

OCEAN ENERGY HARVESTING IN MEXICO: LESSONS LEARNED

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INTRODUCTION

The over-exploitation of fossil fuels has caused serious damage to coastal ecosystems. However, despite the many and varied potential sources of renewable energy in Mexico, harnessing them is limited by: the heavy reliance of the economy on fossil fuels; the simplicity and low costs involved in exploiting fossil resources, given existing infrastructure; the lack of information and knowledge concerning the exploitation of renewable energy sources; the limited research capacity and the high costs involved in developing competitive technologies for sustainable energy production, which means a significant dependence on patient investment; and the very strict social and environmental requirements which are often placed for energy harvesting from renewable sources.

In 2008 the Mexican government set targets for the maximum percentages of power generation from fossil fuels to reduce them to 65 % by 2024, 60 % by 2035 and 50 % by 2050. As a result, a “Law for the Use of Renewable Energies and Financing of Energetic Transition” (LAERFTE) was passed in order to “... regulate the use of renewable energy sources and clean. To achieve the goals set by the LAERFTE, from 2013 Centres of Innovation in Renewable Energies (CEMIEs) were created, to “stimulate and promote synergies for the development and adaptation of the action plan to remove the barriers and technological challenges for the use of renewable energy sources”. In 2017 the CEMIE-Océano was established.

The CEMIE-Océano coordinates applied research, innovation and technology development associated with the extraction of diverse forms of ocean energy, contributing to the establishment of multidisciplinary alliances in the field of renewable energy from the seas.

CEMIE-Océano stimulates the development of research which has a high social and technological impact, as well as oversee the generation of innovative products and comprehensive technology which promote the diversity of the oceanic energy resources available to supply part of the demand for energy in Mexico in a sustainable, effective and profitable way.

The main achievements of CEMIE-Océano have been: national integration of 42 institutions and companies in collaborations, with over 800 people participating to date; training and specialization of human resources; strengthening relations between academia and industry; promotion of innovation and technology transfer; solidifying and expanding scientific and technological research capacities, as well as promoting collaboration with companies in the energy sector, and; developing a portfolio of specific projects.

The CEMIE-Océano consortium has Teams for Technical Implementation (TTI), divided into Business and Technical units, four thematic areas according to the type of energy

source and seven transversal working groups, see Figure 1.

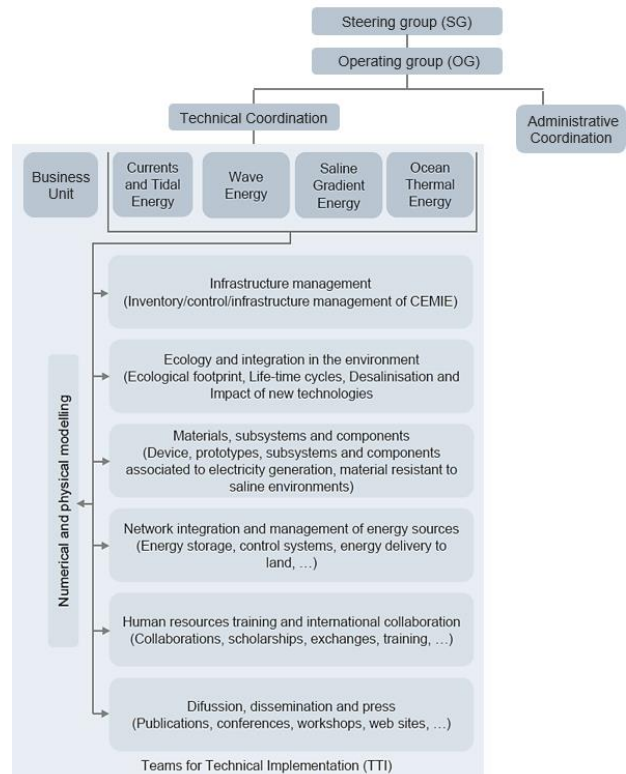


Figure 1 - Structure of the CEMIE-Océano

MAIN RESULTS

Given the limited funding available, it was decided to bring together all national technical capabilities and pursue the ultimate goal of providing and deploying technology apt for the conditions of the Mexican seas, which respect the environment, offering socially responsible solutions. Initially, the groups worked in parallel, with sporadic feedback according to a preliminary technological roadmap.

With the first assessments of the energies available, the recommended materials, a review of the state of the art in energy conversion devices and power grids, and organisation of databases associated with potential ecological impact receptors and social conditions, more dynamic transdisciplinary collaborations were established than those set out in the technology roadmap.

Given that Mexico has around 2 million people living in communities with less than 100 inhabitants who do not have electricity, local generation/consumption was separated from mega electricity generation. Many

objectives were rethought, given the supply chains, the megadiversity conditions typical of a tropical country, the available energy sources are different from those of developed countries in temperate and cold zones, where climatic conditions are very different.

One such project, aiming to take advantage of the ocean current in the Cozumel Channel, of the Caribbean Sea, is presented here.

THE CASE OF COZUMEL ISLAND

In the Mexican Caribbean ocean current speeds are generally low but, in some locations, high values are found. For example, the Yucatán Current travels through the Cozumel Channel with average speeds of 0.88 - 1.04 m/s. These conditions make this channel a promising site for ocean current energy harvesting, especially due to its low intermittency. The physical and ecological characterisation of the Channel, development of an efficient hydrogenator, and the installation of a prototype hydrogenator have been among the projects with the greatest potential in the near future.

PHYSICAL CHARACTERIZATION

Shallow-water bathymetric data has been collected in various field campaigns, and deep-water bathymetric data has been gathered from multibeam information, from the UNAM oceanographic vessel, Justo Sierra, in 2019.

Resource evaluation for the oceanic currents in the Mexican Caribbean, with emphasis on Cozumel Island, was concluded in 2022. This evaluation was performed at different spatial scales, assessing the oceanic currents in deep waters with ADCP measurements, using a validated and adjusted medium scale numerical model (HYCOM) (Figure 2), with measurements at shallower depths (20 m) (Figure 3), where the combined effects of waves and turbulence is being assessed, and with a nested numerical model (ROMS) that includes turbine-scale resolutions and effects (IEA-OES, 2022).

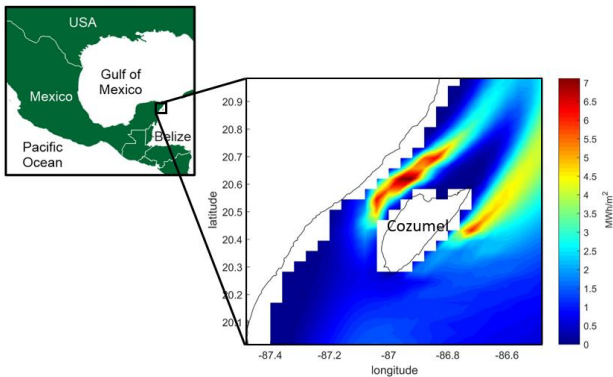


Figure 2 - Accumulated annual energy production in the Cozumel Channel (MWh/m²) (2010 - 2013 HYCOM adjusted).

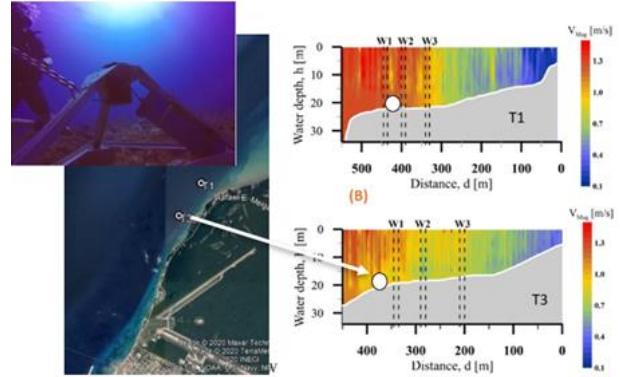


Figure 3 - Potential site for harvesting energy from the ocean current in the Cozumel Channel: current speed measurements.

ECOLOGICAL RESTRICTIONS

The harvesting of ocean current energy raises concerns on potential environmental impacts, including the probability of collision for marine mammals and large fish, noise propagation, alteration in larval dispersion patterns, alteration in coastal morphology and sedimentation patterns, and effects on large scale oceanographic processes (i.e. upwelling and mixing). However, our research indicates that energy extraction at the site is a possibility that would not produce adverse effects in the environment (IEA-OES, 2022) if designed with care.

Since almost 80% of Cozumel is designated as protected areas, the area between two reserves was selected as the harvesting site (Área Natural Protegida de Flora y Fauna de la Isla de Cozumel and Parque Nacional de Arrecifes de Cozumel). Species such as dolphins, marine turtles, sharks and whale sharks are known to reside near and around the island, but more so on the eastern side.

CONCLUSIONS

Despite the limitations in financial resources committed by the federal government, the work in transdisciplinary groups and the sharing of the technical and human capacities of 42 institutions has allowed considerable progress to be made.

Both materials and devices suitable for ocean energy harvesting in very energetic conditions (waves and tides) are not available lacking to be deployed in Mexico. The energy conditions available in Mexico are more common worldwide than those found along most of the northern European coasts, so CEMIE's experience may be of global interest, both to avoid repeating the same mistakes and to help accelerate the maturity of the sector.

This project has been financed mainly by the time of students and academics; technical resources of the participating research centres; by the SENER-CONACYT Sectorial Fund; and by European and Latin American international collaboration funds.

REFERENCES

- IEA-OES (2017): Annual Report: An Overview of Ocean Energy Activities in 2016.
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