PAN AMERICAN MARINE ENERGY CONFERENCE PAMEC 2020

Book of abstracts

Edited by Dr. José Rodrigo Rojas M and Dr. Carlos Meza



Pan American Marine Energy Conference Costa Rica P R O C E E D I N G S OF THE FIRST PAN AMERICAN MARINE ENERGY CONFERENCE

P R O C E E D I N G S OF THE FIRST PAN AMERICAN MARINE ENERGY CONFERENCE





- 531.7 Pan American Marine Energy Conference PAMEC 2020 / José Rodrigo Rojas
- R741p Morales; Carlos Meza Benavides. San José, C.R.: UNED, 2020 1 recurso electrónico (194 páginas): PDF; 7.5 Mb

ISBN 978-9977-930-33-6

Contenido: Este libro incluye los aportes presentados en la Primera Conferencia Panamericana de Energía Marina que se desarrolló en San José Costa Rica, del 26 al 28 de enero de 2020. PAMEC 2020 tiene como objetivo fomentar el desarrollo de energías renovables marinas mediante la colaboración entre investigadores, desarrolladores y proveedores de América y otros continentes.

1. ENERGÍA MARINA 2. COSTA RICA 3. INVESTIGACIÓN 4. ENERGÍAS RENOVABLES 5. COOPERACIÓN INTERNACIONAL 6. INNOVACIÓN 7. NUEVAS TECNOLOGÍAS 8. LIBRO DIGITAL

I. Instituto Costarricense de Electricidad II. Instituto Tecnológico de Costa Rica III. Universidad Estatal a Distancia. IV. Universidad Nacional V. Universidad de Costa Rica VI. Ministerio de Ambiente y Energía.

ISBN 978-9977-930-33-6

PRIMERA EDICIÓN DIGITAL San José, Costa Rica, 2020.

Copyright O 2020 por José Rodrigo Roja Morales Copyright O 2020 por Carlos Meza Benavides

Diseño de portada: Ana Cristina Quesada Valverde

San José, Costa Rica Prohibida la reproducción no autorizada por cualquier medio, mecánico o electrónico, del contenido total o parcial de esta publicación

Content

XI Foreword

XVII Preface

RESOURCE ASSESSMENT

- **3** Field measurements of a floating tidal turbine wake
- 7 Combining observations and simulations into improved assessments of tidal resources
- 11 Evaluation of Wave Energy Extraction in a Sheltered Bay
- **13** Wave characteristics on the Pacific coast of Costa Rica for energy production
- 17 Approaching the wave energy potential in a coastline section of the Nicoya peninsula
- 21 Wave power availability in the Pacific of Mexico and Central America
- 23 Wave power resource assessment in Northeast México

- 27 High-resolution Wave Hindcasts for Resource Characterization in the U.S. Pacific Regions
- 29 GIS based multicriteria analysis for offshore wind power potentials sites in Costa Rica's North Pacific
- 33 Determination of offshore wind power potential in Costa Rica
- **37** Evaluation of the Oceanic Thermal Potential on the Coasts of Panama

ENVIRONMENT

- 43 Multidisciplinary investigations of environmental effects of 1.2 MW Tidal Power plant in the Eastern Scheldt storm surge barrier
- 45 Coastal Energy Development–Recent Canadian Experiences
- 49 SEA Wave: Addressing the long-term environmental concerns associated with the development of wave energy technology
- 53 The Road to Risk Retirement: Evaluating and Communicating Environmental Risks that Affect Consenting



- 57 How international standardization and certification accelerate commercial uptake of marine energy convertors
- 59 Large scale model investigation for monopile decommissioning of offshore wind turbines
- 61 Environmental impacts of ocean energy devices: Life Cycle Analysis

TECHNOLOGY: PRESENT

- 67 Development and Testing of a Tidal Turbine Blade
- 71 Marine HydroKinetic Tools MHKiT
- 75 Floating Tidal Energy Platform PLAT-I
- 79 ANDRITZ Mk1 Tidal Turbine Operating Experience
- 81 Vancouver Wave Energy Testing Station: Continuous electricity output verification from waves of various sizes, Development history and Transparent policies for industrial wave energy power plants
- 85 Assessment of the INWAVE WEC-Hybrid PTO Technology in the Canadian Pacific Coast
- 91 Understanding Transient Load on Turbine Blades to Reduce Risks and Assist Design

95 Conversion System of Undimotriz Energy to Electricity

TECHNOLOGY: EMERGING

- 101 e.Wave: Maximization of wave energy harvesting through the integration of an adaptative mechanical system regulated by sea conditions for point absorber wave energy converters
- **105** Numerical study of the effect of a flap-type Wave Energy Converter in the wave field analyzing the directional wave spectrum
- **109** Electrohydrodynamics for a point absorber WEC: theoretical foundation
- **113** Dynamic analysis of a novel six degrees of freedom device for wave energy extraction
- **115** Tidal energy for hydrogen production through reversible solid oxide cells
- 117 Adoption of Deep Ocean Water Technologies and their Contribution to Sustainable Development in the Caribbean
- 121 Considerations for Offshore Wind Turbine Design in the North Pacific of Costa Rica
- **123** Pressure drop in Reverse Electrodialysis: Analysis using CFD

- 127 Salinity gradient energy potential in Latin America with emphasis in Colombia and Mexico
- 131 Bathymetry and capacity factor study in areas of the Gulf of Baja California and the southwest coast of Mexico
- 133 Analysis of the performance and efficiency of a turbine for an Ocean Thermal Energy Conversion (OTEC) plant by simulation using the Ansys Fluent program
- 137 Design of a prototype of a 1kWe open-cycle OTEC power plant for the Mexican Caribbean Sea
- 141 Criteria for optimal sites selection for the installation of Ocean Thermal Energy Conversion (OTEC) plants in the Mexican Pacific (MP)
- 145 Salinity gradient determination on the Mexican Caribbean Coastal zone and the technical viability to generate blue energy
- 149 Hydrodynamic analysis of a reverse electrodialysis device spacer
- 153 Optimization of a reverse electrodialysis device
- 157 Possible oceanographic and biological effects due to the operation of an OTEC (Ocean Thermal Energy Conversion) plant in the area of Puerto Angel, Oaxaca, Mexico

STORAGE AND INTEGRATION

- 163 Island and Remote Grid Considerations for Marine Energy Development
- 167 NOMAD: Freedom and autonomy by converging marine life and humankind
- 169 The Influence of Hybrid Renewable Energy Systems on Energy Storage
- 173 Synthesis and characterization of IrRuOx/ TiO2 as electrocatalyst for the oxygen evolution reaction

BUILDING SOCIAL AND POLICY SUPPORT

- 179 Governance of Marine Renewable Energy Development In Nova Scotia, Canada
- **181** Lessons learned for Marine renewable energy development in Chile, Peru and Colombia
- **183** MERIC: supporting the development of MRE in Chile
- **186 Keyword Indexing**

Foreword

Costa Rica is a small country in territory but big in commitment to the environmental future of the planet and has lofty sustainability goals with a running climate change policy, an economy decarbonization strategy, and a long promise to keep producing 99% of clean electricity from hydropower, onshore wind, geothermal, biomass and solar energy. In the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity, the country boost a non-conventional renewable energy portfolio with a road map on offshore energy. We know that ocean energy is still in its infancy, and this sector has to overcome a number or challenges to prove the reliability, affordability and accessibility. Despite this, the oceans represent a source of plentiful energy potential, able to driving a blue economy and provide significant socio-economic opportunities, such as jobs creation, improved livelihoods, local value chains and enhanced synergies between coastal stakeholders.

But before I go further, I have the privilege of presenting the book with the summaries of the first Pan American Marine Energy Conference, PAMEC-2020. An international event, held in last week of January, that we gave high priority from the beginning, not just because it is an important theme for our ministry, it's because we believe in the sustainable use of the ocean as a significant reservoir of renewable energy, resilient to climate change and low in emissions of greenhouse gases effect. In fact, energy is a key component of both the sustainable development and climate goals. PAMEC-2020 served as an effective international vehicle for dialogue, cooperation and coordinated actions to accelerate the uptake of offshore renewable in benefit of the glocal energy transformation. The event provided a forum where those at the forefront of technology development in the sector met, interacted, shared their latest knowledge and debate new ideas and issues related to different perspectives of wave, offshore wind, ocean thermal energy, salinity gradient, currents and tidal energy conversion with a focus on building and strengthening research and development ties in the Americas, and globally.

Finally, I want to re-affirm the Costa Rica government's actual, long-term commitment to ocean energy and the exigency to face, at least, five main bottlenecks: technology development, finance sources, environmental and social acceptance, marine supply chain issues and field data gaps. Now is the time to take actions. Now is the time for bold steps. Now is the moment that we show the planet what can be done. PAMEC-2020 is a great example of governments, academy, NGO's and private industry running as one to achieve a common ocean energy goal. The progress of the sector we owe to this type of alliance. However, we cannot afford to rest now. The move

toward renewable offshore energy is already underway, it is unstoppable and it is inevitable.

Thank you very much for the very kind invitation, which I very much appreciate.

Carlos Manuel Rodríguez E. Former Minister Ministry of Environment and Energy of Costa Rica



Salinity gradient determination on the Mexican Caribbean Coastal zone and the technical viability to generate blue energy

Karen Vázquez Morales#1, M.C. Juan Francisco Bárcenas Graniel*2

kvazquez@itsm-tlapa.edu.mx¹ #Ingeniería ambiental, Instituto Tecnológico Superior de la Montaña Ampliación del ejido de San Francisco s/n, Tlapa de Comonfort, Guerrero, México jbarcenas@ucaribe.edu.mx² *Departamento de Ciencias Básicas e Ingeniería, Universidad del Caribe Mz.1, lote: 1, Reg, 78. Esq.Fracc. Tabachines, Mpio, Benito Juárez, Cancún, Quintana Roo, México

Keywords: Mexican Caribbean, fresh water discharging, saline gradient, monitoring, energy potential.

This research is focused around freshwater discharges to the sea that according to measurements, indicate, at least salinity gradients up to 35 ups with temperatures of approximately 26°C. these discharges (volumetric flow rate) coming from the basin, vary in time: inter-annual, seasonal; it is even different from day to day, mainly because of different forcing that impact the sea level variability due to wind, tides, air pressure or even sea temperature, among other reasons. These freshwater discharges are usually clear in appearance; however, they contain carbonates, pollutants coming from the basin and generally, they have a lower temperature than the sea. It is essential to mention that through Quintana Roo coasts, several discharges with volumetric flow rates can be found, the vast majority of them

have not been neither measured nor kept a record, there are not even systematic measurements of physical, chemical or biological criteria, for instance. In this regional context the energy potential evaluation of salinity gradient is a matter that could lead to provide more information t other research areas as well as environmental, social, hydrological areas, etc. measured discharges in this research are in the range of 250 liters per second -Punta Esmeralda en Playa del Carmen-, up to 5000 cubic meters per second, Cenote Manatí close to Tulum- however, other locations with the same or larger scale have been observed. These potential locations were monitored with CTD-Castaway equipment and current meter, both belonging to Universidad del Caribe, data obtained by the CTD profiler were processed in the software Castaway, having graphics related to depth, salinity, and temperature of every and each of the measured spots. The volumetric flow rate was obtained by substituting provided data by the current meter in equations, equation 1 and 2, determined by FAO (2009). Potential values of 191.3kW and 2503.46kW were obtained.

INTRODUCTION

The energy extracted from the ocean is considered as a renewable energy source, with a major potential due to the earth is covered by 70% of the ocean (Siddiqui et al., 2015). Among the types of ocean energy, the generation of energy from saline gradient can be found (Vallejo, 2013).

Mexico has got a wide potential for this resource harvesting due to it is rich in rains that discharge in a large number of rivers that lead to the Pacific Ocean as well as in the Gulf of Mexico (Enríquez et al., 2018).



Although, there is not an existing technology so far, that allows generation of energy from saline gradients at an affordable cost, being familiar with this resource potential in places like Mexico, could call the technological development's world attention in order to make the process of producing blue energy more efficient (Enríquez et al., 2015).

The aim of this study is to focus on a non-performed diagnosis in the state of Quintana Roo, with the aim of taking part in the energy transition performed in the country, due to the performed studies have no generation of energy aims but rather they focus on knowing the quality of water, having an overview about the technical and social viability to generating and implementing equipment that provides blue energy as a result.

This diagnosis will be supported by the determination of the saline gradient in several water discharges, located on the Coastal zone of Quintana Roo, using measurement equipment

and other countries research estimates replica in order to know the technical viability to generate blue energy.

METHODOLOGY

The methodology of this study is divided into three stages, the first one consisting in defining the potential locations of the Mexican Caribbean north zone, creating a database provided by NOAA, Argo, Oceanographic monitoring service, and water quality studies performed on the Coastal zone of Quintana Roo.

On the second stage, saline gradients were measured, as well as temperature and mass flow on the potential locations by replicating the provided methodologies by FAO, (2009), applying the following equations:

in monitoring campaigns by means of CastAway-CTD Sontek and WH-50 current meter, both belonging to Universidad del Caribe.

Lastly an energy potential evaluation was made in the monitored locations based on the Van't Hoff's equation:

$$P_{e(v)} = 2n \cdot \dot{m} \cdot c \cdot R \cdot T$$

RESULTS

Cenote Manatí, Tulum and Punta Esmeralda, Playa del Carmen, were the two potential locations monitored during june – october, 2019. Having the following results:

			SALINITY	School School School	ENERGY
LOCATION	FLOE RATE	CAUDAL	GRADIENT	TEMPERATURE	POTENTIAL
Cenote		3.654	e.	5	
Manatí	0.112 m/s	m ³ /s	22 PSU	25.6 °C	2502.46 kW
Punta		0.2142			
Esmeralda	0.1305 m/s	m ³ /s	31.1 PSU	28.1 °C	191.3 kW



Figure 1. Location of the potential sites



Figure 2. Sampling Sites, Punta Esmeralda.



Figure 3. Sampling sites, Cenote Manatí



Figure 4. Salinity and temperature profiles, Punta Esmeralda.





Figure 5. Salinity profiles, Cenote Manatí

REFERENCES

[1] Siddiqui, M.A., Latifi, S.M.A., Munir, M.A., Kazmi, S.M.H., Randhawa, J.S. (2015). Ocean Energy: The Future of Renewable Energy Generation. Conference IEEE 2015.

[2] Vallejo Castaño, S. (2013). Generación de energía a partir del gradiente salino entre el agua de río y de mar utilizando una celda de electrodiálisis inversa. Tesis de Licenciatura. Universidad Nacional de Colombia, Facultad de Minas, Medellín, 36pp.

[3] Enríquez, C., Reyes-Mendoza, O., Álvarez-Silva, O., Papiol-Nieves, V., Mariño-Tapia, I., Chiappa-Carrara, X., Aragón, J., Fitch, N., Silva-Casarín, R. (2018). Salinity gradient energy resource in

tropical hypersaline Coastal lagoons: perspectives for sustainable use. Proceedings of SEEP2018, 08-11May 2018, UWS, Paisley, UK.

[4] Enríquez, C., Chiappa, X., Roldán, M., & Marín-Coria, E. (2015). Perspectivas sobre el aprovechamiento energético de los gradientes salinos en las costas mexicanas. 8pp.

[5] FAO, (2009). "Manual de estimación del caudal de agua".

http://www.fao.org/tempref/FI/CDrom/FAO_Training/FAO_Training/ General/x6705s/x6705s03.htm



CONFERENCE PHOTOS



































The Pan American Marine Energy Conference, PAMEC 2020, was held in San Jose Costa Rica, from January 26 to 28, 2020. The conference is aimed to foster the development of marine renewable energy through investigation and cooperation among researchers, developers, and suppliers from America and other continents. Before and after the main event, were organized technical workshops in the University of Costa Rica. These workshops were supported by IMARES, UNED, Marine Renewables Canada, ITCR, UNA, ICE, Dutch Marine Energy Centre, Pacific Northwest National Laboratory, Ocean Energy Systems, MERIC, Acadia University, Sandia National Labs, NREL, FORCE and INORE.

Thanks to all

