Chapter

General Criteria for Optimal Site Selection for the Installation of Ocean Thermal Energy Conversion (OTEC) Plants in the Mexican Pacific

Alejandro García Huante, Yandy Rodríguez Cueto, Erika Paola Garduño Ruiz and Ricardo Efraín Hernández Contreras

Abstract

The purpose of this chapter is to provide an assessment of the resource potential for ocean thermal energy conversion (OTEC) in the Mexican Pacific Ocean (MPO). Research methodology adopted in this study is a combination of geographic information system (GIS), to identify the most promising site in the MPO for OTEC deployment. Site selection criteria rely on conditions such as distance to cold water pumping, bathymetry, thermal difference (not less than 20°C), and social and environmental aspects. Finally we concluded that sites located in the states of Guerrero and Oaxaca have the highest potential of the entire MPO, although there are other areas in the states of Baja California Sur, Nayarit, or Michoacan that might have some interest for OTEC technology.

Keywords: OTEC, sites, Mexican Pacific Ocean, thermal difference

1. Introduction

Mexico has public policies that allow the implementation of renewable energy (RE) projects. One of them is the energy reform that indicates the market incentives of clean energy certificates which will be defined by 2019.

Therefore, it will be obligatory for all the companies that generate energy to have obtained or bought these clean energy certificates and the settled goals in the Energy Transition Law (LTE, from its name in Spanish) [1]. This standard establishes a minimum share of clean energy in electricity generation of 25% by 2018, 30% by 2021, and 35% by 2024 [1].

The necessity of developing the RE sector in Mexico has led to government institutions, as the Ministry of Energy (SENER, from its name in Spanish) and the National Council for Science and Technology (CONACyT, from its name in Spanish), to create Mexican Centers Energy Innovation (CeMIEs, from its name in

Spanish). CeMIEs are groups of public or private research, higher education institutions, companies, and government entities that have the objective of working together on projects dedicated to developing technologies, products, and services, which allow Mexico to take advantage of its enormous potential in the main RE. For development of technologies for ocean energies, the CeMIE-Océano (CeMIE-O) was recently set up which focuses on the assessment of wave, current, tides, saline gradient, and thermal gradient energy resources in Mexico [2].

The Mexican Pacific Ocean (MPO) and the Caribbean Sea (CS) are areas which are an excellent thermal potential for OTEC, according to several studies [3–8], which can reduce fossil fuel dependency and provide energy to isolated coastal populations and islands.

The main criteria to determinate optimal site or zones are their location to be less than 10–15 km offshore from the Mexican coastline and the thermal difference (TD) to be equal to or greater than 20°C. Furthermore, other criteria are the distance to the cold water pump area that should not exceed 10 km (for onshore plants) as well as the social and economic factors that exist in these communities.

Finally, the importance of this technology is to provide electricity in the isolated coastal areas as well as other subproducts generated, such as fresh water, seawater air-conditioning (SWAC), cold agriculture (ColdAg), and aquaculture, among others. That is why it is also imperative to calculate the net electric generation given by a particular area and the contribution to social development, the interest of the Mexican and foreign energy sectors in this type of power generators, and the scientific, social, economic, oceanographic, and climatic contribution that can be generated [9].

2. Methods and data

2.1 Study area

The MPO is the study area, as the geographic and oceanic conditions are suitable for the installation of OTEC plant. In this area, the TD between 0 and 1000 m depths and the seasonal variations of the sea surface temperature (SST) were analyzed by [9, 10]. The authors found 43 sites, which meet the afore mentioned main criteria. Sites are located in the Gulf of California (GC), Baja California Sur (BCS); Eastern Pacific Warm Pool in the Pacific Ocean (ETP), Nayarit (NYT), Jalisco (JAL), Michoacán (MCN), Guerrero (GRO), and Colima (COL); and Gulf of Tehuantepec (GT), Oaxaca (OCX).

2.1.1 Temperature

Strong change of temperature in shallow waters called thermocline characterized Eastern Tropical Pacific (ETP) [11–13] (see **Figure 1**). ETP is influenced by "El Niño" (ENSO), which is important in climate variability, in fish production, and in the global carbon cycle [14]. The annual variation in the SST fluctuates between 26 and 30°C [3, 14] with variations of flow by some cold currents as the California Current from the north and the Peru Current from the south. The intrusion of the Costa Rica Coastal Current (CRCC) causes annual variations of 5°C or more in the area near JAL, while, in the GT, the temperature varies between 3 and 4°C (see **Figure 1**).

Databases used for this work to obtain the data include of the Mexican Navy (SEMAR, from its name in Spanish), the National Oceanographic Data Center (NODC) of the United States of America, and the World Ocean Database (WOD)

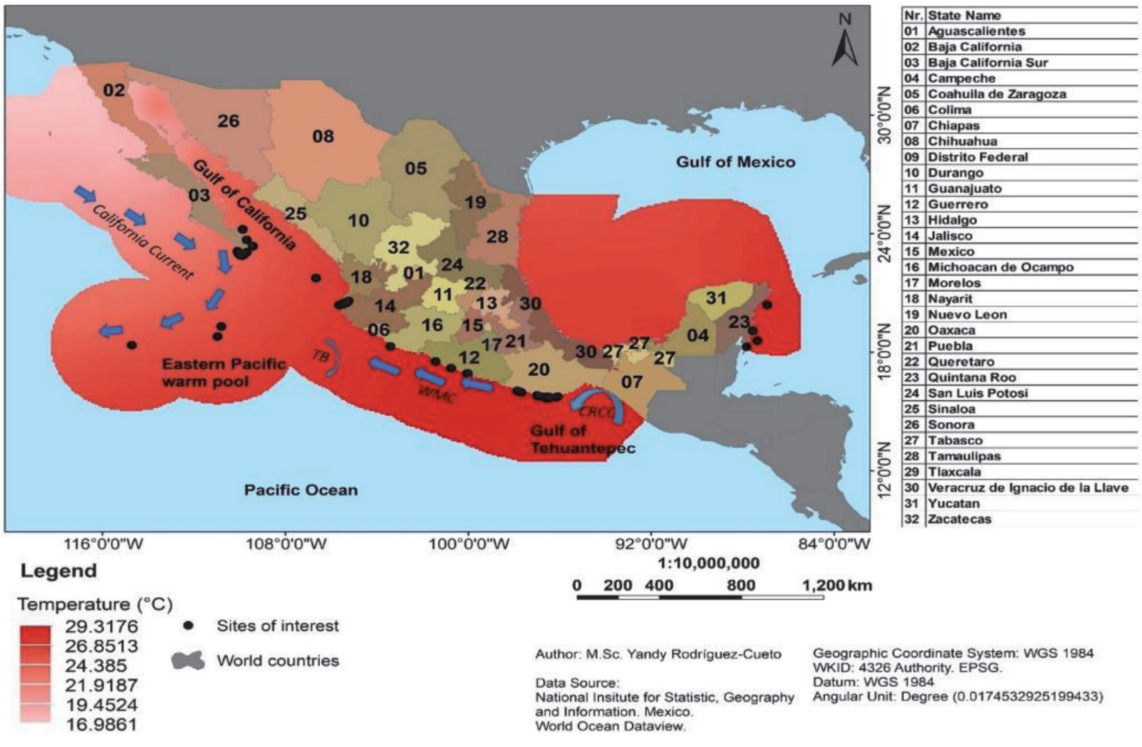

Figure 1.
Eastern tropical Pacific (ETP) and ocean circulation patterns. Shading represents mean sea surface temperature (darker = warmer). Nomenclature: TB (Tehuantepec bowl), WMC (Western Mexican current), and CRCC (Costa Rica coastal current).

2013, of the National Oceanographic and Atmospheric Administration (NOAA), through the Ocean Data View (ODV). Historical and seasonal data of temperatures in the MPO was compiled in order to determine the changes of oceanic TD occurring over time. From the corresponding vertical profiles of temperature, the thermal gradient was computed and plotted.

2.1.2 Analysis and interpretation of data by geographic information systems (GIS)

GIS tools allowed obtaining datasets like TD, which is the result of subtracting SST from the temperature reported for other depths. The exclusion process allows for representing those areas with TD above 20°C. The MPO was divided into three regions: the GT, the ETP, and the GC. Subsequently, the sites with suitable thermal gradients for the operation of an OTEC plant were determined, which will then be plotted on different maps.

3. Net electric power

3.1 Methodology

Nihous [15] proposes a method to estimate the efficiency conversion of thermal energy to power generation for a device (100 MW theoretical plant). In this method, he and his coworkers assumed that the TD is distributed in main parts of this power plant in a structure called "temperature ladder." The formula proposed is based on a single thermal energy generation device and is expressed as:

$$P_{net} = Q_{CW} \frac{3\rho C_p \varepsilon_{tg} \gamma (\Delta T)^2}{16(1+\gamma)T} \tag{1}$$

$$P_{pump} = Q_{CW}\ 0.30\ \frac{\rho C_p \varepsilon_{tg} \gamma}{4(1+\gamma)} \tag{2}$$

where $\boldsymbol{Q_{cw}}$**:** Volume flow rate of the deep seawater intake per unit (latitude-longitude) for a 100 MW plant (309.7174 $m^3\ s^{-1}$); $\boldsymbol{\rho}$**:** Average seawater density as 1025 kg m^{-3}; $\boldsymbol{C_p}$**:** seawater-specific enthalpy equivalent to 0.004 MJ $kg^{-1}\ K^{-1}$; $\boldsymbol{\varepsilon_{tg}}$**:** turbo-generator efficiency as 0.75; $\boldsymbol{\gamma}$**:** flow rate ratio of the surface seawater intake over the deep seawater intake (1.5 for floating systems); **T:** absolute temperature of the OTEC surface seawater intake (K = °C + 273.15); **ΔT:** temperature difference between surface and deep seawater intakes (°C).

The pumping power density defined in Eq. (2) corresponds to 30% of the first term in the right-hand side of Eq. (1) (gross power density) taken at standard conditions ΔT = 20°C and T = 300 K. Despite their simplicity, the proposed power formulas capture the basic behavior of OTEC systems based on pure-fluid, low-temperature Rankine cycles, with thermodynamic efficiencies approximately half the Carnot limit of ΔT over T [15].

With the calculations obtained, net power maps were prepared for the MPO area, both annual and seasonal. With this, sites of interest were determined for the application of this technology and compared with other power values for other types of energy (thermoelectric, photovoltaic, wind, etc.), in order to know the scope of the OTEC cycle and what percentage of the national market could it have at a given time if it can be applied.

4. Social and environmental factors

4.1 Methodology

To describe the importance and impact of social, economic, and environmental factors of sites with potential for OTEC, you must know the variables that allow us to know what the marine environment is like for life, historical information from the PO. DAAC [16] was used to have a general notion that was subsequently compared with information from Marine Copernicus [17] and CONABIO [18] and adjust subsequent effort and investment to characterize and have direct measurements at the sites of greatest interest to OTEC. The marine variables related to water chemistry that may be related to their interaction with living beings.

The availability of water is of the utmost importance for life and the economic development of any region of the world. Information was considered in a superficial principle, but later it was suggested that knowing what depths of which it is intended to extract cold water could give greater knowledge of the oceanic conditions existing in the Mexican seas for these variables or parameters. Salinity, chlorophyll (mg m^{-3}), nitrates (μmol L^{-1}), phosphates (μmol L^{-1}), dissolved oxygen (mL L^{-1}), and silicates (μmol L^{-1}) were used, and the variables were possible at 0, 500, 700, 750, and 1000 m depth.

Finally, social research was done in three regions of Mexico: Baja California Sur (La Paz), Nayarit (Punta Mita), and Oaxaca (Puerto Ángel) where surface temperature measurements have also been made considering the sites of interest for implementation of this technology. The importance of this field study is to know the ideology of the people about the problems existing in their communities and their knowledge about marine renewable energy.

5. Results

5.1 Mean annual historical thermal difference (TG) maps (0–1000 m depth)

Throughout the year at 1000 m depths, it is observed that the TD increases considerably from Nayarit to Oaxaca where optimal TD is around from 22 to 24.5°C in the ETP and GT. The TD at GC, which includes sites as Baja California Sur, varies from 19 to 22°C although seasonal data showed the most representative TD value was below 20°C. From the previous information, the MPO is a favorable area for the installation of OTEC (see **Figure 2**).

5.2 Net electric power

Based on the analysis performed, the net electric power maps (annual average and seasonal) were obtained. The average annual electrical power map shows that the southern and southeastern parts of the Mexican Pacific tend to have a greater amount of energy for most of the year regardless of the type of OTEC cycle used. Guerrero and Oaxaca would produce almost 200 MW of electricity in a year, which translates into about 1500 GWh year^{-1} (see **Figure 3**).

The southern part of the peninsula of Baja California, the Gulf of California, and part of the central Mexican Pacific Ocean would generate powers of between 100 and 140 MW per year. As the OTEC cycle does not require the burning of any fuel for evaporation of the working fluid, the electricity cost is considerably reduced, and, with the secondary products that can be obtained from the cycle (drinking water, air conditioning, aquaculture water, and production through cold water agriculture, among others), populations could enjoy benefits of labor and environmental and social development, which would result in a decrease in rates such as violence and poverty in the country. Additionally, these sites could have their

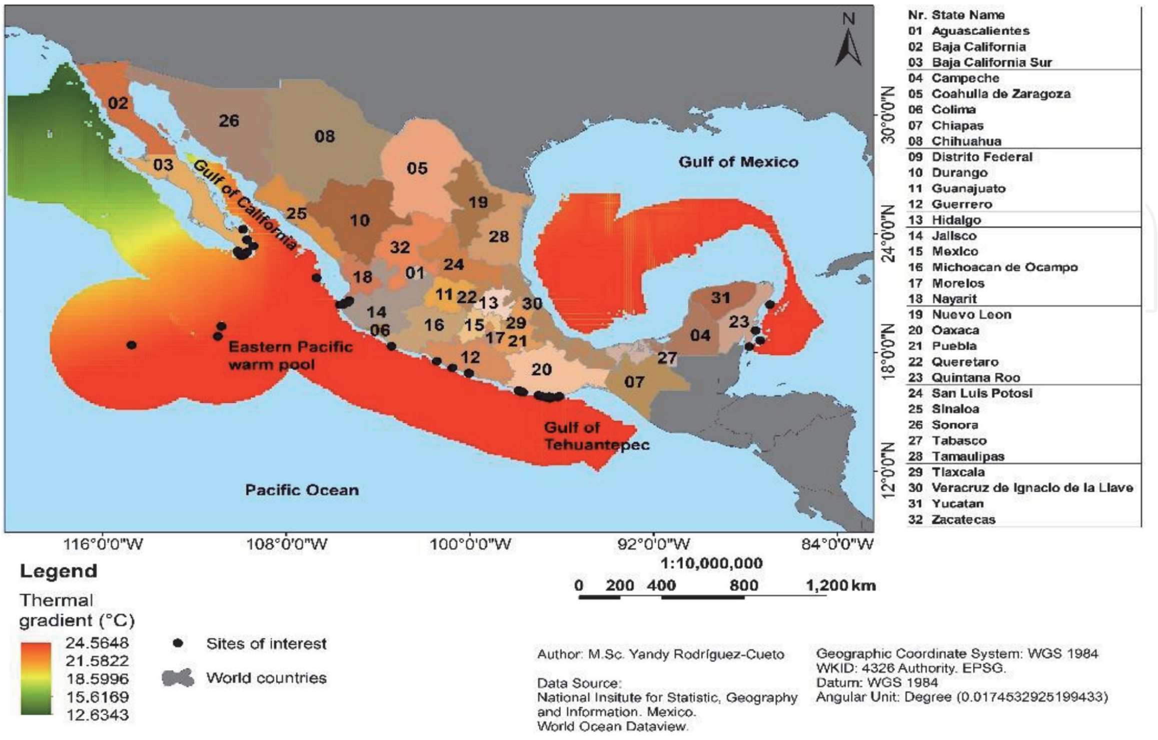

Figure 2.
Mean annual historical (1955–2012) thermal difference between 0 and 1000 m depth.

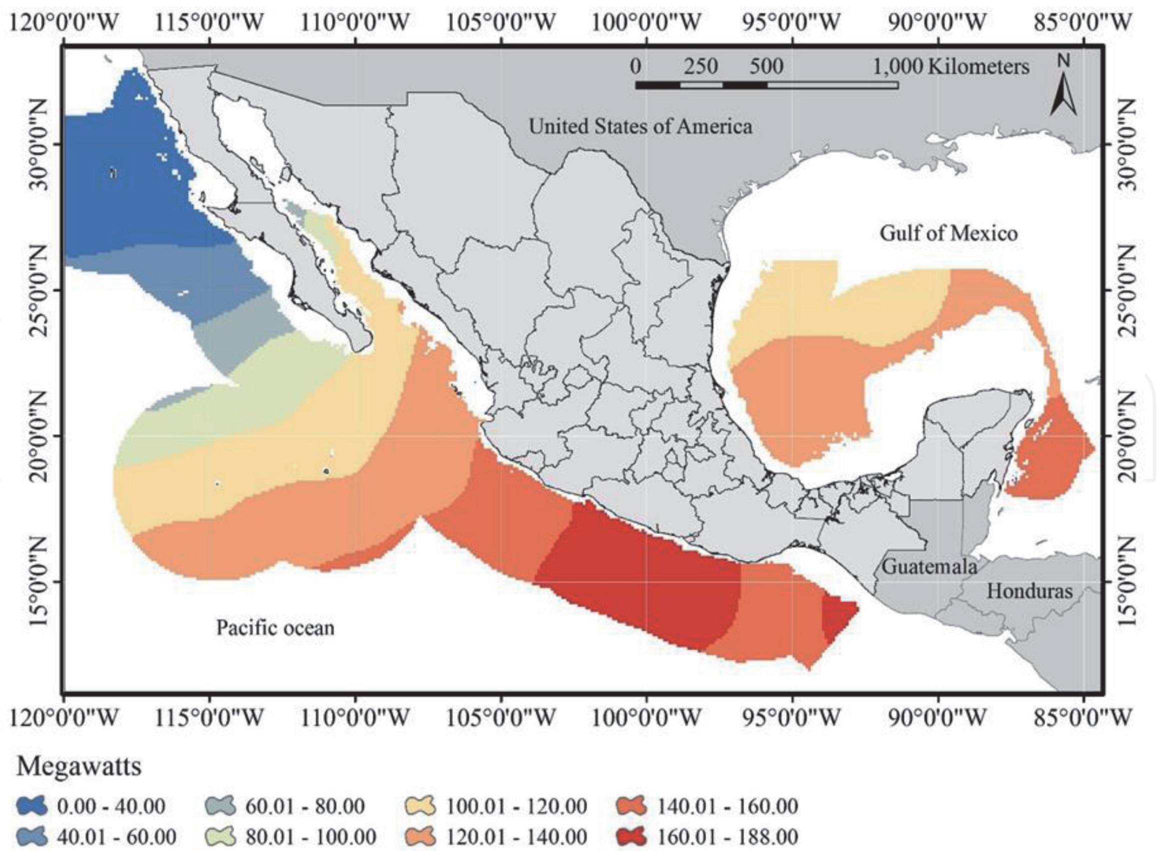

Figure 3.
Mean annual historical (1955–2012) net electric power in the Mexican Pacific Ocean.

energy needs covered so that federal investments in this sector would fall considerably and thus the money could be used in other important social sectors.

However, the OTEC cycle is very sensitive to changes that may exist in the sea, so variations in temperature differentials will generate distinct electric power production. As can be seen in **Figure 3**, there are substantial changes in net power according to seasonality, reaching values ranging between 60 and 200 MW, the best sites for the operation of the plant being the states of Guerrero, Oaxaca, and Chiapas, where plants onshore and offshore can be built and operated (these last plants will operate when there is greater technological development and improvement of structures and parts such heat exchangers, pipes, and submarine cable for the transport of electricity to the port area, among others).

In **Table 1**, the comparison of the OTEC production numbers with other energy sources, both renewable and nonrenewable, is observed.

It is observed that an OTEC plant operating 365 days a year could have a higher average net energy generation than most renewable energies, except for hydroelectric plants that have twice the net production and wind and geothermal plants.

5.3 Environmental factors

If the environmental conditions that are present in the sites that can be considered optimal for establishing an OTEC are well known, it will help in the choice of materials, construction and maintenance of the equipment, and infrastructure and thus have a better planning and idea of costs. Considering installing pipes and pumping deep water to the surface of the sea and then reinjecting at an intermediate depth will modify the marine and coastal environment to some extent. Until the moment the plant is operating it will be possible to evaluate and have a clear

Energy type	Total (MW)	Plant factor	Average anual production net (GWh year^{-1})	Net hours of annual production
OTEC[2]	**100**	**0.8**	**1562.5**	**8760**
Hydroelectric	2400	0.41	3498.1	3555
Solar/Phootovoltaic	30	0.46	19.5	1415
Wind	251.1	0.32	225	2801
Geothermal	225	0.77	1172.3	6767
Bioenergy	53	0.24	26.7	2100
Nuclear power	1608	0.75	7925.8	6572
Carboelectric	2778	0.73	12897.6	6360
Thermoelectric	2100	0.37	2488.7	3203
Dual	367	0.64	1145.5	4877
Turbogas	393	0.28	274.4	2494
Internal combustion	210	0.25	113.5	2162
Regenerative brakes	290	0.56	1071.1	6596
Combined cycle	1454	0.67	5650.2	5800

[1]*Source: SENER (prepared with data from the CFE, CRE, CENACE, SEMARNAT, and the Secretariat of Planning and Energy Transition, 2016). In blue, renewable energy. In red, conventional energies.*
[2]*Theoretical.*

Table 1.
Effective installed capacity (MW) of renewable and conventional energy plants[1] compared to the theoretical OTEC cycle, average annual net production, plant factor, and net production hours.

estimation of costs considering the impact that could have and knowing the ocean dynamics that occurs can help mitigate or minimize consequences.

5.3.1 Temperature

This parameter is the most important for the operation of an OTEC plant because the duty cycle works from the Carnot cycle, which implies that there should be a preferential thermal differential of 20°C or greater, although in some countries such as South Korea, it works with a differential of 18°C in the summer months.

In the case of temperature, by analysis that we have performed at the level of numerical modeling and by results generated in some of the OTEC experimental plants, it is known that this parameter would not generate a thermal pollution process because the discharge water would stabilize once it is placed in the depth whose density is adequate.

Thus, as there is no risk of a possible thermal effect, there is no strong impact on the organisms in the water column. However, it is considered that there should be frequent monitoring of this and other parameters to be completely sure.

An example of this is the analysis performed at one of the sites of interest in Mexico for the implementation of OTEC (Puerto Angel, Oaxaca) by Instituto de Ciencias del Mar y Limnología (ICMyL) of Universidad Nacional Autónoma de México (UNAM) [4], where, according to the data obtained and after analysis (taking as a reference the summer and winter months), it is considered that the operation of the OTEC plant may not generate thermal contamination because the vertical temperature profiles, both without operation and with the operation of the OTEC plant, are similar; the above implies that the discharge water (whose output temperature is $15.5 \pm 1.7°C$ when mixed) will tend to be located in the water column, according to its density.

5.3.2 Salinity

Salinity is an environmental factor of great importance because it is a factor that defines the organisms that can adapt to living in a body of water and resist between certain ranges of salinity. The concentrations of K^+ and Cl^- are relatively conservative, that is, they undergo small variations induced by environmental changes or by their use by living beings. In contrast, the concentrations of HCO_3^{2-}, SO_4^{2-}, and Ca^{2+} depend on precipitation-dissolution processes, microbial metabolism, and climatic changes, including the sea surface temperature. Some minor elements, such as silicon, nitrogen, phosphorus (P), and iron, are of great importance from a biological point of view, although they do not significantly influence the salinity of a body of water.

In the previous example (Puerto Ángel, Oaxaca), this parameter does not have much relevance during the operation of an OTEC plant, but it is considered since it has implication in the density of water bodies. What is observed in both cases (both without operation and with the operation and operation of the OTEC plant) is that the variation in salinity is minimal (between 0.1 and 0.2 UPS) and its tendency is almost linear from 200 m deep.

This implies that the discharge water of the plant would generate small changes in salinity, its density being similar to the waters surrounding the discharge zone, so its effect would be limited.

5.3.3 Chlorophyll (primary productivity)

Chlorophyll is an indicator of primary productivity that occurs in the seas. Chlorophyll a is the compound with the greatest presence in photosynthetic organisms; therefore, the chlorophyll is directly related to plant biomass, to determine the deterioration or balance of an ecosystem.

5.3.4 Nutriments

As a result of the analyses carried out through the CORMIX program by García-Huante [4] at the Institute of Marine Sciences and Limnology regarding the behavior of nutrients in the discharge water of a 100 MW OTEC plant in Puerto Ángel, Oaxaca, it was obtained that all the nutrients would have a high concentration at 113 m depth, which is where the water would end up being located due to its density. Next are the results per nutriment.

5.3.5 Nitrates

Nitrites and nitrates are part of the nitrogen cycle. Nitrate is used as a nutrient by photosynthetic organisms, and its presence in water can accelerate the phytoplankton overgrowth, producing water eutrophication. Nitrite levels higher than 0.75 ppm in water can cause stress in fish, and greater than 5 ppm can be toxic. Nitrate levels between 0 and 40 ppm are generally safe, and any value greater than 80 ppm can be toxic.

In this case, during CORMIX simulation of the operation of an OTEC plant in Puerto Ángel, two possible increases in this nutrient are observed both in summer and in winter. By summer, nitrates would increase to 43.42 μmol L^{-1} to 113 m deep; in winter it would increase to 40.3 μmol L^{-1} to 113 m deep, which could imply an important effect.

5.3.6 Phosphates

In the sea, phosphorus is found as a phosphate $(PO_4)^{2-}$ ion that is an indispensable element in the synthesis of organic matter in the sea and is widely used by phytoplankton; its shortage in photosynthetic activity zones limits primary productivity and all marine life. Its concentration in the sea is very variable seasonally because it depends on fluctuations in the phytoplankton population.

In this case, during CORMIX simulation of the operation of an OTEC plant in Puerto Ángel, there would also be a possible increase in the concentrations in a depth of 113 m from 0.3 to 3.7 μmol L^{-1} during the summer; meanwhile in winter there would also be an increase from 0.3 to 3.8 μmol L^{-1} to 113 m deep, so the effect could be high.

5.3.7 Silicates

In seawater, the silicates are used by diatoms in the form of opal silica to form their frustules, which are like cases that keep them protected from the outside. Diatoms as organisms provide 20% of photosynthesis. Sponges, silicoflagellates, and radiolaries use it as a structural component. In animals, it is part of blood and bones, and in plants, and it protects against biotic stress and abiotic stress.

During CORMIX simulation of operation of the OTEC plant in Puerto Ángel, there are also two possible sites where the concentration of silicates would increase in both summer and winter. For the first case, the increase would be 91.24 μmol L^{-1} 113 m deep; in winter it would be 101.7 μmol L^{-1} at 113 m deep. The effect, from this increase, would be significant.

However, the dilution rate of these nutriments and the surface currents that exist in the area would end by elimination in a matter of 2–3 weeks, according to the simulation performed. Therefore, there would be no high risk in addition to the fact that the discharge water would be located below the photic layer (which in the area usually reaches 100 m depth) depending on the seasonality and the oceanographic processes that occur in the area as the upwelling or ENSO.

Hence, according to the analysis carried out by García-Huante [4], the impact of oceanographic dynamics on the nutrients of the discharge water of the OTEC plant is decisive; it is unlikely that there will be more activity at the trophic chain level. Thus, some type of involvement, both positive and negative, could be ruled out at the biological level in the study area.

5.3.8 Dissolved oxygen

In the sea, oxygen is a necessary element for all life forms. Natural stream purification processes require adequate oxygen levels to facilitate aerobic life forms. The dissolution of oxygen occurs between the surface of the water and the atmosphere, and many factors interfere. It is also produced as a residue of photosynthesis, but it is quickly consumed and depleted in the degradation of organic compounds.

During CORMIX simulation of the operation of OTEC plant in Puerto Ángel, the oxygen would not have negative changes because the poor waters of the bottom, at the time of being pumped, would be oxygenated by the turbulent mixing action both in the extraction and by the passage in the pipes of plant. Based on previous studies (Guenther and Green, 1990, and Vega, 1995), this parameter would not have a negative effect on the environment.

5.4 Social factors

The term OTEC is an unknown technology in the national scene and the experience that, as a working group, have had with the coastal communities in explaining how it works and what it implies. The response observed in the population is generally optimistic, especially in the communities with the greatest lag and the desire that its implementation can bring social benefits that they seek.

The social and economic perspectives of Mexico are different in any region suggested to build an OTEC plant. However, it will be wrong to think that the social benefit will be to provide electricity at no cost, jobs, or money as income for the communities.

In Puerto Ángel, Oaxaca, a community dedicated to artisanal fishing, the aforementioned thought is the prevailing one, followed by the idea that new people will arrive to mobilize their tourism and commerce. They are discouraged that the plant would sell its electricity produced to the CFE or that a private sector will manage it. The community of Puerto Ángel have the fear that strangers who arrive will break their structure and stability by bringing new problems or aggravating those the community have, and they feel that what comes from the government is often negative or against them, but on the other hand, they look at OTEC plant as a window of opportunity to reduce social and economic lag for people who are more optimistic. We talk to the community about the technological applications that can result from implementing an OTEC plant, such as obtaining cold water for cooling, drinking water if desalinated, and salts for chemical industry or agriculture.

In Bahía de Banderas, which the states of Jalisco and Nayarit share, the diversification of economic activities and services that exist in the community causes very different perspectives, ranging from indifference to enthusiasm, about what OTEC represents.

On the other hand, in Baja California Sur, fisherman community and people who live on the coast have a different perspective, while their economy depends on the sea without necessarily being fishermen, such as a merchant, shipyard, and mechanic, supplies for fishing, or maintenance of boats or cars. When that community listen to about the description of OTEC, they ask technical things, for example, what type of pumps will be used, their resistance to corrosion or inclement weather, the profit of generating potable water and electricity using this technology, and application of cold water in refrigeration, agriculture, and aquaculture production.

We are concerned to solve the environmental impacts of reinjection of seawater and how the OTEC plant could modify the energy matrix of the community before deciding on a particular site.

6. Discussion

6.1 Thermal difference

In order to know optimal sites of OTEC installation in MPO, it is necessary to evaluate each one with physical, environmental, socioeconomic, and legal aspects with a biggest vision that allows us to know the advantages and disadvantages of future OTEC practices.

The regions that seem to be promising and optimal for OTEC are ETP and GT. Both areas present the TD favorable throughout the year. There are various sites of great depth close to the coast, having possible access to the electrical grid, and there are important centers of consumption. Among the unfavorable aspects, there is the possible threat of intense hurricanes and the fact that there are protected areas.

Concerning hurricanes, on this side of the Pacific Ocean, they evolve from south to north in such a way that, while in the south the hurricane category is normally 1 or 2, category 5 hurricanes strike the north and even travel as far as the Baja California peninsula.

Two sites are currently under intensive study: Bahía de Banderas, Nayarit, and Puerto Angel, Oaxaca. In the case of the Mexican Pacific Islands (MPI), the areas with the maximum TD are observed near the Marias and Marieta Islands, which are protected areas. In addition, the Islas Marias contains a prison, so that any ocean engineering projects would require special permission from the Mexican government.

6.2 Power net energy

The best places to operate an OTEC plant should be those where the temperature is quite stable. However, the plant can adapt to existing oceanographic conditions so that regions of the central Pacific and southern Mexico can use OTEC without major risk, unlike the southern part of Baja California where values fall considerably and would have an operating time between 4 and 6 months.

This analysis indicates that, under an annual average production of 200 MW of electricity (3125 GWh $year^{-1}$) and with a plant factor of 0.8 (80% operation, 365 days a year and 24 h a day), an OTEC plant could have a higher average net energy generation than most renewable energies and very close to hydroelectric production. As for conventional energy, OTEC is competitive in some cases in terms of production, but not enough because there are some other energy sources that present a much higher production as the hydroelectric, nuclear, and fuel plants (see **Table 1**).

However, the secondary products obtained from OTEC plants give it a higher rating when making a possible decision.

6.3 Environmental and social factors

First, regarding the possible environmental factors, it is important to consider water pollution, due to chemicals emitted by machine parts, and to evaluate the geological characteristics of the sites in case of erosion or earthquake. Then, the electromagnetic effects of power lines and the possibility of marine life attaching onto the devices are worth examining. Finally, it is crucial to verify the effects on protected zones and to perform predictions regarding the occurrence of hazards that are common in Mexico, such as storms and hurricanes.

Last, in the case of social factors, it is important to promote the approval of the community for the activities to be carried out, preserving the culture and traditions of the region. It is also very important to consider areas, which are potential zones of recreation, transportation, aquaculture, or military activities. Moreover, it is crucial to count on academic, government, and industrial participation in the projects. Finally, security factors should be considered where the sites are affected by human migration, criminal activities, and so on.

7. Conclusions

MPO has an excellent thermal potential for OTEC deployment. The most promising regions into MPO are the ETP and the GT, which includes sites from Nayarit to Oaxaca and the MPI. Sites located in the Gulf of California have inadequate gradient for part of the year; nevertheless, other applications such as the utilization of cold water can be of great interest. The communities in these areas would have a high social development expectation, considering the amount of secondary by-products derived from the cycle, the decrease in the cost of electricity production (and therefore in the payment for the service), as well as achieving greater stability to eliminate gradually violence and poverty in these places.

The social perception that broadly reflects the surveys made to the inhabitants of the area of interest for the CEMIE-O denotes some discomfort; infrastructure development linked to strengthening sectors of the tourism industry has been characterized, according to fishermen's point of view, for only taking into account economic and technical criteria. The repercussions that have had decisions such as the relocation of an entire locality, waste management, and some environmental protection interventions are issues that the social groups in question try to solve without many tools at their disposal.

Although there are cases in which the omissions to the social dimension have not escalated into major conflicts, an issue can completely stop large-scale projects. The comprehensive account of the social dimension is that one must have careful planning and a genuine interest in the structure and ways of life of the community in question. This is not only a requirement to be met in the administrative order of project management but the basis of sustainable development as a concept and as a practice.

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Conflict of interest

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; and in the decision to publish the results.

Appendices and nomenclature

SENER	Ministry of Energy
CONACyT	National Science and Technology Council
CEMIE-O	Mexican Energy Innovation Center of Ocean
RE	renewable energy
LTE	Energy Transition Law
OTEC	Ocean Thermal Energy Conversion
MPO	Mexican Pacific Ocean

CS	Caribbean Sea
GIS	Geographic Information System
EEZ	Mexican Exclusive Economic Zone
TD	thermal difference
SST	sea surface temperature
GC	Gulf of California
BCS	Baja California Sur
ETP	Easter Pacific Warm Pool in the Pacific Ocean
NYT	Nayarit
JAL	Jalisco
MCN	Michoacán
GRO	Guerrero
COL	Colima
GT	Gulf of Tehuantepec
OCX	Oaxaca
El Niño	ENSO
CRCC	Costa Rica Coastal Current
SEMAR	Mexican Navy
NODC	National Oceanographic Data Center
WOD	World Ocean Database
NOAA	National Oceanographic and Atmospheric Administration
ODV	Ocean Data View
MPI	Mexican Pacific Islands
CFE	Electricity Federal Commission
ICMyL	Institute of Marine Sciences and Limnology
UNAM	National Autonomous University of Mexico
CRE	Energy regulatory commission
CENACE	National Energy Control Center
SEMARNAT	Ministry of Environment and Natural Resources

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