreme unsteadiness that is evidently inherent in natural wave energy.

COASTAL REGION DESCRIPTION

The coast of the central portion of California, which includes Monterey Bay in the south, to Santa Cruz, to Bodega Bay in the north, faces to the southwest. Because of this angle, the region is exposed to wave energy in the form of swell from the South, SouthWest, West, and NorthWest directions. In addition, local wind waves arrive mostly from the NorthWest and from all directions, during the winter season. Most of this coast has a short shelf which extends 8 to 10 kilometers (5 to 6 miles) offshore before a depth of 91 meters (300 feet) is reached, and another 8 to 10 kilometers for the next 91 meters to be reached. The declivity of the shelf is about 1:100 (-0.6 degrees). In the region offshore of San Francisco Bay, the shelf extends to about 32 kilometers (20 miles). It is on the shelf that any practical wave energy capture and conversion system designed to make use of the free wave energy resource would be moored and connected to the electrical power grid on shore. At a depth of about 182 meters the shelf turns rapidly onto the steep downward slope (1:10 or -6 degrees) into deep water.

COASTAL NATURAL ENERGY RESOURCES

The predominant natural energy resource in the coastal region is wave energy followed by tidal energy, wind energy, and current energy. This study will concentrate on the wave energy and tidal energy resources.

Wave Energy Resource

The long-term average power of the wave energy resource incident to the central California coast in water at 100 meters depth between 36 and 39 degrees north latitude has a yearly average of 24 kilowatts per meter, with a monthly variation from 35 kW/m in the winter to 17 kW/m in the fall, (Beyene, 2006). The wave energy resource that is