

Capture and Conversion of Multidirectional Wave Energy

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ABSTRACT

The wave energy resource incident to the coast of California is usually a simultaneous combination of several wave types each with significant short-term, seasonal, and long-term variations of direction and height. Although many wave energy conversion devices are unidirectional, the symmetrical, dome-shaped "Shallow Surf Ramp" (SSR) is efficiently capable of capturing each of these wave systems simultaneously, while converting the available wave energy into relatively steady electrical power, and transmitting it to shore for grid distribution. Significant deficiencies in the wave resource have been noted to occur as often as several days in succession ten and 10 days each summer month. The SSR concept can provide efficient capture of a wide range of wave energy that can be used to offset these deficient wave resource days.

KEY WORDS: Waves; energy; resource; ocean; California.

INTRODUCTION

The initial objective of the paper is to identify the significant energy and power characteristics of the ocean waves that are incident to the coast of California. A key factor in understanding the wave phenomena is the directions from which the wave energy comes. The final objective is to indicate the potential for a wave capture and conversion system to accommodate simultaneously the multidirectional wave energy that is incident to the California coast.

DESCRIPTION OF THE PROBLEM

Analysts have identified several sources of the wave systems that propagate to or are local to the coast of California. The sum of the energy that is brought to the coast by these systems is variable in time and location. Understanding these variabilities is the first step in development of an effective wave energy capture and conversion system. The overall system, including the power grid distribution subsystem, must be capable of accepting the variable wave energy and producing a steady output of electrical or mechanical energy. The ability of the system to deal with the variabilities of the resource is the key to practical success.

MEANS TO SOLVE THE PROBLEM

Understanding the wave energy resource variability is the first step in adapting the capture and conversion system to the resource. Long-term

data that characterize wave energy that is incident to the California coast have been collected and analyzed (Beyene and Wilson, 2006). Some interesting contemporary features have been noted. Significant wave energy regularly propagates into the coastal waters of the state from several widely-separated sources. The relative contributions of these sources to the total energy resource that could be utilized has been determined by comparison of the Beyene data and the daily surf wave forecasts available from local weather reports. These forecast local wind direction, speed, and range of wave heights, and swell direction, range of wave heights, and periods. The similarities and differences among the four (primary and secondary) wave energy sources is presented so that the simultaneous occurrence of this wave energy can be utilized most effectively. The occurrence of numerous days per month when neither primary nor secondary swell are forecast is noted, and the potential for the local wind wave resource to compensate for the lack of swell-related energy is presented.

A device that utilizes a three-dimensional dome, shaped like a "shallow surf ramp" (SSR), to refract the energy-laden waves to the center of the dome is described and analyzed to indicate the effectiveness of the wave capture and conversion process that deals similarly with these various wave resources.

Wave Energy Resource. The wave energy resource that propagates to the coast of north central California is comprised of four globally diverse wave making regions and types of waves which are variable from day to day, summer season to winter season, and year to year.

Coastal Features. The coast of the central portion of California faces in general to the southwest. Because of this angle the region is geographically exposed to waves from the south, southwest, west, and northwest directions. In addition, local wind waves arrive from all directions. Most of the length 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 grid subsystem 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. It is over this deep water that wave systems propagate