HYBRID FLOATING RENEWABLES TOWARDS COASTAL ENERGY RESILIENCE

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SUMMARY: High density population resides in coastal regions of different countries. Remote islandic region such as in Southeast Asia and Caribbean region have poor energy per capita but still attracts significant tourists. Their regional economy greatly depends on the industrial activities such as fisheries and tourism and presently depends solely on diesel energy systems for its essential needs such as energy and water which gets hampered during natural disasters such as hurricanes and typhoons. This paper proposes the floating tidal energy system that is capable to be towed and easily deployed in remote coastal location and deliver useful power to the electrical loads. The paper will investigate through a case study of floating tidal system towards tropical shallow water conditions through simulation and field based assessment.

Keywords: Tidal energy, Renewable energy, floating structure

INTRODUCTION

High density population resides in coastal regions of different countries. Remote islandic region such as in Southeast Asia and Caribbean region have poor energy per capita. Their regional economy greatly depends on the industrial activities such as fisheries and tourism and presently supported solely on diesel energy systems for its essential needs such as energy and water. This costs up to twenty percent of their GDP towards fossil fuel imports and it greatly hampers the ecology and further challenges the fuel transport logististics during natural disasters such as hurricanes and earthquake period.

Today land based solar energy systems have become prominent as a credible energy source and are adopted into regular energy mix of these region. However in coastal settings due to limited land area for deployment, the present paper proposes the concept of floating renewable energy systems that can wisely utilize the shallow water region and the available tidal energy resources in the site. Tidal instream flow currents are predictable in ocean conditions and can work well with other energy forms such as solar photovoltaic systems. Today, with proper hydrodynamic modeling large floating structures can be developed to support the concept of floating renewable energy platform. This paper shows how the seabed and coastal bathymetry surveys could be used with tidal current & wave measurements to perform hydrodynamics, fluid structure interaction studies, power predictions, e.t.c of these floating energy systems. In addition, through detailed resource mapping and device performance studies the best site locations can be identified for the ocean device deployment to achieve optimum levelized cost of energy, maximum availability and maximum capacity factor. Thus this paper aims to elucidate the hybrid floating energy system as a viable power plant towards tropical coastal and island regions.

TROPICAL TIDAL IN-STREAM ENERGY SYSTEMS

In order to develop a low cost floating tidal turbine system towards low flow tropical tidal conditions, the present study focused on the following tasks:

- Tuning the hydrofoil to the low tidal flow conditions of Southeast Asia.
- Low inertial blade development with anti-seaweed and biofouling resistive functional coatings.
- Testing of the turbine system in the lab was focused towards performance studies and further validated in field conditions.
- Further a novel barge based tidal energy was developed based on the naval architectural principles that is easily towable and deployable to any coastal location to minimize commissioning and decommissioning time and minimize overhaul and maintenance (O&M).

Tidal Turbine Development

The aerofoils were built using a novel artificial intelligence algorithm based on genetic algorithm (Srikanth and Rejish, EWTEC 2015). The algorithm optimized under low flow tidal current condition (~ 1.5m/sec) towards high lift, low drag forces and minimal chances of cavitation and robustness towards roughness that may be caused due to biofouling. The aerofoils developed were further studied in water tunnel through building a 3D rapid prototype model and further verified against CFD before being built into fully developed tidal turbine rotor. Thereby a low flow tidal turbine was achieved to have a unique match for lower tidal flows (4 to 6 knots). In addition the hydrofoil tailoring took the roughness considerations of the blades due to fouling and cavitation failures. The debris and seaweed impacts were taken as a major barrier in installing hydrokinetic turbine in river streams and tidal flows. Some design ideas of minimizing the debris impact and entanglement were incorporated.

A scaled tidal energy system with 1 meter diameter was developed and deployed in lab level test conditions and further tested in Singapore waters.

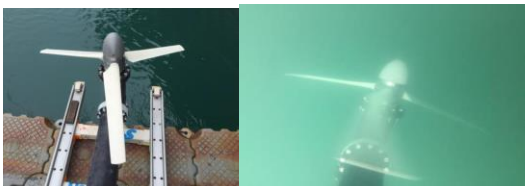

Figure 1. Scaled tidal turbine under field test.

Floating tidal Energy System

Traditional tidal turbines are sea bed mounted which are prone to bio fouling and demands for deep divers to do necessary maintenance. To access these turbine, necessary approvals should be sought and have to be performed in very short time when the tide reversals occur. Further it becomes difficult if the turbines are deployed in busy shipping water lanes. Hence in this study a floating tidal energy system was conceptualized which is easily towable to shores for any major maintenance and can be towed to places of energy needs which makes it flexible to suit energy demands.

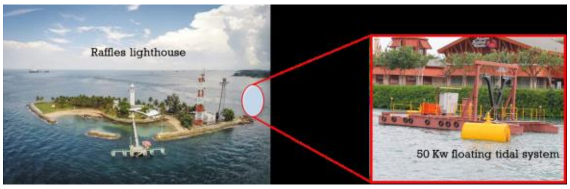

Figure 2. Deployment of floating tidal energy system in Singapore Waters.

Generally, a barge is a flat-bottomed boat, built mainly for transport of heavy goods. Some barges are not self-propelled and need to be towed or pushed by towboats. The benefit of floating barge based tidal energy system is its ease of deployment of tidal turbine in any desired location and depth. The barge is an easy-to-install mooring and anchoring system without the need for seabed-mounted fixed structures. In the first demonstration, the floating tidal turbine system was tested in Indonesian waters in the shores of Babu to power to power a wood pulp factory. From the experience, the design was improvised and further deployed in Sentosa waters to study the dynamic stability conditions. Presently the floating tidal turbine system is being tuned to support the light house to displace the use of diesel power. Figure 2 shows the barge based tidal turbine integrated system with a self-retraction and is capable to operate in 40 meter water depths. The barge was self-contained with the necessary electrical power systems, battery and other energy storage devices to make it a self-contained system.

Conclusion

The present study results has been aimed towards low-flow and near-shore tidal energy extraction, especially for tropical coastal and islandic waters with necessary features to overcome the bio-fouling, corrosion and seaweed issues. Moreover, they are designed for low capital cost and maintenance cost thereby meeting the power requirement of off-grid remote island communities through integration with smart distributed grids. The proposed design demonstrates flexibility and modularity to suit the situation as a reliable multi-kilowatt-scale tidal power plant. Through field deployment in real sea conditions, in Singapore waters and in Indonesia, it is encouraging to see that tidal device developers can support the remote coastal energy users with greater certainty and power quality.

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