MARINE HYBRID ECO-PARKS Techno-economic analysis in potential Latin America markets

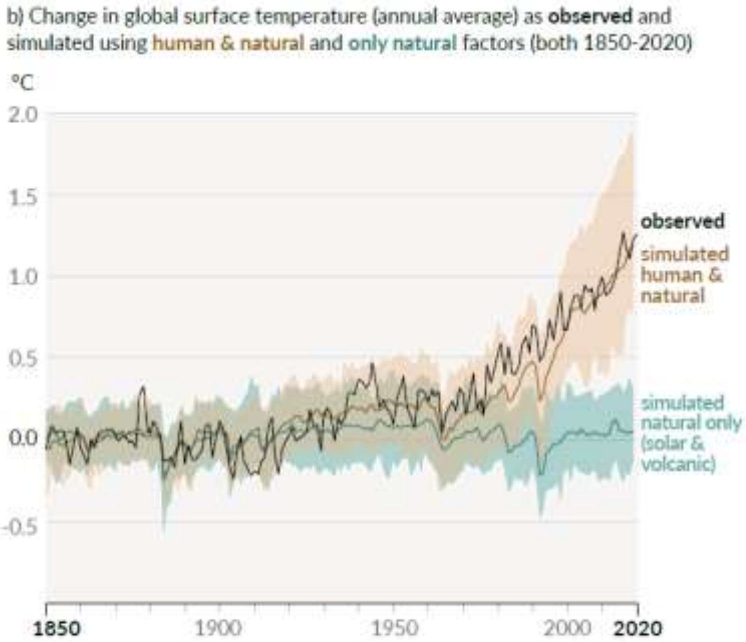
PAMEC 2024
Pan American Marine Energy Conference
Barranquilla, Colombia Jan 22-24, 2024

Dr. Emiliano Gorr-Pozzi[1,*]
Dr. Héctor García-Nava[1]
Dr. Jorge Olmedo-González[2]
M.C. Diego Selman-Caro[3]
Lic. Fabiola García-Vega[3]
Dr. José A. Zertuche-González[1]

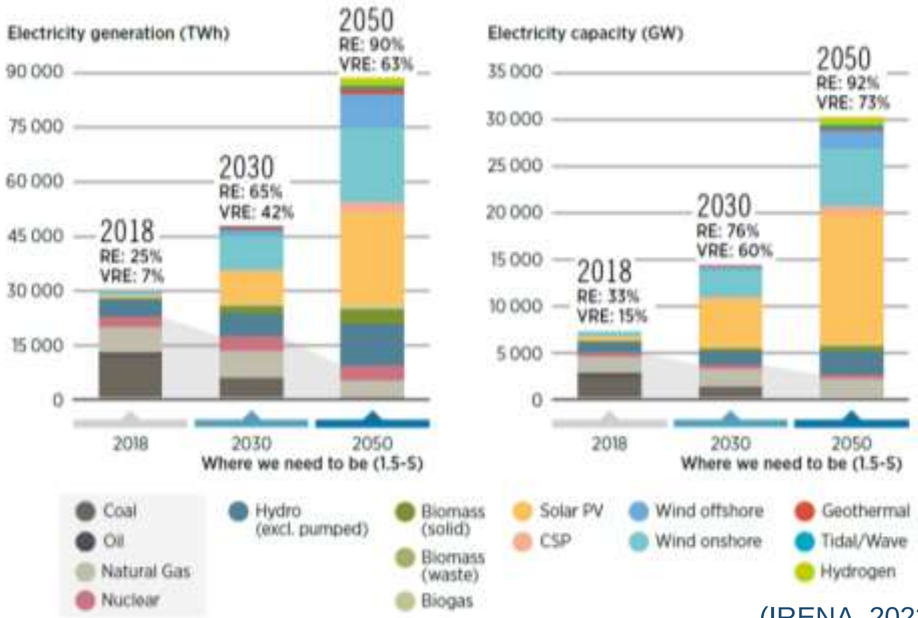
[1] UABC-IIO, Ensenada, Mexico
emigorr@uabc.edu.mx (E.G.-P.);
hector.gnava@uabc.edu.mx (H.G.-N.);
zertuche@uabc.edu.mx (J.A.Z.-G)
[2] IPN, CDMX, México
jorgeolmedog@outlook.com (J.O.-G)
[3] II UNAM, CDMX, México
fgarciav@iingen.unam.mx (F.G.-V)

January 22, Barranquilla, Colombia

MOTIVATION



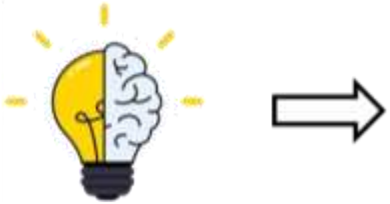
(IPCC, 2022)



(IRENA, 2022)

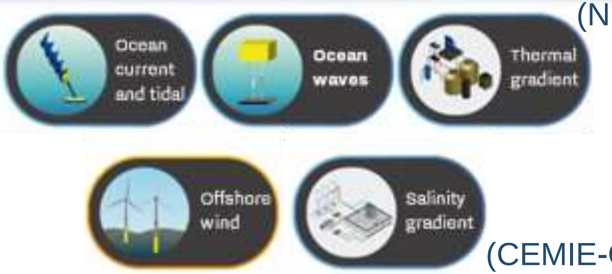
Innovative

Solutions



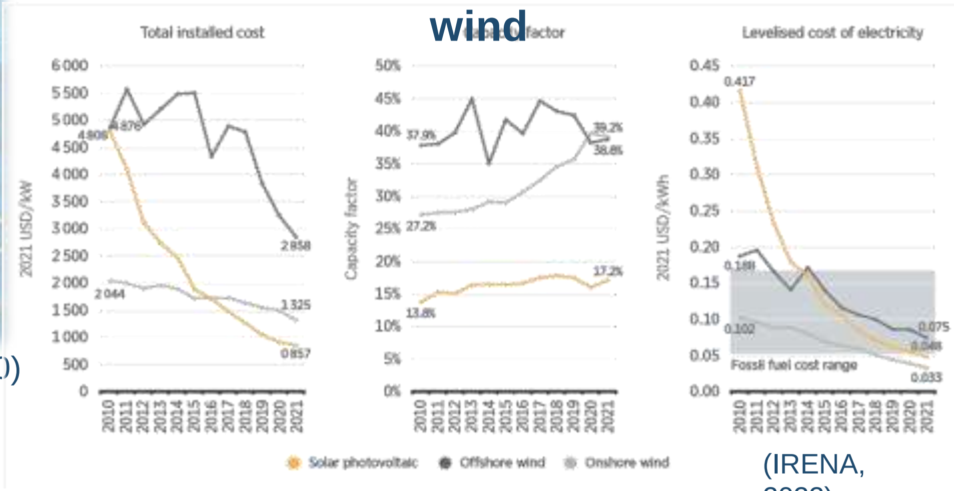
Marine renewable energy (MRE): all forms of energy derived form the seas and oceans.

(NREL, 2020)



(CEMIE-Océano, 2019)

Offshore wind vs. Solar PV & Onshore wind



(IRENA, 2022)

1. INTRODUCTION

Harnessing wave energy

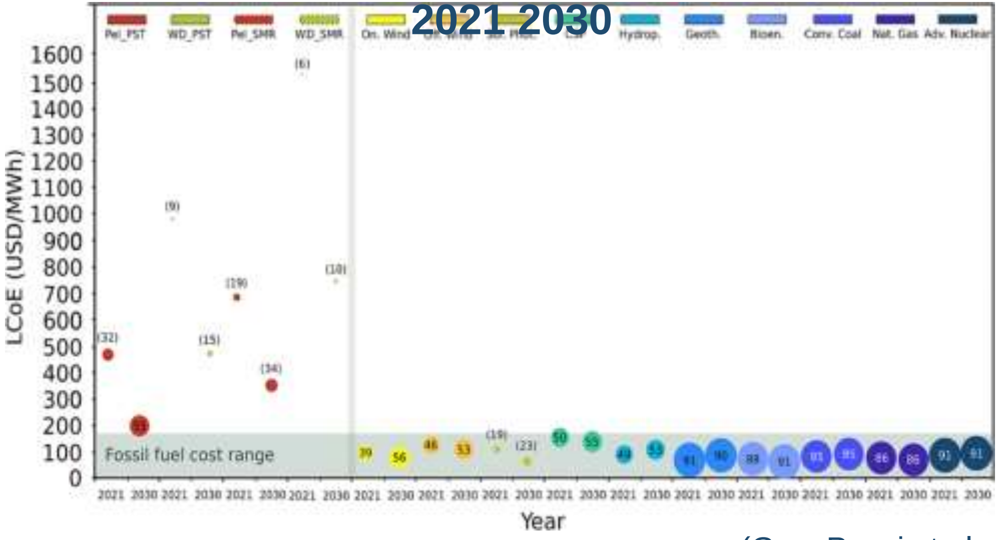
Potential Advantages

- High energy density per unit area.
- Predictable and flows naturally from generation areas to the coast.
- Harvested and transformed into other forms of energy via wave energy converters (WECs).
- Significant progress in the technological redinnes levels (TRL), future energy supply.

Potential Challenges

- Resource variability and intermittency.
- High cost of technology installation.
- Uncertainties associated with the large and diverse portfolio of WEC prototypes, and commercial-scale performance.
- Lack of energy policy sensitivity.

LCoE & Cf by different energy options at 2021 2030

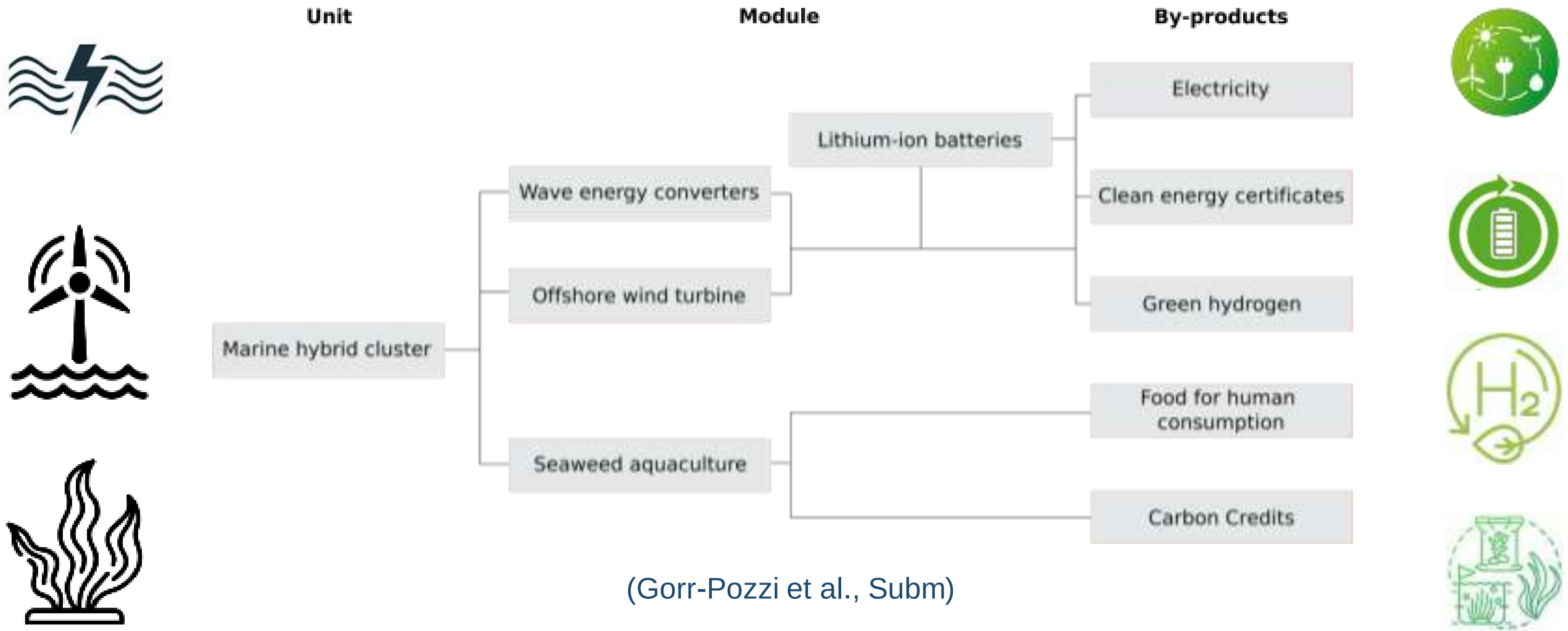


(Gorr-Pozzi et al., 2023)

1. INTRODUCTION

Goal

Evaluate the **techno-economic feasibility** of **Marine Hybrid Clusters** coupled with a **wave-offshore wind hybrid renewable (WWHRS)** and **marine aquaculture** systems to satisfy with electricity, green hydrogen, and food resources and **energize the blue economy** at two potential sites in **Latin America**.

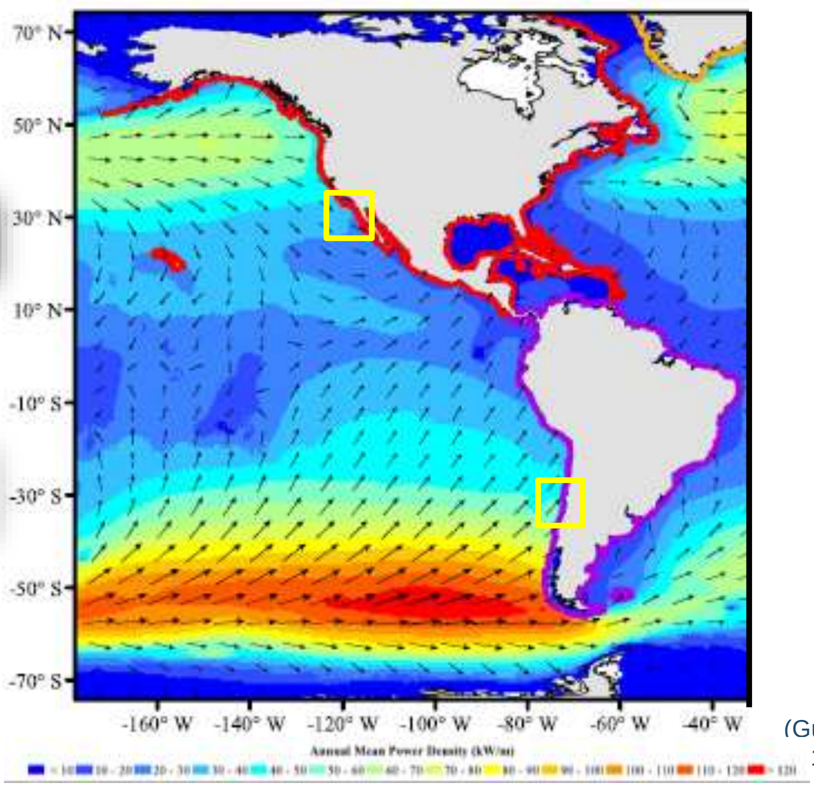


(Gorr-Pozzi et al., Subm)

2. METODOLOGY

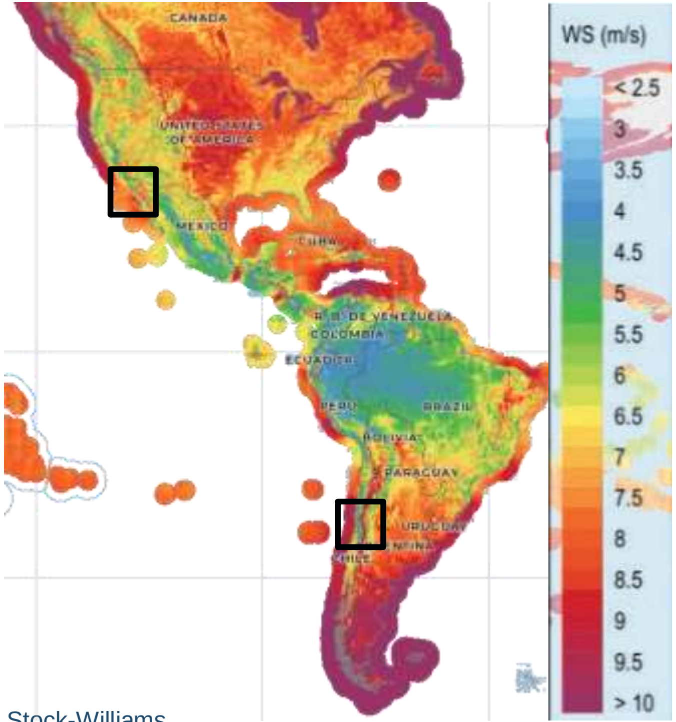
Field site. La Serena (Chile) and Ensenada (México)

Mean Wave Power availability



(Gunn & Stock-Williams, 12)

Mean Offshore Wind Power availability



(GWA, 2024)

2. METODOLOGY

Technical data

Wave power availability & harvested

$$P = \rho g \int\int c_g(f) E(f,\theta) df d\theta$$

$$HP = \sum\sum HR(H_s, T_p) \cdot PWEC(H_s, T_p)$$

Offshore wind power availability & harvested

$$P_w = \frac{1}{2}\rho U^3$$

$$P_{w_{ext}} = \sum n C_p$$

AEP

+

Economic data

WECs

Offshore Wind

Utility-scale Lithium-ion Battery

Alkaline Electrolyzer

Seaweed aquaculture

CapEx
OpEx

Marine Hydrid Cluster profitability

$$LCOE = \frac{CapEx_{t=0} + \sum_{t=1}^{n} \frac{OpEx_n}{(1+r)^n}}{\sum_{t=1}^{n} \frac{AEP_n}{(1+r)^n}}$$

$$NPV = -C_0 + \sum_{1}^{n} \frac{F_n}{(1+r)^n}$$

$$ROI = \frac{R_n - C_n}{C_n}$$

$$PP = \frac{C_0}{C_n}$$

(Ocean Power Delivery LTD, 2014)

(Wavedragon, 2012)

(NREL, 2023)

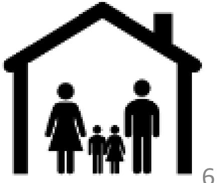
WWHRS Sizing

- 875 MWh Production

Microgrid interconnected electrical scheme

- 5,000 Households
- 68 ha Aquaculture
- 620 MWh Consumption

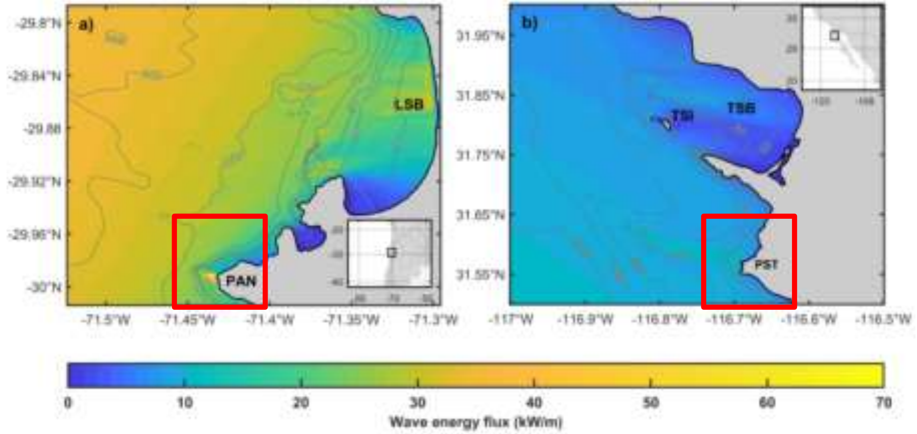
(Blue Evolution, 2022)

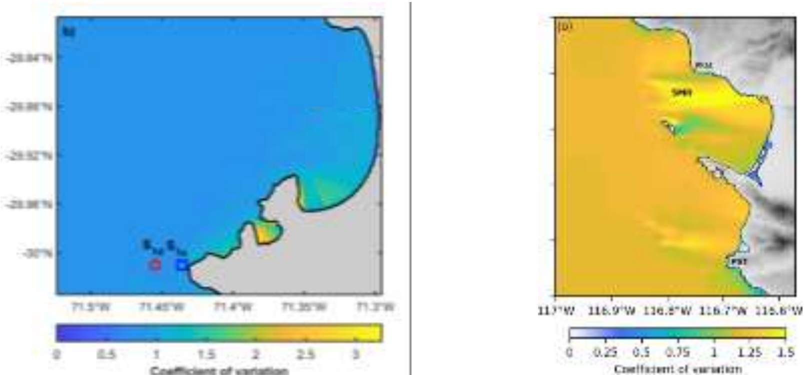


(INEGI, 2023)

3. RESULTS

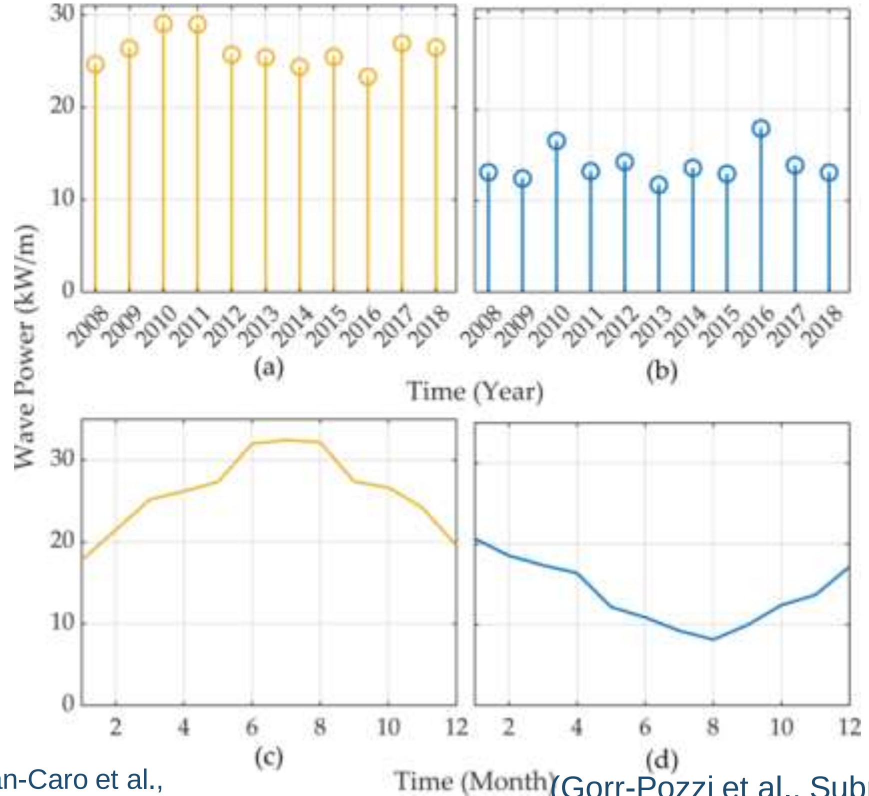
Mean wave power availability and variability





PAN- La Serena

PST- Ensenada



(Selman-Caro et al., 2024)

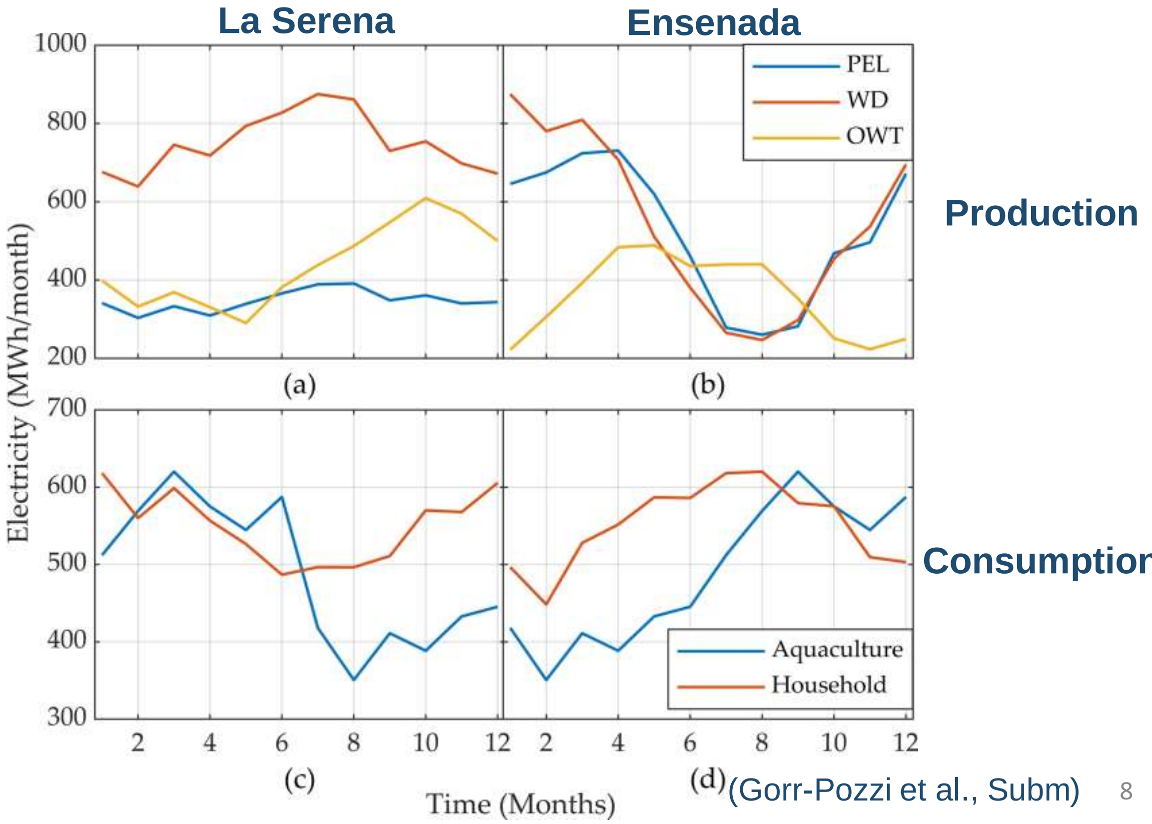
(Gorr-Pozzi et al., Subm)

3. RESULTS

Energy balance. Electricity generation-consumption profiles

TABLE I
DESIGN PARAMETERS FOR WAVE-WIND HYBRID RENEWABLE SYSTEMS (WWHRS) IN THE MAIN SCENARIOS

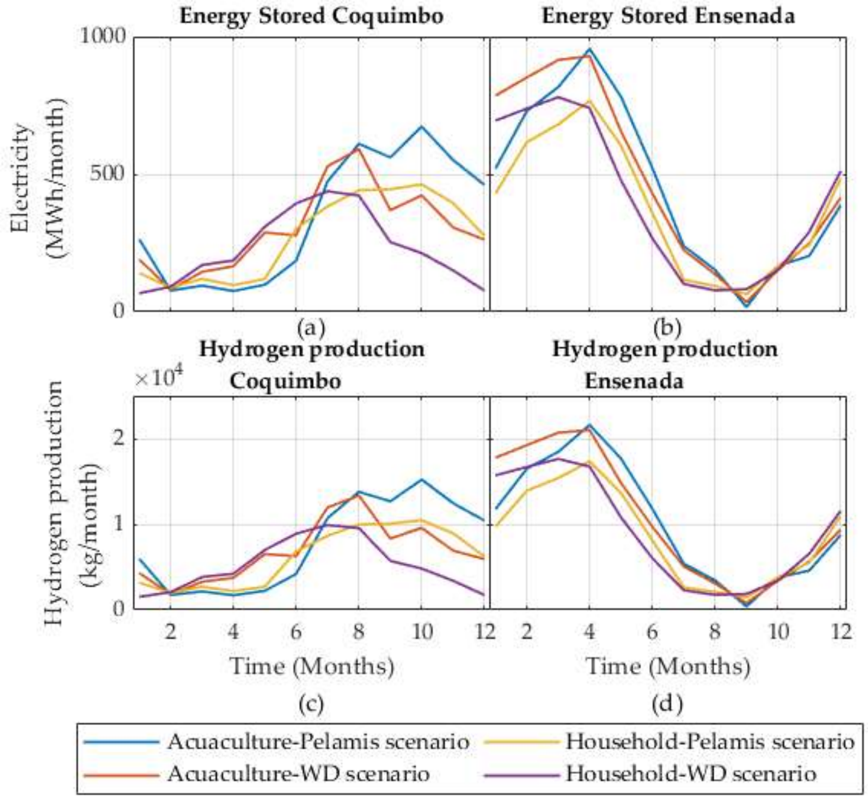
Main scenarios	Hybridization	Number of WEC	Number of OWT
Coquimbo-PEL-OWT Aquaculture Coquimbo PEL-OWT Household	44.23%	6	1
Coquimbo WD-OWT Aquaculture Coquimbo WD Household	N/A	1	0
Ensenada PEL-OWT Aquaculture Ensenada PEL-OWT Household	59.56%	5	1
Ensenada WD-OWT Aquaculture Ensenada WD-OWT Household	60.48%	3	1



(Gorr-Pozzi et al., Subm)

3. RESULTS

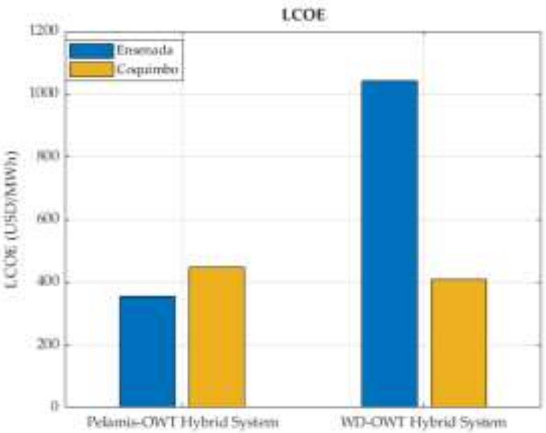
Surplus energy used in utility-scale battery energy storage systems (USBES) and hydrogen production by electrolysis (EHPS)

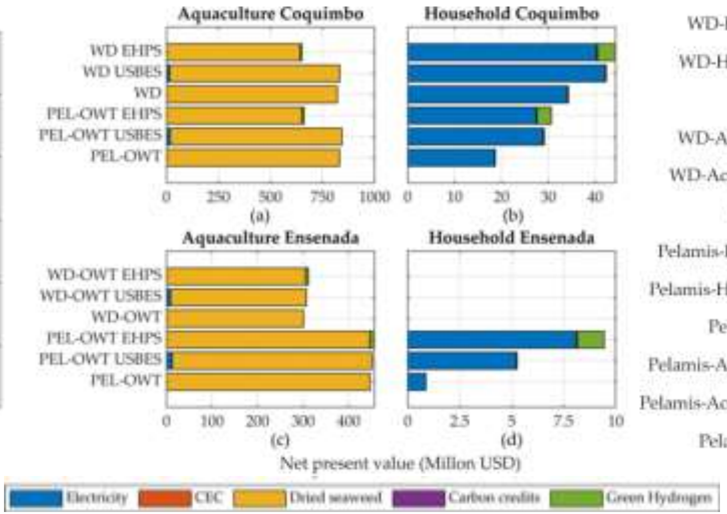


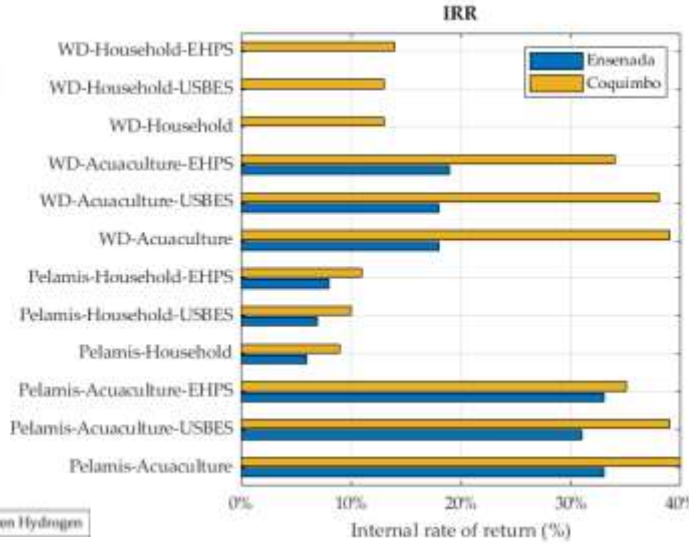
(Gorr-Pozzi et al., Subm)

3. RESULTS

WWHRS profitability







(Gorr-Pozzi et al., Subm)

4. CONCLUSIONS

- The contribution per coupled module to MHC profitability was evaluated.
- Differences in the annual and monthly mean wave power availability in the selected sites. PAN 87% > than in PST.
- La Serena has a lower mean inter- and intra-annual variability in electricity produced by the WECs and OWT than Ensenada.
- The same individual WECs generate different performances and mean annual electricity at the two sites analyzed. The PEL is 120% > in Ensenada than in La Serena, while the WD is 200% > in La Serena.
- Hybridization has allowed the required electricity consumption. The DH varied between scenarios, with the PEL-OWT system requiring less hybridization than the WD-OWT system.
- The results highlight the profitability benefits of a blue economy framework. The seaweed aquaculture module fosters profitability in all scenarios. Higher returns than households, higher in La Serena than in Ensenada.
- The analysis highlights the potential benefits of using batteries for energy storage and the value of green hydrogen as an energy source. Battery-powered aquaculture produces the highest NPV and IRR

CONTACTS

CEMIE-Océano
Asociación Civil

CEMIE-Océano
Estudiantil

Pan-American
Ocean Energy
Student Network

PAMEC 2024
Pan American Marine Energy Conference
Barranquilla, Colombia Jan 22-24, 2024

¡THANK YOU FOR YOUR ATTENTION!

Dr. Emiliano Gorr-Pozzi
(emigorr@uabc.edu.mx)

INSTITUTO DE INGENIERÍA UNAM

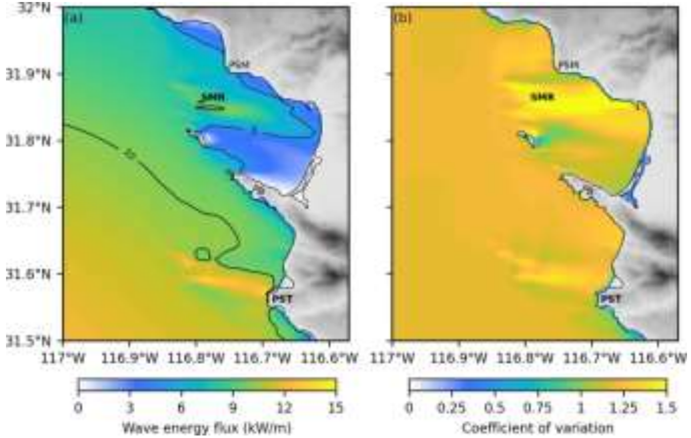
CEMIE-Océano Asociación Civil

Pan-American Ocean Energy Student Network

Appendix

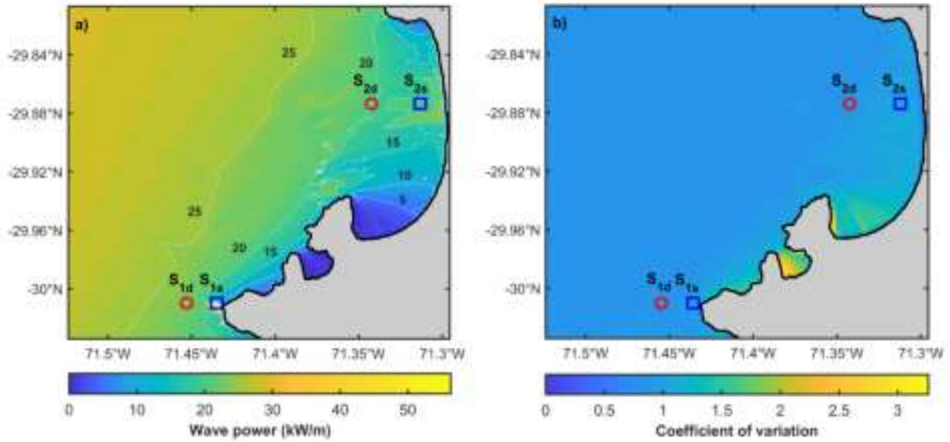
Mean available wave power (a) and coefficient of variation (b)

Ensenada (Mexico)



(Gorr-Pozzi et al., 2021)

La Serena (Chile)

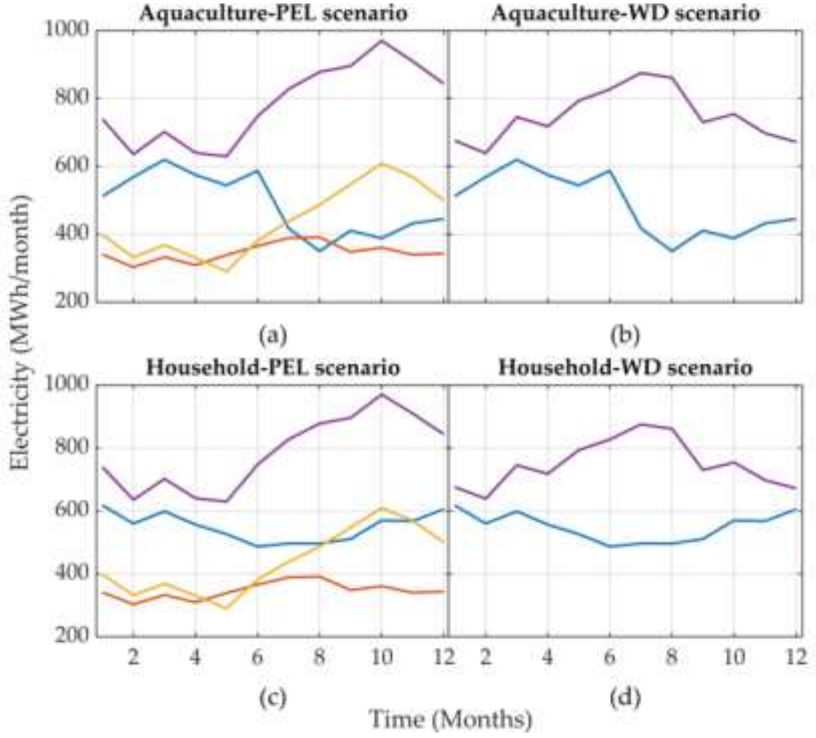


(Gorr-Pozzi et al., 202

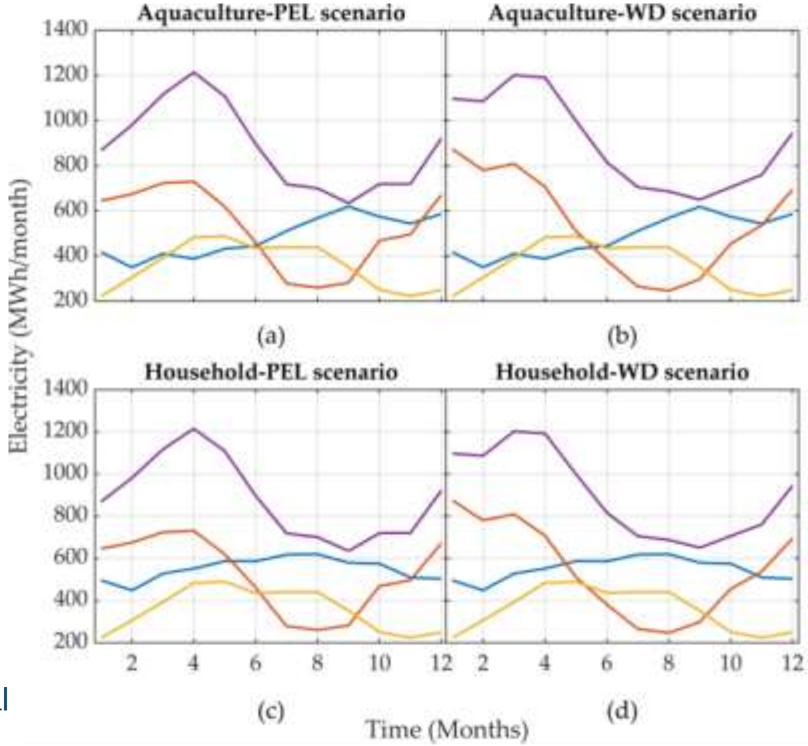
Appendix

Energy balance. Electricity generation-consumption profiles

La Serena



Ensenada



(Gorr-Pozzi et al., Subm)