

## Development of an integrated assessment and planning tool for tidal current energy in the Philippines: a progress report

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### **Abstract:**

*This paper presents a framework and some initial results of the efforts to develop an integrated assessment and planning tool for tidal current energy in the Philippines. Considerations related to site (e.g. resource, grid proximity, bathymetry, etc.), and technology (e.g. technical specs, cost, depth limitations, etc.) have been captured and integrated into a tool designed to be used by agencies and project developers in evaluating the potential sites where tidal in-stream / current energy can be extracted. The same framework can be applied to different types of ocean renewable energy (ORE) for the Philippines and even other countries. Considering a multi-criteria, multi-technology, and multi-site approach towards the development of the ORE industry can be a good way to progress the uptake of such alternative source of energy.*

**Keywords:** Ocean Renewable Energy; Tidal Current; Geographic Information System; Integrated Assessment; Site-Device Matching; Suitability Analysis

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### **1. Introduction**

While the Philippines is highly dependent on the use of non-renewable fossil fuel as energy sources such as oil and coal which supply 50% of its electricity, a substantial amount has been generated by renewable energy sources. Among the potential alternative sources of alternative energy that can be considered is ocean. The Philippines has vast ocean energy considering its archipelagic territory. Earlier in 2006, the Department of Energy (DOE) identified potential sites for ocean renewable energy (ORE) extraction in the country, as well as a potential theoretical capacity of 170 GW, as estimated by the Mindanao State University (Rodriguez, 2011).

In global scenario, ORE has gained unprecedented interest in the industrial world from many quarters. In cadence with the constant advances in research and development in ORE worldwide (International Energy Agency, 2014), papers have been published by Filipino researchers in this field (Abundo et al., 2012). First and foremost step in advancing ORE development in the Philippines is the assessment of available resource or resource assessment (RA). On-site measurements are necessary to calibrate and validate the numerical models used to calculate the distributions of current and power density (Chen et al., 2013). Moreover, several constraints are also needed for the selection of the optimum area of deployment. These may include information such as fishing activity, port proximity, distance from electricity sub stations, special area of conservation habitat classifications and shipping use (Fairley et al., 2011). These information can be incorporated in a Geographical Information System (GIS) database to narrow down high power density areas that satisfy the constraints of ocean power conversion scheme.

The goal of this proposed project is to set groundwork for the advancement of ORE development in the Philippines. Specifically, the objectives are as follows: (1) Assess the tidal current energy potential of the country; (2) Assess site suitability for the development of tidal current energy and generate suitability maps; (3) Perform preliminary environmental impact assessment; (4) Develop a robust webGIS-based marine spatial planning tool for the analysis of the country's potential sites for

tidal current energy; (5) Perform modelling of energy conversion and estimation of energy yield.

## 2. Material and methods

The use of Geographic Information Systems (GIS) for assessing renewable energy potential has been in place for more than a decade now (Serri et al., 2012). Recent studies concerning offshore wind potential through GIS evaluations have been carried out for Europe and the USA (Alesheikh et al., 2002). GIS allows for the collection, storage, processing, analyses and display of geospatial data for informed decision making. With the development in WebGIS technology, GIS capabilities became more accessible to anyone through the Internet. This allows for easier information dissemination with geospatial analysis capabilities (Georgia Tech Research Corporation, 2012). Combining GIS tools with the resources of the web will enable better dissemination of ORE information which may aid in planning and decision making.

Estimation of annual energy yield is also an important achievement in the course of ORE development. Simulation and modelling of energy systems would provide a preliminary insight of how much energy and other benefits could be extracted from ocean energy potential sites. These are beneficial steps to take prior to installation and validation, as they probe and quantify, to appreciable accuracy, parameters that will affect the risks for investment and that will impact the existing energy sector, especially those in the nearby islands and immediate local communities.



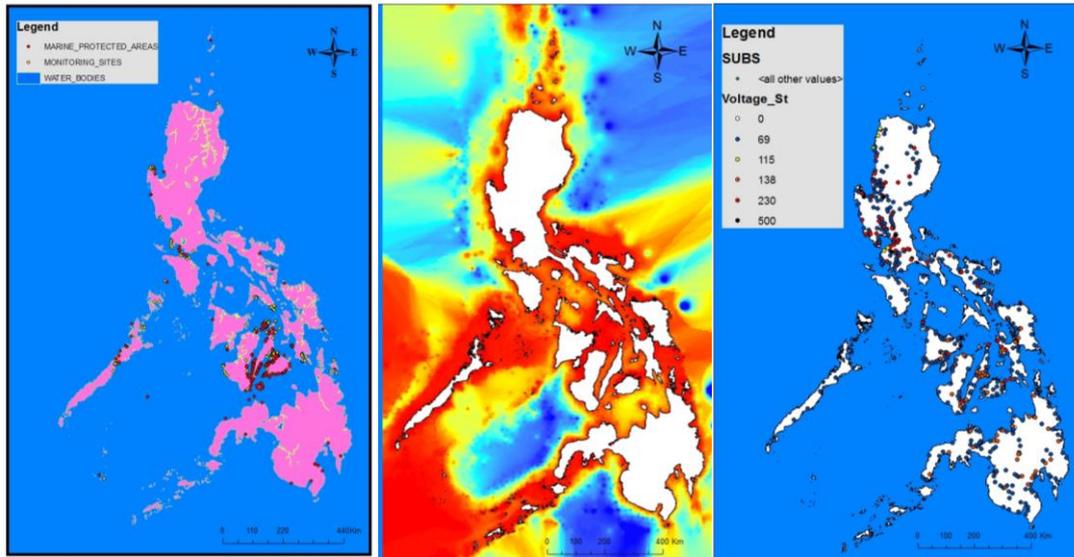
Figure 1. Proposed Marine Spatial Planning Tool: WebGIS platform (L) and Functional Layers (R)

The framework of the WebGIS (Yin and Feng, 2009) where the MSP tool will be built upon is shown in Fig. 1. It is structured in four levels: Application Layer, Service Layer, Function Layer and Storage Layer. The storage layer is where geospatial data, its metadata and configuration information are stored in a geodatabase. The functional layer is where functional modules such as map visualizations, data queries and searches and maps generation are provided. Also, this is where map tile caching is implemented. The service layer links the browser and the server. It provides metadata services and spatial data services based on the functional modules (Fig.1). The application layer provides web interface to the users.

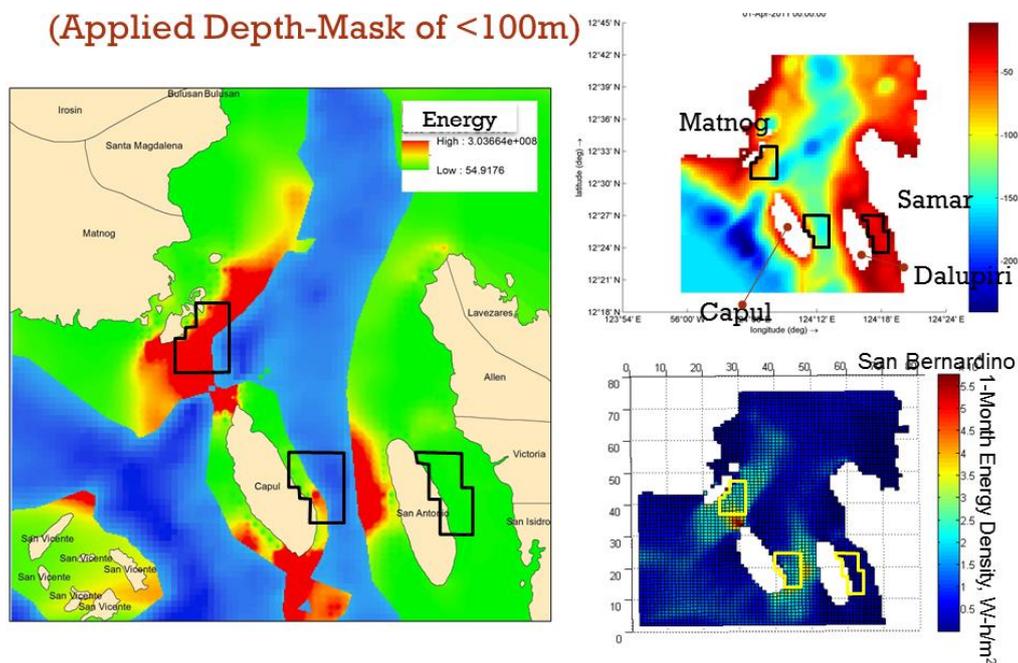
## 3. Results & Discussion

Shown below are some initial results of the efforts of this work. Fig. 2 shows a partial collation of information used as map layers for the geographic information system (GIS). Relevant to the development of any site to be developed as an ocean power plant on top of the resource available are the consideration of restricted zones and areas, location of infrastructure, depth of water, existence of marine and maritime use, etc.. Some proximity to relevant or desirable characteristics will dictate or at least be considered as part of the evaluation in terms of the suitability of a site.

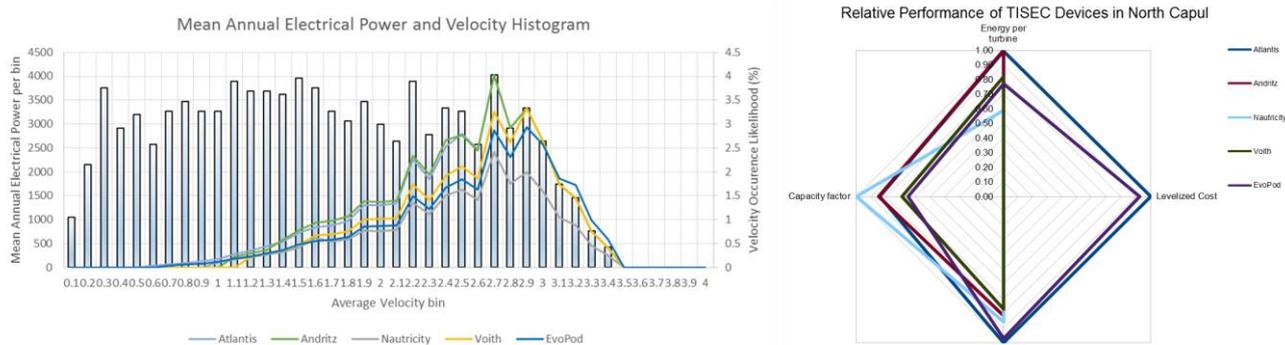
Fig. 3 shows a site within the San Bernardino Strait (one of the high energy potential sites in the Philippines for tidal current energy extraction). The lower right hand side of Fig. 2 shows the energy resource available, the upper right hand side shows the bathymetry of the domain and the left hand side shows a masked version of the domain removing those with depths greater than 100 m (depth at which most 1<sup>st</sup> generation tidal turbine developers are not keen to deploy due to techno-economic reasons).



**Fig. 2** Partial Geographic Information System (GIS) Map Layers: Marine Protect Areas & Monitoring Sites (Left), Bathymetry (Center), Substations (Right)



**Fig. 3** San Bernardino Strait Domain: Bathymetry (Top Right), TISE Resource (Bottom Right), Depth-Masked Energy Resource Map (Left); In Black/Yellow Polygon: Awarded DOE Service Contract Areas



**Fig. 4** Velocity Histogram and Tidal Turbine Device Power Output (L); Tidal In-Stream Energy Conversion (TISEC) Device Suitability Score for a location within the San Bernardino Domain (R)

Shown in Fig. 4 is an example output for 1 particular location using 5 different tidal current energy devices with different technical specifications. Comparing the performance of the device-in-the-water using the criteria of availability, capacity factor, relative Levelized Cost of Energy, and Annual Energy produced, we one can easily compare which technology is desirable or is “matched” for the site of interest.

#### 4. Conclusion

The 2-year project of developing an integrated assessment tool for tidal current energy in the Philippines has just began its first steps. Although the framework has been designed and prototyped, a number of hurdles still need to be surmounted: from resource simulation validation, to actual environmental impact assessment, to site-device suitability scoring. The authors, however, are proud to convey that because of this work, the study sites and pilot locations for progressive development of ocean renewable energy in the Philippines have been narrowed down systematically, now backed-up properly with facts and data which enables the uptake of the industry as a whole.

#### 5. Acknowledgement

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