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Techno-Economic and Socio-Environmental Study of a Floating Photovoltaic Project on Lake Yojoa, Cortés, Honduras

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Abstract*– Honduras is a country that is undergoing a transition to renewable energies, steering away from fossil fuels. However, the electricity loss in the transmission and distribution lines has slowed down this transition. The exponential increase in the electricity tariff due to the accretion of fossil fuel cost, and the restrictions imposed during 2020 due to the COVID-19 pandemic have affected economically the small and medium restaurants in the touristic zone in Lake Yojoa, Honduras. The implementation of a floating photovoltaic microgrid-type system can diminish the economic impact endured by the restaurants by implementing a new monomial tariff for electricity, and attract more tourist to the area, activating the economy and promoting the transition to renewable energies at the same time. In this study, the feasibility of the technical, economic, social, and environmental aspects of the project were evaluated; utilizing real measurements obtained from a reference restaurant and utilized for all the 67 restaurants in the area. In the economic aspect, a new monomial tariff was obtained, utilizing the national grid's electricity tariff and the floating photovoltaic project's electricity tariff, and furthermore the values of the levelized cost of electricity (LCOE), internal rate of return (IRR), return on investment (ROI), and recovery period of the project for both scenarios: with and without financing, being the financed scenario superior to the other. Environmentally the results obtained showed a decrease in CO_2 emissions and socially the project had an 87% acceptance rate with the restaurants. This investigation can be used by the central government as a basis for future floating photovoltaic projects that help with the decentralization of energy generation and to mitigate the electric power loss in the transmission lines.

Keywords-- floating photovoltaic project, microgrid, monomial tariff, decentralization, energy generation, Lake Yojoa

I. Introduction

Honduras has been one of the countries affected economically by the economic paralysis resulting from the SARS-COV19 pandemic and the two hurricanes that impacted the country at the end of 2020 (Eta and Iota), leaving the nation devastated [1]. Once the pandemic restrictions eased, an upturn in the country's economic recovery began to be seen in 2021, but at the same time, according to Carranza [2] consumers have felt a direct impact on their pockets due to the constant increases in fuel prices during this year. The impact of fuels on the national economy, after all this year 2021 has had an irreversible upward trend (refer to chapter two, section 2.1), can be seen in the prices of products and services consumed by Hondurans. This has affected all economic markets nationwide, including electricity generation. According to Mejía [3], he indicates that the government has been absorbing the increase in energy tariffs since the second quarter of 2022, but if this measure is not continued, charges will suffer substantial increases, and if a subsidy is not given again in 2023, the real cost will have to be passed on to the subscriber, who will have to pay a substantial increase.

The implementation of floating photovoltaic projects has been used in various sectors around the world, having its different scope depending on whether you have a more environmental approach or a more technical approach, such as optimization of photovoltaic power generation or decentralized power generation. For example, Farrar et al. [4] implements the use of a floating photovoltaic system helps to decrease water evaporation, Khan et al. [5] implements the use of a floating photovoltaic project inside a large lake to provide power to a mosque, Choi [6] compares conventional and floating photovoltaic projects, finding as a result 11% more power generation in photovoltaic projects, and Makhija et al. [7] compares the use of different photovoltaic power generation systems for electrification of rural areas in India, finding that generation with a floating photovoltaic system has the lowest energy cost and net present value. The implementation of floating photovoltaic projects and other different methods of sustainable innovation in different rural or semirural locations around the work have led to possible increases in tourism. For example, Calderón-Vargas et al. [8] demonstrates an increase equivalent to 34.9% above the minimum wage for every family with sustainable lodging for tourist using solar panels in Cocachimba, Peru, Aranibar, E. y Patiño, A. [9] denotes a historic impact on the development of Lake Titicaca product of sustainable tourism, denoting tourism as the main point of the economic improvement in that location, and Chen et al. [10] concluded that the introduction of eco-homes in rural regions increases the Tourism Development Potential (TDP), thus, increasing the income all-around in those locations.

This research, unlike the previous ones, focuses on implementing a floating photovoltaic microgrid project with a monomial tariff, which can be lower than the national interconnected system (SIN) tariff to the 67 restaurants of Lake Yojoa, being this a project for self-consumption of the restaurants, without disconnection from the national interconnected system, possibly helping the restaurants economically and with possible positive environmental impacts, as well as an increase in tourism activity as a result of sustainable development. This is done using an electrical grid analyzer, which is connected to a reference restaurant, which is

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used to replicate its data obtained in the 67 restaurants and, thus, determine its feasibility.

II. Context

Honduras is the Central American country with the most installed capacity in solar photovoltaic power, starting with just 4 MW of installed capacity in 2014 [11] and reaching 510.8 MW of installed capacity by May 2022 [12] Honduras has several large lagoons and reservoirs, with Lake Yojoa being the largest and most extensive freshwater lake in the national territory [13]. On the shores of Lake Yojoa there are restaurants that take advantage of the natural attractiveness of the lake to entice customers, which has made Lake Yojoa an appealing touristic zone. All these restaurants consume electricity from the National Interconnected System (SIN), in which the cost of electricity has increased drastically due to the rise in the cost of generating electricity from fossil fuels, and which for the moment has been partially subsidized by the government. something that is not sustainable in the long term.

Figure 1. Comparative graph between projected and real average marginal costs in 2022.

Source: [14]

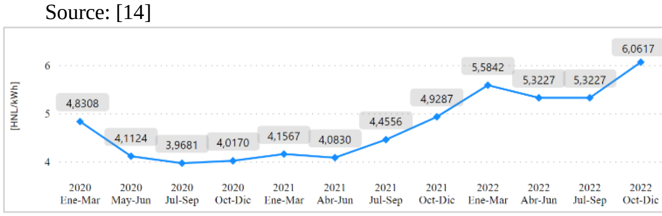

Figure 2. Evolution of the average electricity tariff.

Source: [15]

This continued rise in electricity generation has yielded the following tariff structure for the second half of 2022:

Table 1
Tariff Structure for Residential Service users on the third and fourth quarter of 2022

Electricity Service	Tariff [HNL/kWh]	
Residential	July – September 2022	October – December 2022
First 50 kWh/month	4.4147	5.0400
Following kWh/mes	5.7447	6.5583

Source: Own elaboration based on [16]

Table 2
Comparison between average electricity tariff adjustments (3rd and 4th quarter 2022)

Service	Average Tariff [HNL/kWh]		Increase	
	3rd Q	4th Q	[HNL/kWh]	[%]
Residential*	5.74	6.50	0.76	13.16%
Low Voltage	5.80	6.60	0.80	13.79%
Medium Voltage	4.59	5.28	0.69	15.00%
High Voltage	4.16	4.82	0.66	15.93%

Source: Own elaboration based on [16]

A. *Definition*

The main problem lies in the possible negative economic impact that restaurants could suffer when the central government stops subsidizing the increases in the electricity tariff. These tariff increases would cause an increment in their operating and maintenance costs, resulting in a subsequent rise in their selling prices, which is likely to cause a decrease in clientele and, thus, diminishing the income of these restaurants.

B. *Justification*

The increase in the tariff is already a nationwide issue. The National Electric Energy Company is already suffering serious economic damage with 38% technical and non-technical losses in its power transmission and distribution network and the central government with the absorption of the tariff increase. There will come a time when this increment will inevitably be passed on to the commercial sector of the country, further damaging the national economy. It is reasonable to say that, economically, the private commercial sector has suffered economic blows as a result of the pandemic and two hurricanes at the end of 2020 [17] combined with inflation, it would result in an additional economic burden for the small and medium business owner who have their restaurant in the region.

III. Methodology

This research has a mixed approach, with a longitudinal design and a descriptive scope. The type of study employed is non-experimental. This research focuses on the roadside restaurants in the southeastern part of Lake Yojoa, between the municipalities of Santa Cruz de Yojoa and Taulabé.

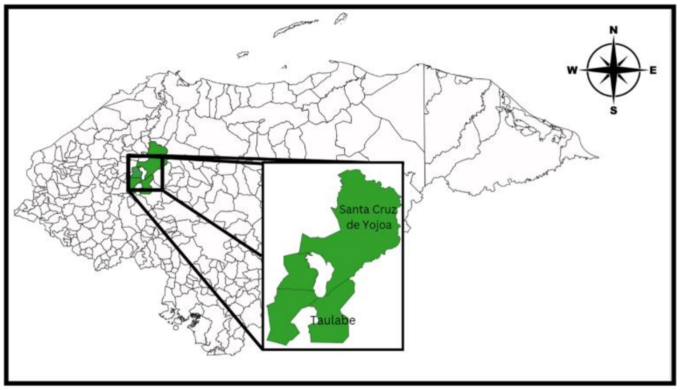

Figure 3. Lake Yojoa georeferenced map.
Source: Own elaboration

Figure 4. Lake Yojoa georeferenced map.
Source: Own elaboration with images from Google Maps

This research employs the use of an electrical network analyzer to measure the real electricity consumption of a restaurant. This restaurant is used as reference for the other 66 restaurants. The connection of the electrical analyzer for one week is essential for the creation of a synthetic load profile. This typical week of electricity consumption is replicated to the other weeks of the year, which is then scaled to the monthly electricity consumption of the last 12 months of the reference restaurant, creating a synthetic annual electricity consumption profile. The synthetic load profile is used to be replicated to the other 66 restaurants, having a total synthetic annual energy consumption data, which is used for the dimensioning of the project by the SAM software.

TABLE 3
SYSTEM ADVISOR MODEL MAIN INPUT PARAMETERS

Input Parameters	
Type	Characteristics
Location and Resource	• The area location and weather data of the zone is uploaded.
Module	• A reference PV module is chosen to make a preliminary dimensioning of the system.
Inverter	• A reference inverter is chosen to make a preliminary dimensioning of the system.
Shading	• Possible shadings that can affect energy generation are denoted.

Source: Own elaboration

Utilizing the results obtained from the SAM software simulation, the photovoltaic technology to be used in the project is determined by utilizing a sensitivity analysis of different dimensioning scenarios. Using Helioscope, the project is dimensioned to determine the distance from the project to the customers and to measure the area to be utilized by the flotation equipment and photovoltaic modules.

Once the project has been dimensioned, an economic study is carried out to determine the funding alternatives for the floating photovoltaic system. Subsequently, the possible environmental impacts resulting from the installation, operation and maintenance of the floating photovoltaic project are assessed. Furthermore, utilizing PV Syst, the CO_2 emissions produced by the project are calculated.

Once the results of the technological, economic, and environmental studies are obtained, the social assessment process is carried out to determine the social approval of the project by the owners of the restaurants and the public.

IV. RESULTS

A. Average Electricity Consumption

Using the information from the electrical network analyzer that was imported into SAM, the average hourly energy demand data was obtained, which was then scaled to the total of the 67 restaurants, obtaining the electrical energy demand curve and how this will be covered by the energy generation of the various project proposals provided by SAM. The total yearly electricity consumption of the sample group resulted in 3,363.40 MWh/year.

TABLE 4
SENSITIVITY ANALYSIS BASED OF SAM SIMULATIONS

Scenario	Total electricity generated (kWh)	Total electricity injected (kWh)
900 kWp	1,291,973.87	49,361.07
1,050 kWp	1,507,302.87	132,906.73
1,200 kWp	1,722,631.85	255,799.69

Source: Own elaboration

The 1,050 kWp scenario was chosen as a guide for the project dimensioning, since it has a higher coverage percentage differential and a lower grid injection ratio than the 1,200 kWp scenario.

TABLE 5
COMPARISON BETWEEN COVERAGE AND INJECTION BETWEEN SCENARIOS

Scenario	Coverage relative to previous scenario (%)	Injection relative to previous scenario (%)
1,050 kWp	3.91%	5.00%
1,200 kWp	2.75%	6.03%

Source: Own elaboration

B. Technological Study

The type of photovoltaic module selected was the CS7L-600MS, since the module is bifacial and can take advantage of the solar radiation reflected by the surface of the water of Lake Yojoa. The inverter selected was the 110KTL SUN2000 due to its reliability and performance in Honduras. The flotation and anchoring equipment selected was the Hydrelio Air due to its capacity to support photovoltaic modules of up to 700W. The transformer chosen for the project is a 1500 KVA Pad-Mounted step-up transformer that boosts the voltage from 480 V to 34.5 kV.

The project is located 200 meters away from the restaurants and is divided into two (2) floating and anchoring positions of 4,000 m2 each, leaving 175 meters between the two floating structures of the solar project.

Figure 5. Dimensioning of the floating photovoltaic arrays
Source: Own elaboration

Each of the flotation structures is equipped with 4 inverters in the center, thus having a correct distribution of the strings and ensuring that the arrangement is as orderly as possible.

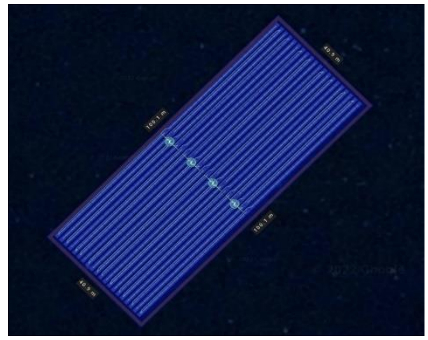

Figure 6. Distribution of PV modules and inverters on floatation equipment
Source: Own elaboration

C. Economic Study

The floating photovoltaic system provides the restaurants with the electrical energy produced by the project and the electrical energy from the SIN that enters through the bidirectional meter. Low, medium, and high voltage consumers are charged the electricity subsidy granted by the government to customers who consume less than 150 kWh per month. In the fourth quarter of 2022, the cross-subsidy represents an increase of 8.413% of the tariff for each kWh consumed. The exchange rate of the lempira to the US dollar was taken as L. 24.7993 per US dollar.

Since the project has more than one (1) MW of installed power capacity, it is assumed that the project falls within the type C classification of autoproducers. Since the project is classified as type C, the medium voltage tariff will be used to charge for the electricity consumed that the project's bidirectional meter reflects [18].

TABLE 6
COMPARISON BETWEEN TARIFF AND CROSS-SUBSIDIZED TARIFF

Low Voltage Tariff ($/kWh)		Medium Voltage Tariff ($/kWh)	
Without Cross-Subsidy	With Cross-Subsidy	Without Cross-Subsidy	With Cross-Subsidy
$ 0.2641	$ 0.2863	$ 0.1803	$ 0.1954

Source: Own elaboration

The sensitivity analysis yielded that a 40.86% of the generated photovoltaic electricity would be self-consumed, while the rest of the consumed electricity would be supplied by the national grid. The electricity tariff of the photovoltaic project was assumed to be $ 0.27/kWh.

TABLE 7
TOTAL YEARLY ELECTRICITY CONSUMPTION COST PER SOURCE

Source of Electricity	Annual Consumption (kWh)	Tariff ($/kWh)	Electricity Consumption Cost ($)
Floating PV Project	1,374,396.14	$ 0.27	$ 371,086.96
SIN	1,989,004.02	$ 0.1954	$ 388,717.15
Total Electricity Consumption Cost			$ 759,804.11

Source: Own elaboration

Utilizing the total electricity consumption cost for the year, the monomial tariff for the restaurants was calculated, as shown in Table 9.

TABLE 8
MONOMIAL TARIFF CALCULATION

Annual Consumption (kWh)	Total Cost ($)	Monomial Tariff ($/kWh)
3,363,400.16	$ 759,804.11	$ 0.2259

Source: Own elaboration

Taking an annual growth rate of 1.5% of the SIN electricity tariffs, the annual degradation of the photovoltaic modules, the total energy produced during the 30-year life of the project and the total cost of electricity consumed by the restaurants, the total cost of both scenarios, with and without the project, was compared.

TABLE 9
COMPARISON BETWEEN TOTAL COST OF ELECTRICITY WITH AND WITHOUT THE FPV PROJECT

Total Cost of Consumed Electricity without the Project ($)	Total Cost of Consumed Electricity with the Project ($)	Total Cost Differential (%)
$ 36,149,944.92	$ 25,691,709.48	28.93 %

Source: Own elaboration

The cost of the flotation equipment was estimated based on studies done by the National Renewable Energy Laboratory or NREL in the United States, since flotation equipment cost data is limited. This is estimated to be $0.40/Wdc including import and installation costs; a value of $0.15/Wdc was assumed as the import and installation cost for Honduras [19] The importation cost of the PV modules was provided by the supplier of the modules [20]. The total investment of the project results in a total of US$1,144,360.00.

TABLE 10
TOTAL EQUIPMENT AND INSTALLATION COST

Equipment	Quantity	Cost ($)	Import ($)	Total Cost ($)
PV Module	1,750	$ 0.30/W	$ 36.00*	$ 378,000
Inverter	8	$ 9,545	N/A	$ 76,360
Transformer	1	$ 25,000	N/A	$ 25,000
Floating and Installation	N/A	$ 0.40/W	$ 0.15/W	$ 577,500
Cables	3,500m	$ 25/m	N/A	$ 87,500
Total Cost			$ 1,144,360	

Source: Own elaboration

Two scenarios were evaluated: with external financing and one without any financing. These studies yielded the following results:

TABLE 11
RESULTS OF STUDY WITHOUT EXTERNAL FINANCING

Output Parameters	
Recuperation time (years)	4 years
Net Present Value ($)	$ 1,685,222.46
Internal Rate of Return (%)	25.71%
Return on Investment (%)	14.41%
LCOE ($/kWh)	$ 0.0521

Source: Own elaboration

TABLE 12
RESULTS OF STUDY WITH EXTERNAL FINANCING

Output Parameters	
Recuperation time (years)	8 years
Net Present Value ($)	$ 1,777,044.93
Internal Rate of Return (%)	64.63%
Return on Investment (%)	17.19%
LCOE ($/kWh)	$ 0.0543

Source: Own elaboration

D. *Environmental Study*

Using PV Syst software, a CO2 emissions simulation report was generated for the floating photovoltaic system during its lifetime. It showed that the installation of the project could offset up to 13,762.2 tons of CO2 emissions over the 30-year lifespan of the project.

The potential environmental impacts that may be caused by floating photovoltaic projects have not been sufficiently studied, having almost negligible reference data. However, even with this limitation, possible environmental impacts found in different floating photovoltaic projects with similar conditions were highlighted.

The following were considered as potentially the most significant positive environmental impacts:

- Possible drop in water temperature and consequently, diminishing the evaporation of Lake Yojoa.
- Possible reduction of aquatic flora under the project, providing a possible low-current zone, enabling a possible natural habitat for aquatic fauna.

The following were considered as potentially the most significant negative environmental impacts:

- Possible contamination due to corrosion of the anchoring and flotation system.
- Possible water contamination due to chemicals used during operation and maintenance of the floating photovoltaic systems.

Although contaminating impacts are unlikely, these must be studied further to be properly mitigated [21] [22].

E. Social Study

The social approval of the project was estimated utilizing a series of surveys, using the results obtained from the technological, economic, and environmental studies from this investigation. The approval rating of the project between the 67 restaurant owners yielded an 87% positive approval rating, as shown in Figure 7:

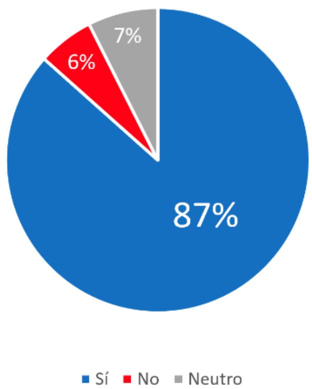

Figure 7. FPV project approval by business owners.
Source: Own elaboration

To estimate the project´s touristic attractiveness, a two-part survey was conducted. The first part involved the frequency rate in which travelers would visit Lake Yojoa and the motive for their visit, and the second part would measure the same scenarios if the floating solar system were to be implemented near the restaurants. The survey employed a total of 330 natural Honduran residents, yielding the following results:

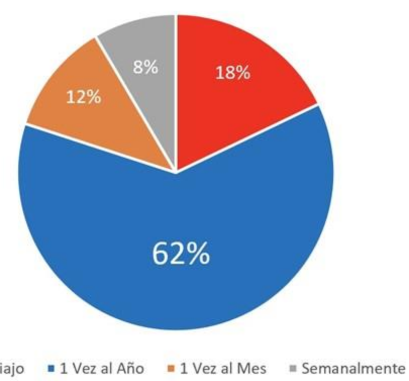

Figure 8. Visiting frequency by the public in Lake Yojoa prior to the FPV.
Source: Own elaboration

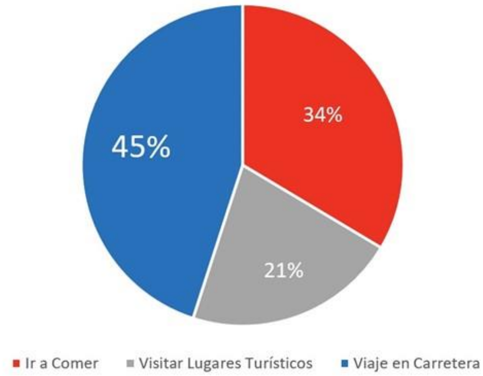

Figure 9. Reason of visit by the public in Lake Yojoa prior to the FPV.
Source: Own elaboration

Once finished with the survey, the feasibility results of the project were presented to each person being surveyed and, thereafter, they were asked to answer the survey once again, yielding the following results:

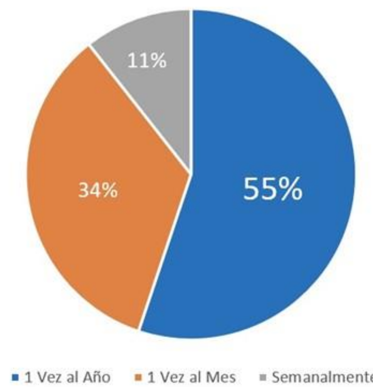

Figure 10. Visiting frequency by the public in Lake Yojoa after FPV.
Source: Own elaboration

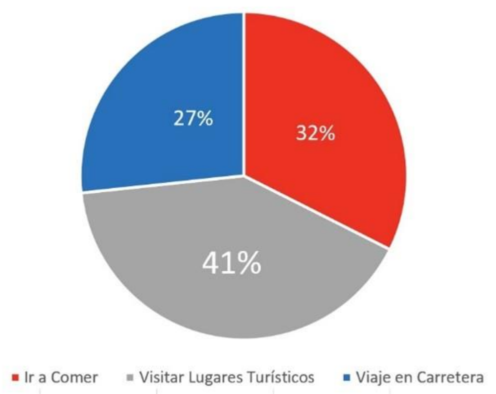

Figure 11. Reason of visit by the public in Lake Yojoa after FPV.
Source: Own elaboration

With the implementation of the floating photovoltaic project, the overall frequency of outside visitors to the area is increased, especially the frequency of tourist visits, which increases by 20%.

IV. Conclusions

This research was based on the execution of four studies: technological, economic, social, and environmental, to demonstrate the feasibility of a floating photovoltaic microgrid project to cover the electricity consumption of 67 restaurants at a lower rate compared to the SIN, economically and touristically benefiting the area of Lake Yojoa, Honduras. Based on the results obtained, the following conclusions were obtained:

- The annual synthetic electricity demand of the area is 3,363.40 MWh/year. This electricity demand can be supplied up to 40.85% by the floating photovoltaic project, injecting a maximum of 8.82% of the electricity produced to the national grid.
- There was a high acceptance of the floating solar photovoltaic project, with 87% of the members of the restaurants in Lake Yojoa, Honduras in favor of the project.
- The best photovoltaic technology to use is bifacial monocrystalline, since it can capture the reflected irradiation from the water, resulting in higher power production.
- The project's monomial tariff reduces the total cost of the energy consumed by 28.93% over the lifespan of the project, saving $10,458,235.44.
- The best flotation and anchoring technology to use is Hydrelio Air made from high density polyethylene with a parabolic anchor, thereby avoiding the installation of concrete piles and minimizing the environmental impact of the project.
- The area to be utilized by the floating solar photovoltaic project has a total of 8 thousand m^2, being sectioned into two equal parts for its better appreciation and operation.
- The environmental impacts of the project could not be precisely quantified because there is not enough information on other similar projects; however, it is possible to deduce a reduction in evaporation and water temperature because of the flotation systems.
- The two economic scenarios evaluated are both feasible, with the scenario with external financing demonstrating a better return on investment.

A limitation presented during the research was the impossibility of obtaining the real electricity demand of the node of the 67 restaurants, since it was only possible to obtain a monthly average consumption by means of surveys to the restaurants. Only 1 restaurant with the closest to average electricity consumption was taken for measurement, replication, and consumption scaling. With data from ENEE or from the distribution company in the area, it would be possible to obtain the actual electricity consumption and thus obtain a more accurate techno-economic dimensioning.

Even with this limitation, this research can be used for the decision-making process for future floating photovoltaic projects in the different watersheds of Honduras and can be used as an example of a decentralized energy generation system, which can help the transition of the national energy matrix from fossil fuels to a completely renewable energy-based energy matrix.

This type of research can be applied on a small scale, as well as to a specific community in a city or on a large scale, as well as with different cities or entire municipalities within a department and not just limited to 67 restaurants.

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References

[1] ReliefWeb, “La República de Honduras: 2020 Huracanes Eta e Iota - Llamado urgente de asistencia - Honduras | ReliefWeb,” reliefweb.int, Feb. 03, 2021. https://reliefweb.int/report/honduras/la-rep-blica-de-honduras-2020-huracanes-eta-e-iota-llamado-urgente-de-asistencia

[2] S. Carranza, “Los combustibles han subido 20 lempiras por galón este año,” www.elheraldo.hn, Sep. 13, 2021. https://www.elheraldo.hn/economia/combustibles-han-subido-20-lempiras-por-galon-este-2021-honduras-HQEH1492445 (accessed Dec. 03, 2022).

[3] Á. Mejía, “Tarifas de energía eléctrica tendrán una sustancial alza al no seguir congeladas,” www.elheraldo.hn, Oct. 03, 2022. https://www.elheraldo.hn/economia/tarifas-de-energia-electrica-tendran-una-sustancial-alza-al-no-seguir-congeladas-BH10353266 (accessed Dec. 03, 2022).

[4] L. W. Farrar, A. S. Bahaj, P. James, A. Anwar, and N. Amdar, “Floating solar PV to reduce water evaporation in water stressed regions and powering water pumping: Case study Jordan,” Energy Conversion and Management, vol. 260, no. 115598, p. 115598, May 2022, doi: 10.1016/j.enconman.2022.115598.

[5] M. R. B. Khan, J. Pasupuleti, and R. Jidin, “Technical and Economic Analysis of Floating PV System for Putra Mosque in Malaysia,” IEEE Xplore, Sep. 01, 2020. https://ieeexplore.ieee.org/document/9250936 (accessed Dec. 03, 2022).

[6] Y.-K. Choi, “A Study on Power Generation Analysis of Floating PV System Considering Environmental Impact,” International Journal of Software Engineering and Its Applications, vol. 8, no. 1, pp. 75–84, Jan. 2014, doi: 10.14257/ijseia.2014.8.1.07.

[7] S. P. Makhija, S. P. Dubey, R. C. Bansal, and P. K. Jena, “Techno-environ-economical analysis of floating PV/on-ground PV/grid extension systems for electrification of a remote area in India,” Up.ac.za, no. 40866, Apr. 2021, doi: 2199-4706 (online).

[8] F. Calderón-Vargas, D. Asmat-Campos, and A. Carretero-Gómez, “Sustainable Tourism and Renewable Energy: Binomial for Local Development in Cocachimba, Amazonas, Peru,” *Sustainability*, vol. 11, no. 18, p. 4891, Sep. 2019, doi: https://doi.org/10.3390/su11184891.

[9] E. R. Aranibar Ramos and A. J. Patiño Huayhua, “Turismo, camino hacia la sostenibilidad: una aproximación al Lago Titicaca Peruano,” *ReHuSo: Revista de Ciencias Humanísticas y Sociales*, vol. 7, no. 3, pp. 46–62, Sep. 2022, doi: https://doi.org/10.33936/rehuso.v7i3.5150.

[10] Y. Chen, Y. Li, X. Gu, N. Chen, Q. Yuan, and M. Yan, “Evaluation of Tourism Development Potential on Provinces along the Belt and Road in

China: Generation of a Comprehensive Index System," *Land*, vol. 10, no. 9, p. 905, Aug. 2021, doi: https://doi.org/10.3390/land10090905.

[11]I. Pantaleón, "Energía solar en Honduras: El país es el quinto lugar en capacidad instalada en Latinoamérica," *Forbes Centroamérica • Información de negocios y estilo de vida para los líderes de Centroamérica y RD*, Apr. 2022. https://forbescentroamerica.com/2022/04/01/energia-solar-en-honduras-el-pais-es-el-quinto-lugar-en-capacidad-instalada-en-latinoamerica (accessed Oct. 17, 2022).

[12]G. de P. Cambio e Innovación Empresarial, "Boletín Estadístico Mayo 2022 Empresa Nacional de Energía Eléctrica Gerencia de Planificación, Cambio e Innovación Empresarial Contenido," May 2022. Accessed: Oct. 17, 2022. [Online]. Available: http://www.enee.hn/planificacion/2022/junio/Boletin%20Estadistico%20MAYO%202022.pdf

[13]E. Red, "Área de Uso Múltiple Lago de Yojoa (Honduras) - EcuRed," *Ecured.cu*, 2022. https://www.ecured.cu/%C3%81rea_de_Uso_M%C3%BAltiple_Lago_de_Yojoa_(Honduras) (accessed Oct. 17, 2022).

[14]Comisión Reguladora de Energía Eléctrica, "Historial de Tarifas - CREE," *CREE*, 2022. https://www.cree.gob.hn/historial-de-tarifas/ (accessed Oct. 21, 2022).

[15]Comisión Reguladora de Energía Eléctrica, "Leyes, Reglamentos, Normas Técnicas y Procedimientos - CREE," *CREE*, 2022. https://www.cree.gob.hn/leyes-reglamentos-y-normas-tecnicas/ (accessed Oct. 25, 2022).

[16]Comisión Reguladora de Energía Eléctrica, "Informe de Ajuste Tarifario - Cuatro Trimestre 2022," *CREE*, Sep. 2022. https://www.cree.gob.hn/wp-content/uploads/2019/02/Informe-de-Ajuste-Tarifario-Oct-Dic-2022-.pdf (accessed Oct. 19, 2022).

[17]C. E. para A. L. y el C. CEPAL, "Balance Preliminar de las Economías de América Latina y del Caribe," *CEPAL Boletín Preliminar Honduras*, 2020. https://repositorio.cepal.org/bitstream/handle/11362/46501/19/BP2020_Honduras_es.pdf (accessed Oct. 17, 2022).

[18]Comisión Reguladora de Energía Eléctrica, "Aprobación de Autoproductores Acuerdo CREE 25-2022 ," *CREE*, May 06, 2022. https://www.cree.gob.hn/wp-content/uploads/2019/02/Acuerdo-CREE-25-2022-Aprobaci%C3%B3n-NT-Autoproductores-GS-LD-JM-1.pdf#:~:text=Que%20la%20Ley%20General%20de%20la%20Industria%20El%C3%A9ctrica%20establece%20la,reglamentarias%2C%20lo%20relativo%20a%20la

[19]V. Ramasamy and R. Margolis, "Floating Photovoltaic System Cost Benchmark: Q1 2021 Installations on Artificial Water Bodies," 2021. Available: https://www.nrel.gov/docs/fy22osti/80695.pdf

[20]Made-in-China, "Canadiansolar 600W Panel Bifacial Mono Perc for Solar System," *Made-in-China.com*, 2022. https://canadian-solar.en.made-in-china.com/product/dZFGwZfWNikO/China-Canadiansolar-600W-595W-590W-585W-580W-Panel-Bifacial-Mono-Perc-for-Solar-System.html (accessed Nov. 16, 2022).

[21]Aditya Anindito Widayat, Samsul Ma'arif, Kianda Dhipatya Syahindra, and Eko adhi Setiawan, "Comparison and Optimization of Floating Bifacial and Monofacial Solar PV System in a Tropical Region," *ResearchGate*, Oct. 23, 2020. https://www.researchgate.net/publication/349431459_Comparison_and_Optimization_of_Floating_Bifacial_and_Monofacial_Solar_PV_System_in_a_Tropical_Region (accessed Dec. 02, 2022).

[22]Deltares, "Floating solar energy," *Deltares*, 2020. https://www.deltares.nl/en/issues/sustainable-energy-water-subsoil/floating-solar-energy/ (accessed Oct. 24, 2022).