Development of Ocean Thermal Energy Conversion in Barranquilla, Colombia

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I. Introduction

OCEAN Thermal energy Conversion, "OTEC", is a renewable energy source that exploits the temperature difference between upper and deeper layers of the ocean and could have the potential to provide large amounts of baseload power to island and tropical coastal regions. Fig. 1 depicts the basic operational principle of an OTEC plant.

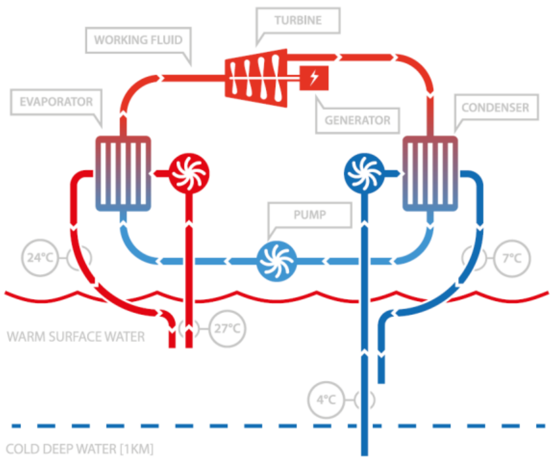


Fig 1. Principle of operation of a closed cycle OTEC plant

The first proof of concept of the technology was obtained in Cuba in the late 1920s [1] but since then development has been mainly focused in the Pacific where a number of pilot installations have been installed in Hawaii, Japan, Taiwan, Korea and Nauru [2]. Interest in the development of the technology in the last few years have increased the amount of research of the possibilities of implementation of OTEC systems in the Caribbean.

Previous studies have investigated the resource potential in Colombia finding positive results for implementation of the technology in the island of San Andres and indications of good thermal resource potential in the Caribbean waters of Colombia [3]–[5]. Barranquilla having relatively close access to deep water, good industrial capacities, and a large electrical demand and being the host of the largest Colombian shipyard is an interesting candidate for further development of OTEC systems in the region. Colombia being a relatively large economy with access to the Caribbean basin is a good position to further develop OTEC technology in the Americas.

II. Methodology

The analysis on the possibilities for OTEC development in Barranquilla was made by in the following manner:

First an analysis of the resource potential for the Colombian Caribbean coast was made (Fig. 2) followed by an analysis of the ocean thermal potential off the coast of Barranquilla. The resource assessment is done by looking at regions with average ocean temperature differences between surface and depth above 20C, based on information from the *World Ocean Atlas* and *GEBCO* datasets. Bathymetric data from nautical charts from the *United Kingdom Hydrographic Office*.

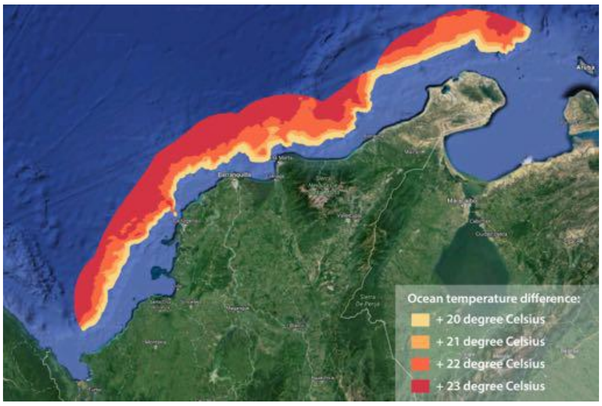


Fig 2. OTEC resource within 80km of the coast in Caribbean coast of Colombia

The area of interest with optimal thermal resource was further narrowed to accommodate for other marine user by identifying the prevalent marine traffic density and routes around the area (Fig. 3). Access to necessary infrastructure, such as ports, electrical substations were also identified in the research.

The locations identified were then compared to assess the viability of offshore OTEC deployment in the region of interest.

Estimates of costs for fabrication and operations of a floating 10MW OTEC installation based on publicly available information was used to estimate possible costs of energy [6], [7]. The information on feasibility was contrasted to the possibilities based on the regulatory framework for installation of small renewable energy plants in Colombia.

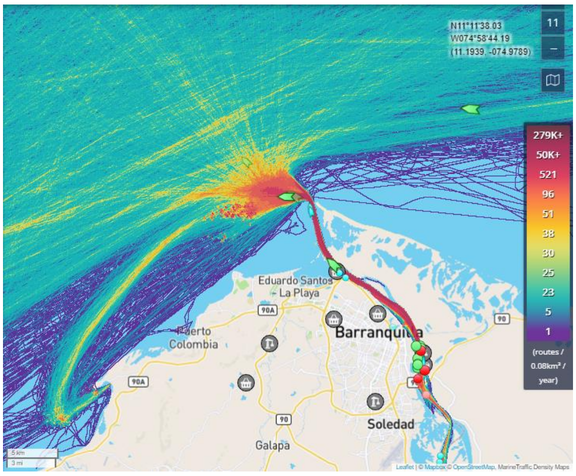
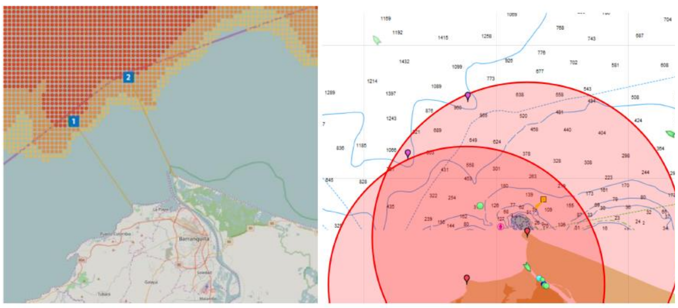


Fig.3 Marine Traffic Density for 2022 around Barranquilla

III. Results and Conclusions

Approximately 8GW of generation based on Diesel or Heavy Fuel Oil is installed throughout the island nations in the Caribbean. The Caribbean region of continental Colombia itself is expected to have the largest average year on year growth of electricity demand for the country (approximately 3.9%).

Although the island of San Andres has been previously identified by other researchers[3] as one of the most suitable locations based on its close access to the OTEC resource in the Caribbean (less than 3km from coastline), Barranquilla is deemed the best likely candidate for implementation of larger, offshore, OTEC systems that could be connected to the larger electricity of grid of the country based on its overall potential for scalability.



(A) Surface temperature (B) Depth

Fig. 4. Possible locations for a floating OTEC facility (located at approximately -75.00, 11.04 decimal degrees and -74.89, 11.30 decimal degrees)[9]

An analysis of the potential of offshore OTEC implementation off the coast of Barranquilla is made in which a multi-criteria analysis involving average temperature differences, distance to the coastline, access to large population centers and infrastructure is made. Fig. 4 shows the possible locations identified. Locations 1 and 2 have distance to shore of approximately 20km and are both located within 30km to population centers. Location 1 has access to the transmission network substation within 89 km and Location 2 within 112 km[8].

Environmental conditions were analysed including climatological conditions, ocean bathymetry, temperature profiles, geological conditions, prevalent winds and earthquake and tsunami risks among others. Barranquilla lies just south of the hurricane belt providing which provides a relatively stable location for testing of new marine technologies.

A 10MW OTEC pilot plant has been suggested for construction in Colombia[6], studies include detail analysis and site-specific conditions for the design of mooring systems for an floating OTEC system with positive recommendations.

The Atlantico region of Colombia, where Barranquilla is located, has been focusing on the further development of their marine and offshore capabilities which includes the strengthening of the nearby shipyard of *Cotecmar* which could serve as a manufacturing and operations and maintenance hub for OTEC systems.

Initial environmental impact assessment shows that possible impacts of OTEC devices can be mitigated when taking the right measures, making their operation benign and environmentally positive.

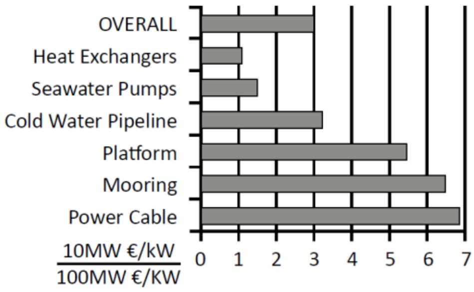


Fig. 5. Per unit cost comparison between 10MW and 100MW OTEC plant [10]

Although relatively small in size a 10MW plant can serve as stepping stone to the development of OTEC of plants in the order of 100MW and above. In this case the levelized cost of energy could be significantly lowered as economies of scale apply for certain key components such as the power cable, mooring lines and platform as can be seen in Fig. 5.

From the analysis the technical feasibility of manufacturing of multi-megawatt OTEC systems in Barranquilla and their implementation is confirmed. The study concludes that the deployment of an initial 10MW OTEC plant off the coast of Barranquilla is technically feasible and could be socially desirable with the possibilities of generating a significant amount of jobs (over 900) in its construction, while becoming a catalyst for the further development of this technology.

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