Oregon Wave Energy Trust
Utility Market Initiative

Task 4.3.1: Forecasting Requirements

www.oregonwave.org

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The Utility Market Initiative was prepared by *Pacific Energy Ventures* on behalf of the Oregon Wave Energy Trust.

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About Oregon Wave Energy Trust

The Oregon Wave Energy Trust – (OWET) - with members from fishing and environmental groups, industry and government - is a nonprofit public-private partnership funded by the Oregon Innovation Council in 2007. Its mission is to serve as a connector for all stakeholders involved in wave energy project development - from research and development to early stage community engagement and final deployment and energy generation - positioning Oregon as the North America leader in this nascent industry and delivering its full economic and environmental potential for the state. OWET's goal is to have ocean wave energy producing 2 megawatts of power - enough to power about 800 homes - by 2010 and 500 megawatts of power by 2025.

Forecasting Requirements

Utility Forecasting Requirements

It is recognized that the greater the variability and unpredictability of a resource, the higher the cost to a utility to integrate the resource into their system. Therefore, developing and evaluating forecasting tools that can provide appropriate levels of accuracy is an important element of the developing wave energy industry.

The wave energy resource off Oregon's coast is variable. However, based on analysis conducted by EPRI and others and the nature of the resource (waves are created weeks in advance before coming to shore), wave energy resources can be predicted. Outlined below are general utility requirements for wave energy forecasts. The levels below are proposed measures of effectiveness for wave energy forecasting tools.

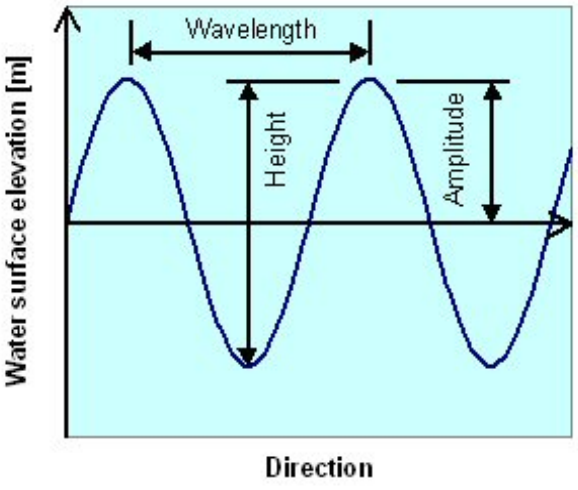
- ANNUAL: Annual MWh production distributed over a 12 month period.
- WEEKLY: Week-Ahead Hourly Average MWh Forecast with reasonable accuracy
- DAILY:
    - Three (3) Day-Ahead Hourly Average Forecast with no greater than a +/- 7.5% deviation from forecast.
    - Day-Ahead Hourly Average MWh Forecast with no greater than a +/- 5% deviation from forecast.
- HOURLY: One-Hour-Ahead Hourly Average MWh Forecast with no greater than +/- 1.5% of schedule.

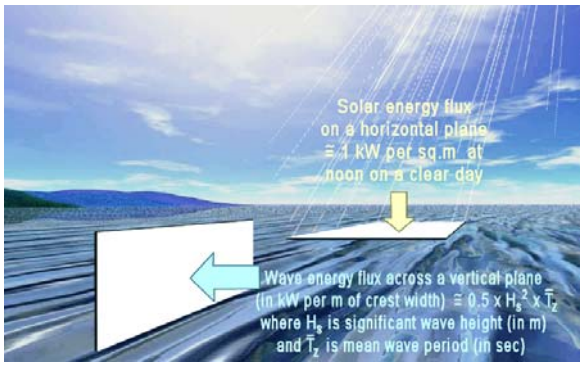
Wave Energy Resource Potential

The energy content of waves is function of wave height and wave period.

Wave height is a measure of the amplitude of oscillation of water particles, in the vertical direction with respect to a fixed point. The significant wave height is a commonly used term and is approximately equal to the average height of the highest one-third of the waves.

Wave period is the time that elapses between successive peaks or troughs of a wave passing a fixed point. Like wave heights, waves exhibit a range of periods. The zero up-crossing period is one such commonly used term and is the average time interval.





Wave energy is calculated by power flux. Wave power density is defined as the flux of energy across a vertical plane intersecting the sea surface and is calculated using the following formula:

Power Flux = .42(**Wave Height**^2)(**Wave Period**)

Source: EPRI
Note: The 0.42 multiplier in the above equation is exact for any sea state that is well represented by a two-parameter Bretschneider spectrum, but it could range from 0.3 to 0.5, depending on the relative amounts of energy in sea and swell components and the exact shape of the wave spectrum.

Validation of NOAA WaveWatch III Wave Forecasting Model

- WaveWatch III is a third-generation wave forecasting model developed by NOAA and used by many coastal water users (US Coast Guard, fisherman, etc.) to track swells and storms.
- Wave Watch III provides forecasts for 4 different hours in the day for next hour and 1, 2, and 3 days out.
- As part of the UMI effort, EPRI and SAIC analyzed the accuracy of WaveWatch III and its ability to forecast wave size and wave period, the two primary components of wave energy generation.
- The study evaluated a single buoy off the coast of the Oregon- California border which had a database that included NOAA's WaveWatch III forecasts as well as National Data Buoy Center's actual measured wave heights and periods.
- The analysis was conducted for the time period of April 2008 through March 2009.
- The EPRI analysis developed a mean absolute error (MAE) for each month of the year. An annual average MAE was also developed. Relative to the annual average, the mean absolute error for both wave height and wave period was approximately 15%.
- At this time, without additional generation information, we cannot determine the accuracy of this forecasting tool relative to utility requirements listed above.

Future Work to Improve Forecasting Accuracy

- Continued evaluation of WaveWatch III to include multiple locations and multi-year analysis.
- Evaluate the effects and sensitivity of wave height and wave period error on expected generation levels.
- Enhance the frequency of forecasts from WaveWatch III.
- Evaluate the benefits of adding advanced predictive techniques such as regression analysis and neural nets.
- Work with the Northwest National Marine Renewable Energy Center at OSU to align efforts and explore deploying wave energy measurement instruments near shore.