Selection of the Electrical Generator for a Wave Energy Converter

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Abstract

This paper presents the analysis made to select the appropriate electrical generator for a new design of Wave Energy Converter (WEC), identifying the features that have influence on the WEC's performance, the efficiency and economical feasibility of the system.

The proposed WEC is a near shore submerged converter that takes advantage of the oscillating water column created by the wave when it passes on the converter's platform. The wave column moves the platform, transmitting the force to a single acting cylinder, that pumps sea water to the coast, where is turbined generating electricity. A constant flow is obtained by means of accumulators located inside the module. The nominal power of the facility depends on the number of modules connected in parallel, producing 25kW per module. The facility size is between 100kW (4 modules) and 500kW (20 modules).

After introduced the proposed WEC, a review of different solutions adopted by other WEC system is presented.

There are two generator types suitable for variable speed operation: the synchronous permanent magnet generator (PMG) with the frequency inverter and the asynchronous induction generator. On the other hand, for constant speed operation the synchronous PMG and the squirrel-cage induction generator fulfil the requirements. However, before selecting the generators, it is mandatory to study the operation of the generator and the status of the host power network of which the generator will be a component.

The WEC control algorithm governs the optimal performance of the facility. The energy absorbed by the WEC is maximum when platform's movement is tuned to the incident wave frequency. The PLC acts on system pressure and generator's load torque in order to work in resonance. The paper includes a study about the influence of the generator system on the control.

There are two options: to work with variable speed to take advantage of the highest efficiency, or work with constant speed, reducing the initial investment. In both cases the PLC sets the generators load with the available wave size information for the given rotation speed (variable or fixed). The paper analyses the energy output difference between variable and constant speed strategies. The study is based on the efficiency of the turbine for both dispositions, followed by a evaluation of the energy loss for a given location, applied as example on a hypothetical implantation in Bilbao Port.

The WEC works with variable pressure to adapt the absorption to the actual wave size, and the efficiency of the Pelton turbine only depends on the working pressure. Then, the expected efficiencies can be obtained for different working pressures supposing constant speed (synchronism). The wave energy resource for a given location is defined by a bivariate distribution of significant wave height, *Hs* (m), and wave period, *T*, (s), counting the occurrences for each wave size and period during a given time period. Multiplying the occurrences by the power absorbed for each Hs-T combination, the result is a good estimation of the potential power of the given location. The lost power due to constant speed for the location can be defined because the efficiencies are defined for each wave condition.

Beside the variable-constant speed strategy influence on the efficiency and expected energy output for a given location, the initial cost of the facility and the exploitation cost (maintenance and reactive energy requirements) are decisive when studying the feasibility of the investment.

We have found necessary and valuable to accomplish this review and reflection about the selection of the generator. The influence of the generator on converter's performance has been studied, as well as its implementation in the system´s control. In addition, an example of feasibility study has been applied on a given disposition to evaluate the different generators with real data (four modules, 110kW rated power, located in Bilbao port). Each conversion system has shown advantages and disadvantages, year by year prices are more affordable and technologies are improving. The generator must be selected for each location in collaboration with the promoter.