Hydrogen electrolyte potential of the Abanico hydroelectric power plant located in the province of Morona Santiago (228-24)

E. Barragán-Escandón (1), S. Arostegui-Gutierrez (1), E. Zalamea-León (2)
X. Serrano-Guerrero (1)
Energy Transition Research Group, Universidad Politécnica Salesiana, Cuenca, Ecuador, 010103.
(1) Facultad de Arquitectura y Urbanismo, Universidad de Cuenca, 0101168
Phone: +593984843054, e-mail: jserranog@ups.edu.ec

1. Introduction

A key strategy for optimizing the utilization of clean energy sources involves integrating energy vectors to effectively manage surplus power generated from renewable sources. This study specifically delves into the assessment of a hydrogen (H_2) generation project utilizing energy generated by the Hidroabanico power plant.

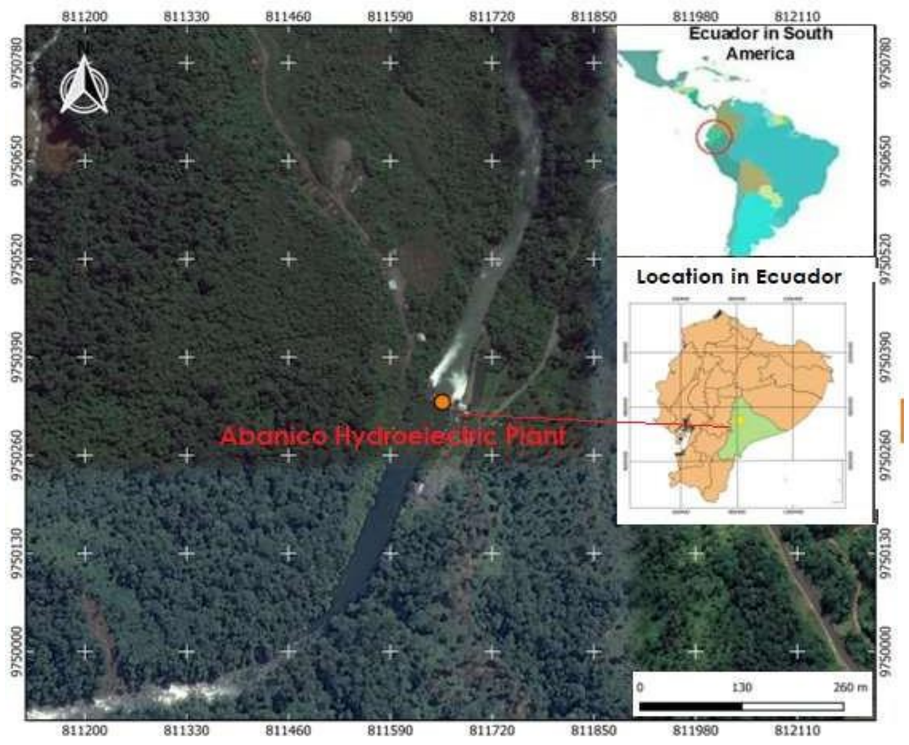

Fig 1. Power plant location

2. Methodology

The company Hidroabanico has requested that 20% of the hydraulic energy entering the plant be used for the production of H_2.

2.1 Data acquisition

The information was collected using PowerLogic ION8600 billing metering units as the primary meter and the ION8650 backup meter. Monthly production values were analyzed from 2008 to 2021. The average energy consumption for each month was calculated, and subsequently, it was determined that 20% of this energy could be converted into H2 [13].

2.2 H_2 production through PEM electrolyzer

The green hydrogen is obtained from renewable energy sources, with solar and wind energy being the cleanest options. In this study, parameters from a PEM electrolyzer were employed due to the significant advantages offered by this technology. These systems are modular in nature, facilitating their transportation and installation [10]. This technology can operate at high current densities and voltages, producing H_2 of exceptionally high purity, reaching levels of up to approximately 99%.

A PEM electrolyzer is fed by hydroelectric power. This energy enters a rectifier for AC to DC transformation. After the rectification of the current, it enters the electrolyser. Inside this device the molecular splitting of H2O takes place. The water enters the anode where electrolysis takes place releasing H+ ions, which pass through the membrane forming molecular H_2. After this, the gas is accumulated at the cathode to be stored [16].

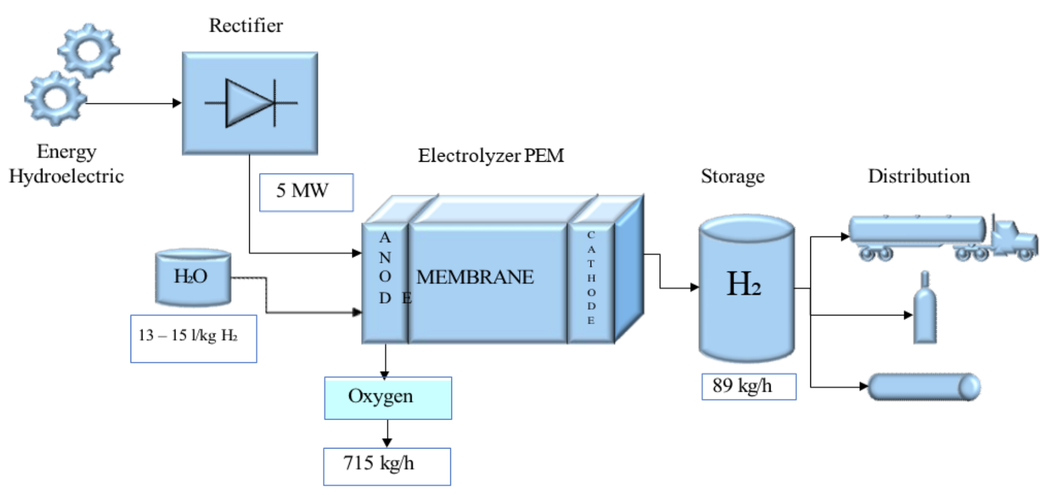

Fig. 2. Schematic diagram for green H_2 production

The calculations used parameters from a 5 MW ANDRITZ pilot power plant, which can produce 89 kg/h of hydrogen at 30 bar pressure. The system requires 13 to 15 liters of impurity-free water to ensure H2 purity. The hydrogen quantity is calculated from equation (1).

$$H_2 = \frac{E * n}{E_2} \qquad (1)$$

Where:

E is the electrical energy consumed MWh
n is the rectifier efficiency (90 %)
Ee is the efficiency of the process converting energy into hydrogen (0.05 MWh/kg of H2)

3. Results and Discussion

3.1 H2 Production

The electricity generation averages 312195 MWh per year. The 20% of this production reaches 62439 MWh/year.

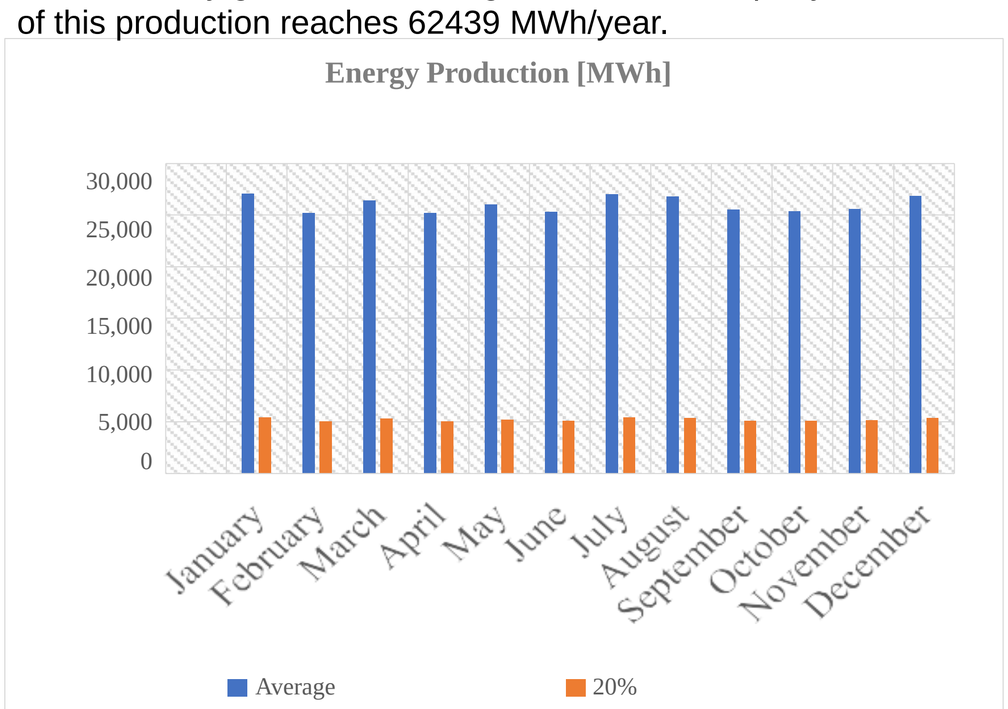

Fig 3. Average power plant production

In the context of this research, it was possible to determine a total amount of hydrogen production of 1,123 tons of hydrogen per year. However, this quantity of hydrogen is 2.8 times smaller than what could be obtained by utilizing photovoltaic panels in urban areas, as indicated in [18].

3.2 Hydrogen uses

One of the most promising and significant advances in the quest for a cleaner, more sustainable future lies in the development of H_2 fuel cell-powered vehicles.

3.3 Cost analysis

For the Andes region, a price between $6.39 - 8.60 per kg of H_2 generated was estimated. The price of electricity produced by Hidroabanico is fixed at 0.047 USD/kWh. Regardless of electrolyzer, the average costs for the implementation of a 1MW power unit vary significantly from $450/kW for alkaline technologies to $870/kW for PEMs. There are no H_2 plants in the region or in Ecuador.

3.4 Discussion

The production cost in Ecuador of H2 is 1.77 $/kg [28], considering the average cost of electricity, water, supplies, electrifier, annual investment, and operation and maintenance. This would be around 2 million dollars for the analyzed project.

4. Conclusions

The evaluation of green hydrogen generation from the Hidroabanico hydroelectric power plant shows promising results. Over 13 years, we determined a monthly average of electricity generation, using 20% for hydrogen production. We propose a PEM electrolyzer by its capacity for high-purity hydrogen production. The calculation of hydrogen production resulted in a total of 1,123 Tn/year.

Ecuador still has significant untapped hydroelectric potential, which could also translate into a capacity as a hydrogen (H2) producer. Therefore, it is necessary to analyze this energy vector as part of the national energy transition.