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Green hydrogen assessment through the cost-benefit and potential energy generation study in Honduras

Evaluación del hidrógeno verde mediante un estudio de coste-beneficio y potencial de generación de energía en Honduras

María Celeste Parada Acosta*[1], Alicia María Reyes-Duke[2], Héctor Villatoro Flores[3]

[1] EUDE Business School, Madrid, España
[2] Ingeniería en Mecatrónica, Facultad de Ingeniería, Universidad Tecnológica Centroamericana, San Pedro Sula, Honduras
[3] Ingeniería en Energía, Facultad de Ingeniería, Universidad Tecnológica Centroamericana, San Pedro Sula, Honduras

Abstract / **Introduction**. Countries around the world are establishing targets for renewable energy generation. However, they are not able to meet these targets due to the intermittency of renewable energies. Hydrogen as an energy carrier can be considered a solution for the intermittency of renewable energies because it allows energy storage, provides frequency stability to the electrical network, and decreases the dependence on fossil fuels for energy generation. This article addresses the analysis of green hydrogen potential from solar photovoltaic and wind energy from the existing renewable plants in Honduras. **Methods**. Wind and solar photovoltaic energy generation from every plant studied in this research were evaluated using data obtained from simulations. Power-to-Power hydrogen plants were sized for each plant studied. Four different scenarios were proposed to evaluate the green hydrogen potential. **Results.** In the first two scenarios, hydrogen potential from all the solar photovoltaic energy and wind energy was evaluated. In the other two remaining scenarios, the potential from the hydrogen plants with the highest cost-benefit was estimated. **Conclusion.** This work can serve as a reference for sizing hydrogen Power-to-Power plants and can be taken into consideration for future power generation expansion plans in Honduras.
Keywords Hydrogen, Natural resources, Profit, Solar energy, Wind power

Resumen / **Introducción.** Países de todo el mundo están estableciendo objetivos de generación de energías renovables. Sin embargo, no son capaces de cumplir estos objetivos debido a la intermitencia de las energías renovables. El hidrógeno como vector energético puede considerarse una solución para la intermitencia de las energías renovables porque permite almacenar energía, proporciona estabilidad de frecuencia a la red eléctrica y disminuye la dependencia de los combustibles fósiles para la generación de energía. Este artículo aborda el análisis del potencial de hidrógeno verde a partir de energía solar fotovoltaica y eólica de las plantas renovables existentes en Honduras. **Métodos.** Se evaluó la generación de energía eólica y solar fotovoltaica de cada una de las plantas estudiadas en esta investigación utilizando datos obtenidos de simulaciones. Para cada planta estudiada se dimensionaron plantas de hidrógeno de potencia a potencia. Se propusieron cuatro escenarios diferentes para evaluar el potencial del hidrógeno verde. **Resultados**. En los dos primeros escenarios, se evaluó el potencial de hidrógeno de toda la energía solar fotovoltaica y de la energía eólica. En los otros dos escenarios restantes, se estimó el potencial de las plantas de hidrógeno con mayor coste-beneficio. **Conclusiones.** Este trabajo puede servir como referencia para el dimensionamiento de las centrales de hidrógeno Power-to-Power y puede ser tomado en consideración para futuros planes de expansión de la generación de energía en Honduras.
Palabras clave Energía eólica, Energía solar, Ganancia, Hidrógeno, Recursos naturales

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Corresponding author: maria.paradaacostanv23@alumni.eude.es
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INTRODUCCIÓN

In 2019 Honduras showed reliance on reservoir hydroelectric power plants for renewable energy generation (Secretaría de Estado en el Despacho de Energía, 2020), (Fernandez, J. L. O., 2019). Thermal generation plants installed capacity represents 30% of the installed capacity in Honduras (Empresa Nacional de Energía Eléctrica, 2022) due to the need for dispatchable energy for the national electrical network. Hydrogen is the lightest element on Earth, but its energy potential is greater than the potential of other fuels such as gasoline. However, hydrogen is not found alone on the planet, it is combined with elements such as oxygen and carbon, but it can be obtained by electrolysis, which is a process that separates hydrogen and oxygen molecules from water by injecting a direct current. Green hydrogen can be obtained by renewable energy harnessing (for example wind and solar energy). This process is generating the least carbon dioxide emissions among all existing processes. For that reason, green hydrogen contributes to meeting global carbon dioxide emission reduction targets. In June 2022, the percentage of renewable capacity in Honduras was 66.3% of which 17.6% and 8.1% corresponded to solar photovoltaic and wind plants, respectively. Green hydrogen can be generated with the renewable capacity of Honduras. Various articles evaluate the green hydrogen potential from renewable sources of different countries. Ayodele and Munda analyzed the potential of green hydrogen generated from wind sources studied in five of South Africa's nine provinces (Ayodele & Munda, 2019). Huang and Liu explored the potential for green hydrogen production with solar and wind energy using an entropy method (Huang & Liu, 2020). In addition, Mason analyzed a three-year wind power surplus for green hydrogen production (Mason, Verbytska, & Miller, 2019).

Similar to the studies mentioned before, this article also evaluates the hydrogen potential from renewable sources of Honduras. With that novelty that four different scenarios for hydrogen production by sizing hydrogen Power-to-Power plants were evaluated and a cost-benefit analysis was run as a decision criterion in two of them.

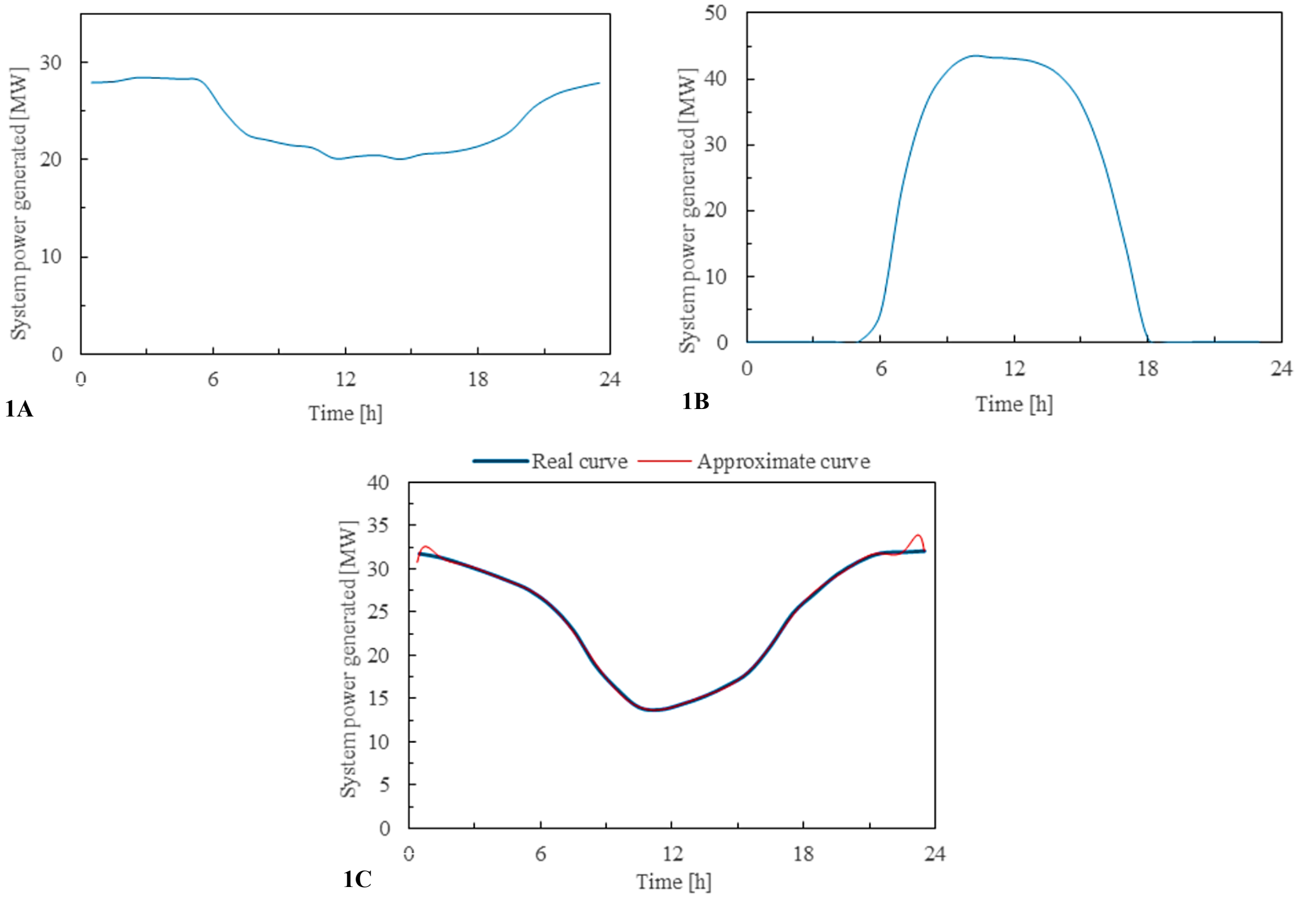

Figure 1A: Example of wind average annual system power generation profile. **1B:** Example of solar average annual system power generation profile. **1C:** Example of the approximate curve of polynomial regression.

Methods

Proposed scenarios

It has been noted that the most common economic model is the sizing of renewable plants whose total generation is destined for hydrogen production. For that reason, four scenarios were proposed to evaluate the green hydrogen potential. The scenarios presented in this article evaluate the green hydrogen and energy production potential if:

1. All the solar photovoltaic energy of sixteen existing plants in Honduras is used for hydrogen production (scenario 1).
2. All the wind energy of three existing plants in Honduras is used for hydrogen production (scenario 2).
3. Only the solar photovoltaic energy harnessed from the hydrogen Power-to-Power plant with the highest cost-benefit is used for hydrogen production (scenario 3).
4. Only the wind energy harnessed from the hydrogen Power-to-Power plant with the highest cost-benefit is used for hydrogen production (scenario 4).

It is important to mention that the first two scenarios were proposed to analyze the green hydrogen potential without an economic barrier, while the two remaining scenarios do consider this barrier.

Power generation simulations

The simulations of power generation from wind and solar photovoltaic energy were executed in System Advisor Model (SAM). The data of the installed capacity, number of photovoltaic modules, wind turbines, and other necessary details for the simulations of the solar photovoltaic and wind plants were found in decree no. 376-2013 of La Gaceta and in (Mejía, Calderón, & Flores, 2022). Once the simulations are executed, the average annual system power generation profile is exported to know the data of power generated and time. Figure 1A shows an example of an annual wind system power generation profile. Figure 1B shows an example of an annual solar photovoltaic power generation profile.

Harnessed energy calculation

For scenarios 3 and 4, each possible power of electrolyzers that is multiple of the chosen electrolyzer were analyzed to find the cost-benefit. It is essential to calculate the harnessed energy of each one of them. To estimate that harnessed energy a Riemann sum was used. Calculating the energy by drawing small rectangles with 0.1 hour of width to have a more detailed approximation of the energy.

Since the data of power and time from the simulation is not that detailed, a polynomial regression was done in GNU Octave by choosing the degree of a polynomial whose curve most closely approximates the behavior of the original curve (Fig. 1C). An equation can describe the curve found and it has the following form:

$$y=a_0x^n \pm a_1x^{n-1} \pm a_2x^{n-2} \dots a_nx+b \qquad (1)$$

Equation 1 allows finding the power at any time of the day to calculate the harnessed energy for each power of electrolyzers. For scenarios 1 and 2, the power of the electrolyzer will be the maximum power that can harness all the energy generated from the renewable plants.

Sources and water consumption

The electrolyzers consume water during the electrolysis process. Using (Secretaría de Energía, Recursos Naturales, Ambiente y Minas, 2022) and its measure tool, water sources were determined by choosing the closest water source to each renewable plant and its hydrogen Power-to-Power plant. The water consumption was determined by calculating the number of mols of water in one kilogram of water using the following equation:

$$\text{Number of mols} = \frac{mass}{molar\ mass} \qquad (2)$$

With the number of mols of water in one kilogram of water, the number of mols of hydrogen in the same amount of water can be estimated using the following equation:

$$2H_2O \rightarrow 2H_2 + O_2 \qquad (3)$$

Equation 3 shows that it is one mol of hydrogen for each mol of water. Once the number of hydrogens mols in one kilogram of water is known, the mass of hydrogen in one kilogram of water can be calculated by clearing mass in Equation 2. With that information, the amount of water needed to produce any amount of hydrogen can be calculated. Water consumption will also depend on the electrolyzer and the type of water that is going to be used. The equivalence in the type of water use is (U.S. Department of Energy, 2022):

$$1\text{ L pure water} \rightarrow 1.43\text{ L tap water} \rightarrow 3.33\text{ L seawater} \qquad (4)$$

It is important to know that electrolyzers consumed demineralized water. Lampert cited Blanco and mention that in the demineralization process the loss of water resources is about 50% (Lampert, Cai, & Elgowainy, 2016) and (Blanco, 2021).

Power-to-Power hydrogen plants sizing

Once the harnessed energy by each power of electrolyzers is calculated for scenarios 3 and 4, and the maximum power that can harness all the energy generated is determined for scenarios 1 and 2, the hydrogen Power-to-Power plants can be sized. For scenarios 3 and 4 all the different powers of electrolyzers are going to be sized. The energy consumption of the electrolyzer can be obtained from the technical datasheet of the electrolyzer to calculate the amount of hydrogen that can be produced daily. The daily storage is the same amount of hydrogen that can be produced in one day. The working time of the electrolyzer can be calculated by dividing the daily storage capacity and the hydrogen flow of the electrolyzer. Water consumption during the lifetime can be calculated by multiplying the hydrogen production in the lifetime of the plant and the water consumption of the electrolyzer per unit of hydrogen. Water storage capacity is the water consumption during the lifetime divided by the number of days of the lifetime of the plant.

The working time of the fuel cell is 12 hours, which is the night period where the energy produced by the fuel cell is going to be injected into the national electrical network. It is necessary to calculate first the amount of energy that can be produced in one day from green hydrogen. That can be calculated with the hydrogen consumption of the chosen fuel cell obtained from its technical datasheet. The power of the fuel cell can be estimated with the following equation:

$$P_{fc} = \frac{E_{daily}}{t} \qquad (4)$$

Where P_{fc} is the power of the fuel cell [MW], E_{daily} is the energy that can be produced in one day from green hydrogen [MWh], and t is the working time of the fuel cell [hour]. This analysis is applied to each renewable plant that is studied in this paper.

Cost-benefit analysis

The cost-benefit is the decision criterion for choosing the optimal sizing of the hydrogen plant for scenarios 3 and 4. It can be estimated with the following equation:

$$\textit{Cost-benefit}=\frac{B}{C} \quad (5)$$

Where B is the benefit from selling the energy at the same price that the contract of the existing renewable plant stipulates, and C is the cost, which includes the cost of investment of the hydrogen plant, operation and maintenance, water consumption, and electricity consumption from secondary equipment (hydraulic pump, compressor, and demineralizer). The cost-benefit is also calculated in scenarios 1 and 2 to analyze the economic feasibility of the hydrogen plants.

RESULTS

Using (Secretaría de Energía, Recursos Naturales, Ambiente y Minas, 2022) the water sources were determined. The results are shown in Table 1. The type of water available for electrolyzer consumption is tap water. The tap water consumption of electrolyzers per kilogram of hydrogen is 25.56 kg. The chosen electrolyzer is a John Cockerill DQ 500 which is an alkaline water electrolyzer. It was chosen because it is one of the highest powers of electrolyzers available on the market.

Table 1. Water sources.

Plant	Basin	Microbasin ID
Cerro de hula	Nacaome	2204010
Cinco Estrellas	Sampile	2101027
Cohessa	Goascorán	2305006
Chincayote	Coco/Segovia	1801017
Choluteca dos	Sampile	2101021
Choluteca uno	Sampile	2101016
Enerbasa	Choluteca	1901008
Fray Lazaro	Choluteca	1901012
Nacaome dos	Goascorán	2305011
Nacaome uno	Goascorán	2305005
Fotersa	Sampile	2101019
Helios	Sampile	2101029
Lajas	Choluteca	1903043
Llanos del sur	Choluteca	1901012
Mecer	Sampile	2101029
Marcovia	Choluteca	1901024
Los Pollitos	Chamelecon	405036
Prados sur	Sampile	2101043
San Marcos	Choluteca	1903038
Soposa	Goascorán	2305006

Based on data from Secretaría de Energía, Recursos Naturales, Ambiente y Minas (2022).

The type of water available for electrolyzer consumption is tap water. The tap water consumption of electrolyzers per kilogram of hydrogen is 25.56 kg. The chosen electrolyzer is a John Cockerill DQ 500 which is an alkaline water electrolyzer. It was chosen because it is one of the highest powers of electrolyzers available on the market.

Table 2 shows that the electrolyzer has a different water consumption than the theoretical one. Its water consumption is 10.33 kg of demineralized water which equals 29.54 kg of tap water.

Table 2. Electrolyzer, fuel cell and hydrogen tank, technical details.

Electrolyzer technical details	
Electrolyzer power [MW]	2.5
Nomila hydrogen flow [kg/day]	1068
Output pressure [bar]	30
Hydrogen density [kg/m^3]	0.08904
Hydrogen purity [%]	99.999
Energy consumption [kWh/kg H_2]	48.31
Demineralized water consumption [kg/ kg H_2]	10.33
Expected lifetime [years]	20
Fuel Cell technical details	
Fuel cell power [MW]	1
Hydrogen purity [%]	>98%
Hydrogen consumption [kg/hr]	63
Input pressure [bar]	5
Hydrogen tank tecnhical details	
Storage pressure [bar]	500
Operational temperature [°C]	-40 to 60
Hydrogen mass store at 500 bar [kg]	9.5

Table 3. Inputs of sizing and cost-benefit analysis.

Inputs	Value	Unit	Source
Electrolyzer electricity consumption	0.04831	MWh/kg H_2	Datasheet
Electrolyzer water consumption	29.54	kgH_2O / kg H_2	Datasheet
Fuel cell hydrogen consumption	63	kg H_2/MWh	Datasheet
Electrolyzer capital cost	1,000,000	$/MW	(Mahsa, et al., 2020)
Fuel cell capital cost	3,000,000	$/MW	(Mahsa, et al., 2020)
Hydrogen tank capital cost	455.00	$/ kg H_2	(Mahsa, et al., 2020)
Water tank capital cost	0.038212	$/ kg H_2O	(Crozzoli, et al., 2020)
Compressor capital cost	2,500,000	$/MW	(Crozzoli, et al., 2020)
Hydraulic pump capital cost	104.74	$	
O&M electrolyzer	2%	Of capital cost	(Chun-Ha, et al., 2009)
O&M fuel cell	2.5%	Of capital cost	(Chun-Ha, et al., 2009)
Water cost	0.00033	$/ kg H_2O	
Energy sell price	According to contract	$/MWh	Decree no. 376-2013
Inflation	1.5%		Decree no. 404-2013
Compressor electricity consumption	0.00112	MWh/ kg H_2	(Crozzoli, et al., 2020)
Demineralizer electricity consumption	0.000002	MWh/ kg H_2O	(Loyo Gómez, 2018)

A MAHYTEC hydrogen tank was chosen to store the hydrogen because of its high storage pressures. A ClearGen fuel cell from Ballard was selected because of its scalability and flexibility in cell arrangements to equal the sized fuel cell power. Table 2 shows the principal technical parameters of the MAHTEY hydrogen tank and the ClearGen Fuel Cell. As the electrolyzer needs direct current to work, an AC-DC rectifier is needed.

A horsepower (1 hp) hydraulic pump was used for filling the water tank. This power of hydraulic pump was chosen because the time of filling needs to be equal to or under twelve hours (which is the night period). Hydrogen compressors of 55 kW were used (Crozzoli, Gullo, Milanesi, Sánchez Barros, & Trivellini, 2020), due to its flow rate (it is the same as the electrolyzer). These were used to increase the energetic density of hydrofen by storing it at 500 bars in the tanks. Table 3 shows the input parameters for the sizing and cost-benefit analysis of the plants for all four scenarios.

Scenario 1

With all the solar photovoltaic energy of the sixteen studied plants, Honduras can produce 26,169,041.62 kilograms of green hydrogen with the electrolyzers and 415,381.61 MWh of energy to inject into the national electrical network in the night period with the fuel cells per year. The results of the sizing of each plant are shown in Table 4.

Table 4. Hydron Power-to-Power plant sizing for scenario.

Plant	Electrolyzer capacity [MW]	Hydrogen storage tank capacity [kg]	Fuel Cell capacity [MW]	Cost-benefit [-]
Scenario 1				
Cinco Estrellas	45.0	7,752.0	10.0	1.0398
Cohessa	47.5	8,369.5	11.0	1.0529
Choluteca dos	22.5	3,895.0	5.0	1.0403
Choluteca uno	17.5	3,068.5	4.0	1.0474
Enerbasa	17.5	3,116.0	4.0	1.0563
Nacaome dos	37.5	6,412.5	8.5	1.0353
Nacaome uno	37.5	6,412.5	8.5	1.0353
Fotersa	15.0	2,565.0	3.5	1.0337
Helios	22.5	3,648.0	5.0	1.0044
Mecer	22.5	3,648.0	5.0	1.0044
Marcovia	30	5,168.0	7.0	1.0399
Prados Sur	22.5	3,990.0	5.0	1.0542
Soposa	47.5	8,369.5	11.0	1.0529
Lajas	7.5	1,282.5	2.0	1.0343
Llanos del Sur	12.5	1,900.0	2.5	0.9676
Los Pollitos	12.5	2,175.5	3.0	1.0435
Scenario 2				
San Marcos	32.5	11,846.5	16	1.1748
Chinchayote	35	11,932.0	16	1.1462
Cerro de Hula	52.5	22,838.0	30	1.2478
San Marcos	32.5	11,846.5	16	1.1748
Scenario 3				
Cinco Estrellas	2.5	714	1	1.3241
Cohessa	2.5	715	1	1.3247
Choluteca dos	2.5	703	1	1.3154
Choluteca uno	2.5	693	1	1.3075
Enerbasa	2.5	693	1	1.3079
Nacaome dos	2.5	718	1	1.3275
Nacaome uno	2.5	718	1	1.3275
Fotersa	2.5	684	1	1.3000
Helios	2.5	700	1	1.3133
Mecer	2.5	700	1	1.3133
Marcovia	2.5	712	1	1.3229
Prados Sur	2.5	720	1	1.3290
Soposa	2.5	715	1	1.3247
Lajas	2.5	634	1	1.2578
Llanos del Sur	2.5	665	1	1.2850
Los Pollitos	2.5	689	1	1.304
Scenario 4				
San Marcos	15	7,429	10.0	1.2968
Chinchayote	12.5	6,184.5	8.0	1.2968
Cerro de Hula	25	12,369.0	16.5	1.2981

Scenario 2

With all the wind energy of the three studied plants, Honduras can produce 17,013,024 kilograms of green hydrogen with the electrolyzers and 270,048 MWh of energy with the fuel cells to inject into the national electrical network in the night period annually. The results of the sizing of each plant are shown in Table 4.

Scenario 3

All the plants sized in this scenario show their higher cost-benefit in the lowest electrolyzer power (2.5 MW). This is explained by Equation 6.

$$\text{Cost-benefit}=\frac{k_0}{k_1\cdot\frac{\text{Installed Power}_e}{\text{Harnessed energy}_e}+1} \tag{6}$$

Where k_0 is a constant from the selling price of the energy, the energy consumption of the electrolyzer, and the hydrogen consumption of the fuel cell. k_1 is a constant from the specific capital cost of the installed power of the electrolyzer, the operation and maintenance cost, and the price of the compressor. Installed Power is the installed power of the electrolyzer, and harnessed energye is the harnessed energy by the electrolyzer from the renewable plant. The relation between installed power and harnessed energy can be described as specific performance. In this scenario, the specific performance decreases when the electrolyzer power increases as shown in Figure 2A.

The explanation of the decreasing specific performance is: Since specific performance can be considered as the useful working time of the plant, Figure 2B shows an example of the working time of the plant with the highest electrolyzer power. The x-axis of the shaded area shows the hours in which the highest power of electrolyzers is not working. As a result, the specific performance of the highest electrolyzer power is lower in comparison with the specific performance of the lowest electrolyzer power. To appreciate that, Figure 2C shows that the x-axis of the shadow area is smaller than the one studied in Figure 2B. This means that the lowest electrolyzer power works more useful hours than the highest power electrolyzer.

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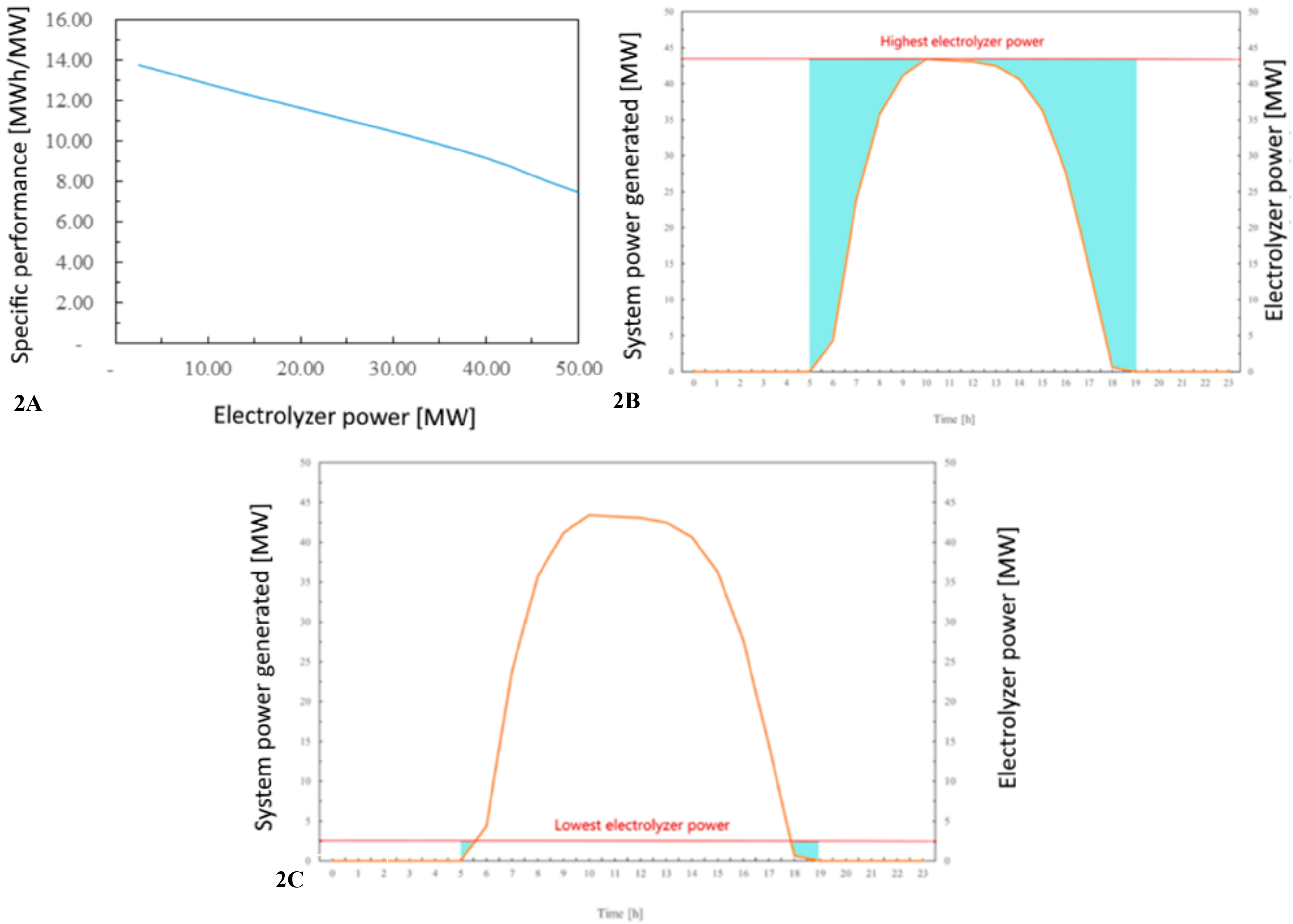

Figure 2A: Example of specific perfomance versus electrolyzer power curve. **Figure 2B:** Example of the specific performance at the highest electrolyzer power. **Figure 2C:** Example of the specific performance at the lowest electrolyzer power.

For this reason, the highest cost-benefit happens at the lowest electrolyzer power (it has the highest specific performance). The annual hydrogen potential with only the solar photovoltaic energy harnessed from the hydrogen Power-to-Power plant with the highest cost-benefit is 4,075,154.26 kilograms of green hydrogen with electrolyzers and 64,684.99 MWh of energy to inject into the national electrical network in the night period with fuel cells. The results of the sizing of each plant are shown in Table 4.

Scenario 4

The hydrogen potential with only the wind energy harnessed from the hydrogen Power-to-Power plant with the highest cost-benefit is 9,480,102.46 kilograms of green hydrogen with the electrolyzers and 150,477.82 MWh of energy to inject into the national electrical network in the night period with the fuel cells per year. The results of the sizing of each plant are shown in Table 4

The efficiency of the plants is 32.86% due to the multiple conversion process the energy is being to. This efficiency is accurate according to (International Renewable Energy Agency [IRENA], 2019) and (Zúniga-Paguada, 2019) which shows that the efficiency of hydrogen Power-to-Power plants it is around 29%.

CONCLUSION

Four scenarios for green hydrogen potential in Honduras were evaluated. The scenario with the highest amount of green hydrogen and energy produced was scenario 1 which evaluates the green hydrogen potential from all the solar photovoltaic energy of the existing plants in Honduras which is 26,169,041.62 kilograms of green hydrogen and 415,381.61 MWh of energy per year. Following scenario 1, it is scenario 2. In scenario 2 Honduras can produce 17,013,024 kilograms of green hydrogen and 270,048 MWh of energy per year. Scenarios 3 and 4 show the highest cost-benefit but the lowest green hydrogen and energy potential of the four scenarios: with a green hydrogen potential of 4,075,154.26 kilograms of green hydrogen and 64,684.99 MWh of energy for scenario 3, and 9,480,102.46 kilograms of green hydrogen and 150,477.82 MWh of energy for scenario 4.

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Authors' contribution

All authors participated in the conception and preparation of the manuscript and approved the final version.

Conflicts of interest

The authors declare that they have no conflicts of interest.

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It was used for text editing.

REFERENCES

Ayodele, T. R., & Munda, J. L. (2019). *Potential and economic viability of green hydrogen production by water electrolysis using wind energy resources in South Africa*.

Blanco, H. (2021, July 22). *Hydrogen production in 2050: How much water will 74 EJ need? Energy Post*. https://energypost.eu/hydrogen-production-in-2050-how-much-water-will-74ej-need/ (Consultado el 23 de julio de 2022)

Chun-Ha, L., Xin-Jian, Z., Guang-Yi, C., Sheng, S., & Ming-Rou, H. (2009). *Dynamic modeling and sizing optimization of stand-alone photovoltaic power systems using hybrid energy storage technology*.

Crozzoli, P., Gullo, F., Milanesi, J., Sánchez Barros, A., & Trivellini, L. (2020). *Análisis de prefactibilidad de una planta productora de hidrógeno*. Instituto Tecnológico de Buenos Aires.

Empresa Nacional de Energía Eléctrica. (2022). *Boletín estadístico: Junio 2022*.

Fernandez, J. L. O., Avila, J. L. O., & Ordoñez, R. A. (2019). Potential effect on the energetic matrix of Honduras with the installation of residential photovoltaic generators for self-consumption. 2019 *IEEE 39th Central America and Panama Convention (CONCAPAN XXXIX)*, 1–6. IEEE. https://doi.org/10.1109/CONCAPANXXXIX47272.2019.8976994

Huang, Y., & Liu, S.-J. (2020). *Chinese green hydrogen production potential development: A provincial case study*. IEEE. International Renewable Energy Agency (IRENA). (2019). *Hydrogen: A renewable energy perspective*.

Lampert, D., Cai, H., & Elgowainy, A. (2016). *Wells to wheels: Water consumption for transportation fuels in the United States*.

Loyo Gómez, M. de L. (2018). *Reporte final de estadía*.

Mahsa, D., Campana, P., & Thorin, E. (2020). *Power-to-hydrogen storage integrated with rooftop photovoltaic systems and combined heat and power plants*.

Mason, I. G., Verbytska, A., & Miller, A. J. V. (2019). *Using surplus electricity to produce green hydrogen*.

Mejía, A., Calderón, N., & Flores, W. (2022). *Mapa de generación renovable en Honduras*. Observatorio de Energía de UNITEC.

Secretaría de Energía, Recursos Naturales, Ambiente y Minas. (2022). *Agua de Honduras*. https://aguadehonduras.gob.hn/ (Consultado el 15 de julio de 2022)

Secretaría de Estado en el Despacho de Energía. (2020). *Balance energético nacional*.

U.S. Department of Energy. (2022). *Electrolyzers water consumption*.

Zúniga-Paguada, C., & Reyes-Duke, A. M. (2025). Potential and economic feasibility of green hydrogen production from hydropower in Honduras. *E3S Web of Conferences*, 629, Article 05007. https://doi.org/10.1051/e3sconf/202562905007