

ANTEIA WAVE BUOY: Integrated solution to meet market needs

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Abstract- Utilization of ocean energy resources can contribute to the world's future sustainable energy supply and to reduce carbon emissions, whilst minimizing impacts on marine environments.

Although it has now taken the first generation of renewable energy technologies to competitive levels, Europe still needs to diversify its electricity supply further if it is to meet its 2050 policy objective of reducing greenhouse gas emissions to 80 – 95 % below 1990 levels.

In this context, meteoceanic data must be taken into account during all the phases of marine renewable energy generation. Some data is relevant in order to perform safer operations at sea, there are other parameters that can optimize the power generation and it is also a key question in the study of the survivability of the devices that will led to improved investors confidence.

In order to meet market needs, Zunibal has developed an innovative wave measurement system that can provide the decision-maker with accurate information to bring down the uncertainties and improve the efficiency of the marine renewable energy devices. With this system, both developers and farm operators could have real time information on the environmental characteristics in order to optimize marine operations (during establishment, implementation and maintenance stages) and energy capture.

Some of the advantages that ANTEIA Wave Buoy offers are low weight (26 kg) and diameter (0.6 m), that gives advantage during deployment, maintenance and recovery phases, battery rechargeable by solar panels, that allows more life time and its tried-and-tested reliability with more than one year at sea in BiMEP test area.

Keywords- Forecasting, monitoring, optimization, maritime operations, real time simulation

I. INTRODUCTION

Virtually all activities of the blue economy depend critically on offshore operations such as transport, installation and maintenance of marine structures. For instance, offshore

operations amount to over 30% of total costs in offshore wind. This high proportion is of the same order in other sectors such as aquaculture and offshore oil and gas.

A major driver of costs, uncertainties and risk in offshore operation is the uncertainty in marine weather forecasting, most acutely, in ocean wave parameters. Uncertainty in wave height prediction multiplies risk to crews several fold, reduces operating times of costly vessels and reduces predictability or return on investment. This increases cost of capital, which typically is 30-50% of total costs for the blue economy.

Wave measurement buoys have been used since 1960's in offshore operations to monitor existing meteocean conditions in the vicinity of an operational area. Recently their use has become more common in offshore renewable energy projects.

The advantage that this system provides to the marine operation is the increased weather window due to a better understanding of the real-time meteocean conditions on site. The risk of planning an operation based only on the weather forecast can be reduced using these on-site systems with the support of a dedicated meteorologist interpreting the data.

In addition, and directly related to the optimization of power generation in marine energy converters, the fact is that these devices are normally configured to work at a default set point, according to most recent sea state information, or configured by some kind of forecast. If a wave sensor can inform instantaneously how sea state parameters are evolving, the energy converter device may be tuned to optimize energy conversion, obtaining as much energy as possible in all moments. This means that the device could improve the energy conversion by using all the sea power states by the dynamic reconfiguration of the PTO, resulting in an improvement in revenues from generated power.

Likewise, this information could be used by both energy conversion devices and farm operators to implement protection actions against extremal sea states. Through the availability of real-time data, hazardous environmental situations could be detected and alerts could be sent in order to avoid damage to farm assets. This advantage could

increase confidence in some actors such as insurance companies and regulators.

This paper aims to provide the comparative analysis of commercial wave buoys versus ANTEIA and to show the advantages and benefits of using this system in marine renewable projects.

For this purpose, the paper has been structured in four sections:

- II. Methodology: Description of the system and comparative analysis of commercial wave buoys;
- III. Case studies: This section presents two case studies to show the use of ANTEIA data to optimize energy conversion;
- IV. Results and findings: In this section it is outlined the benefits and experience of using ANTEIA system in marine renewable projects;
- V. Conclusion: Final outcomes.

II. METHODOLOGY

ANTEIA Wave Measurement System has been developed to fulfill the most recent market requirements and it is composed by the following elements:

1. ANTEIA Wave Buoy: It is a small and easy to deploy buoy, with a weight of 26 kg and 0.6 m diameter. The physical characteristics and the materials with which it is made, gives many advantages like the use of small boats for deployment and recovery and the potential of deploying an array of buoys to cover as much areas as possible, as well as opening the way to reducing the operational costs linked to the buoy maintenance.



Figure 1. ANTEIA Wave Buoy

2. Mooring system: This buoy has a bespoke mooring system, allowing free movement for optimum wave parameters detection. This mooring is specially designed for the buoy and can be fitted to different depths and current conditions.

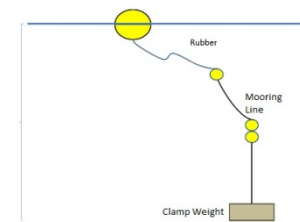


Figure 2. Mooring system configuration

3. Real-time data portal (zuniwave.com): Zunibal has developed its own website for data visualization.

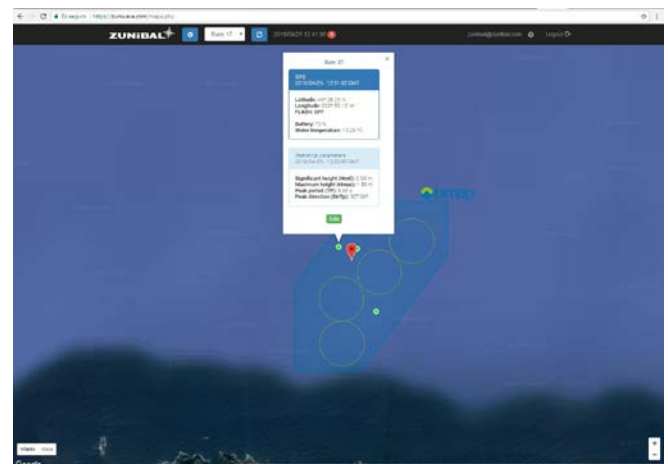


Figure 3. <http://zuniwave.com> view of BiMEP

By means of this website, Zunibal offers the following relevant information:

- Display of the latest wave data;
 - Historical data download, both statistical and spectral wave data;
 - Data visualization through a set of dynamic graphics;
 - Wave-by-wave data display and download options.
4. 24x7 technical assistance policy: In this case, the assistance and the monitoring of the state of the buoys is given by automatic warnings when it is noticed some problem, mostly, low battery or mooring break.

In terms of technology involved in this innovative system, the wave parameters are obtained from GPS information, unlike traditional systems which use inertial technology. The advantages of this novel technology are the following:

- No need for calibration;
- Provide a time absolute reference (GPS time);
- Increased accuracy as a single integration is needed to obtain wave parameters, instead of a noisy double integration of accelerations.

The data obtained from this system is related to all wave parameters (i.e., wave heave, period and direction), both statistical and spectral data, every 30 minutes and includes the possibility of having wave-by-wave information in real time.

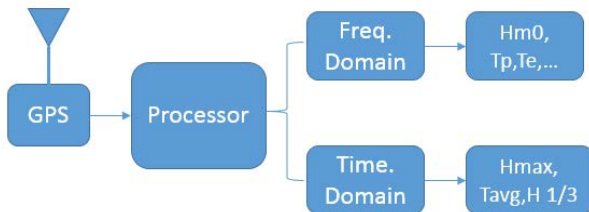


Figure 4. Data flow

The use of surface buoys for wave measurement is common in oceanography and also in ocean energy, oil and gas applications. The most common types of surface buoys for wave measurement are Particle Following and Pitch-Roll-Heave buoys, produced by a variety of companies such as Fugro, Axys and Interocean.

In order to validate the accuracy of this new system, extensive analysis has been conducted on data streams from seven buoys deployed in two locations. Two independent specialist organizations have been commissioned for this analysis. Both deployments are in wave energy test sites, which allowed for close interaction with users and best tailor the product to ocean energy requirements.

Deployment Locations:

Buoy	Latitude	Longitude	Depth (m)
ANTEIA 1	43°28.07'N	2°53.23'W	81
ANTEIA 2	43°28.23'N	2°53.16'W	81
ANTEIA 3	43°28.21'N	2°52.90'W	19
ANTEIA 4	43°27.64'N	2°52.66'W	58
ANTEIA 5	43°28.42'N	2°52.53'W	90
BiMEP	43°28.09'N	2°53.09'W	80

Table 1. Deployment locations in BiMEP area (Bay of Biscay)

Buoy	Latitude	Longitude	Depth (m)
ANTEIA 22	28° 02.83' N	15° 23.32' W	39
ANTEIA 23	28° 02.72' N	15° 23.12' W	40
LPE	28° 02.75' N	15° 2.453' W	34

Table 2. Deployment locations in PLOCAN area (Canary Islands)

In both areas there is historical data record from other commercial wave buoys which are recognized world-wide and that has been used to validate the data obtained by ANTEIA Wave Buoy.

Detailed wave data comparison is shown in figures 5, 6, 7 and 8.

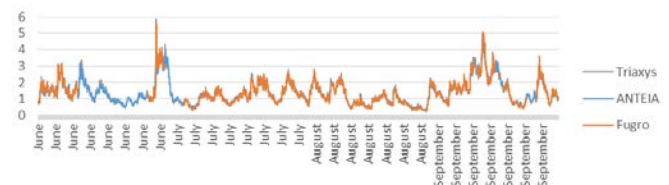


Figure 5. H_{m0} comparison between ANTEIA Wave Buoy and Fugro and Triaxys Wave Buoys in BiMEP

Figure 6 shows a scatter with an r^2 of 0.98 between ANTEIA Wave Buoy and Fugro and Triaxys buoys, deployed at BiMEP area.

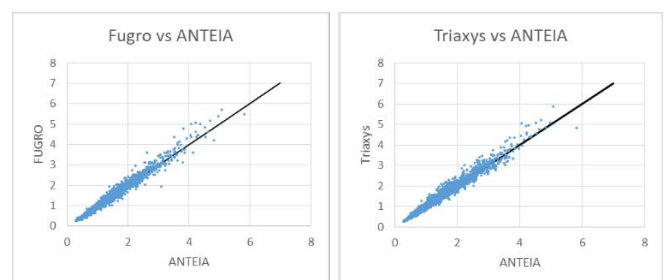


Figure 6. H_{m0} scatter plot: a. Fugro vs. ANTEIA; b. Triaxys vs. ANTEIA

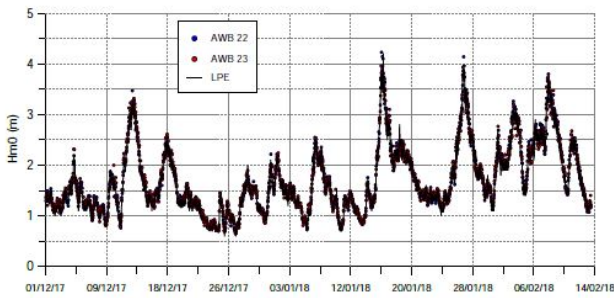


Figure 7. H_{m0} comparison between ANTEIA Wave Buoys and Triaxys Wave Buoy in PLOCAN

Figure 8 shows a scatter with an r^2 of 0.97 between ANTEIA Wave Buoy and Triaxys buoy (LPE), deployed at PLOCAN area.

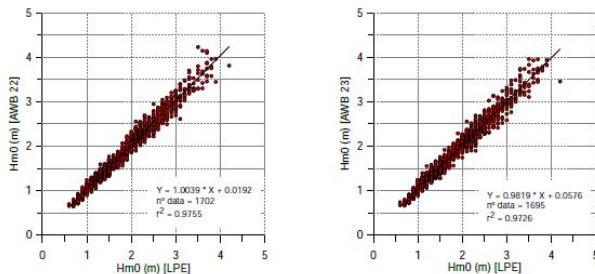


Figure 8. H_{m0} scatter plot Triaxys vs. ANTEIA (22 and 23)

III. CASE STUDIES

The case studies conducted to show the advantages and benefits of the use of wave data to optimize energy generation by marine devices were the following:

A. OCEANTEC Energías Marinas S.L.

OCEANTEC Energías Marinas S.L. is a Spanish Company which has developed a floating OWC spar buoy converter. This technology is been tested in real conditions at BiMEP and it provides high-quality operating data and experience within the H2020 OPERA Project (www.opera-h2020.eu). The technical department has been using metocean data for the proper management of the device and the project research activities.

Firstly, they used the data from Triaxys buoy and in the last few months, they have been using ANTEIA's data to plan offshore work at the converter and to compare wave information of the area.

In this sense, the technicians from OCEANTEC Energías Marinas S.L. have been using data obtained from the different files that can be downloaded from Zunibal's website.

The most important data required for this application are: H_s , T_e , T_p and spectral data.

B. EnerOcean S.L.

EnerOcean S.L. is a SME focused in all kind of Marine Renewable Energies that is currently active in national and international projects related to offshore wind, wave and tidal energy conversion and supporting technologies.

EnerOcean S.L. is currently involved in two main projects: *WIP10+ Project* (www.wip10plus.eu): "Wind integrated platform for 10+ MW power per foundation", funded by DEMOWIND Era-Net and cofunded by CDTI, BEIS and EU Horizon 2020 Framework Program; and *ORPHEO Project* (proyecto-orpheo.es): "Optimización de la Rentabilidad de Plataformas Híbridas en Energía Eólica y de las Olas", funded by Programa para Promover el Desarrollo Tecnológico, la Innovación y una Investigación de Calidad, cofunded by the Spanish Ministry of Economy and Competitiveness and the European Union.

The relevant data for the first project is data related to H_s and T_p , which is used for studying the remaining life of structural fatigue models.

For the second project, the spectral data is used, a posteriori, to verify the operation of the controllers, real time wave estimators already integrated in the platform, or even, of the hydrodynamic models of the platform.

IV. RESULTS & FINDINGS

During the period of trials in the different areas, it has been observed that the following wave data must be used, to improve the entire lifecycle of marine energy farms:

- Design phase: The energy converter developers are using T_e data for mooring design optimization;
- Operation: Spectral data is commonly used for in-depth analysis of the energy converter conditions and energy conversion optimization;
- Survivability: Through H_{max} data the marine energy converters can obtain a report on the survival rates to maximum height waves. This probes the technology robustness and could increase investor confidence;
- Maintenance: H_{m0} and T_p are relevant data for maritime operations. Based on this data, the energy converter developer could decide to carry out or not certain operations at sea.

V. CONCLUSION

The use of an oceanographic buoy such as ANTEIA Wave Buoy is an opportunity for addressing different market needs such as:

- First of all, an ocean energy device can optimize its power generation, by improving its control algorithms;
- Secondly, energy converter design can be optimized, and risk and cost reduced by obtaining information site-specific wave conditions;
- Finally, opens a way to a better characterization the energy field in large farm concessions thanks to the deployment in arrays for a similar cost of current market instruments.

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