Energy Transition in Bahia: Development of Renewable Energy and the Potential for Green Hydrogen Production.

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Abstract: This article analyzes the development of renewable energy in the state of Bahia and its potential for green hydrogen (H2V) production within the context of the global energy transition aimed at reducing greenhouse gas emissions. The research uses a methodology based on document review, technical analysis, and integration of data from official and specialized sources, including the H2V Bahia Atlas and Decree No. 21,200/2022, which established the State Plan for the Green Hydrogen Economy. The study highlights Bahia's leadership in wind and solar energy generation in Brazil, as well as its strategic assets, such as the Camaçari Industrial Complex, port and road infrastructure, and ongoing railway projects, such as the FIOL and the FCA renovation. These factors, combined with favorable geographic conditions and legal certainty, position Bahia as a competitive hub for attracting national and foreign investment in the H2V chain. The results highlight that the development of this sector requires a comprehensive strategy that includes logistics infrastructure, workforce training, research and development, a carbon credit market, and international cooperation. The conclusion is that Bahia has the potential not only to lead the production of green hydrogen in Brazil but also to take advantage of this new economic cycle as a driver of regional development, reindustrialization, and sustainable economic growth.

Keywords: Energy transition, Renewable energy, Green hydrogen, Bahia, Infrastructure.

1. Introduction.

This paper aims to provide a brief analysis of the development of renewable energy in the state of Bahia and the potential for green hydrogen production within the context of the energy transition process aimed at reducing greenhouse gas emissions into the atmosphere.

To this end, we initially sought to demonstrate the global challenge of the energy transition, which aims to reduce greenhouse gas emissions, especially CO2, by replacing fossil fuel-based energy consumption with renewable sources.

Subsequently, the work addresses the Brazilian panorama of investments in renewable energy infrastructure, especially wind and solar in the Northeast region, and the potential for Green Hydrogen production - H2v, with a concentrated focus on the State of Bahia, given the leadership in the production of renewable energy by this subnational entity revealed by the data presented.

Finally, the work concludes by demonstrating the opportunity of the potential of the H2v industry within the Bahian energy transition process, highlighting the need to adopt strategic planning to take advantage of this economic cycle in promoting sustainable economic and social development in the regions where it is implemented.

2. Methodology

This work was prepared using a methodology based on documentary research, technical analysis, and data integration from official and specialized sources. The objective was to present an overview of the role of the State of Bahia in the development of the Green Hydrogen (H2V) production chain within the context of the energy transition. The main procedures adopted were: (i) review of literature and official sources; (ii) analysis of structural and logistical data; (iii) prospective analysis and analysis of economic and social impacts; (iv) integrated and well-founded writing.

Regarding the review of literature and official sources, scientific articles referenced on the topic were researched, and documents and technical studies from recognized institutions were analyzed, including the Atlas H2V Bahia (2023), prepared by the Government of the State of Bahia in partnership with SENAI CIMATEC, to identify areas suitable for H2V production, generation potential and mapping of existing infrastructure, as well as State Decree No. 21,200/2022, which institutes the State Plan for the Green Hydrogen Economy, providing legal security and strategic guidelines for the sector, and data from the National Energy Balance (EPE/MME) and the National System Operator (ONS) on the Brazilian energy matrix and renewable energy generation in Bahia.

During the structural and logistical data analysis phase, infrastructure data available in the H2V Atlas and government sources were considered, focusing on: (i) port, rail, and road networks for H2V production flow; (ii) existing industrial structure at the Camaçari Petrochemical Complex; and (iii) potential for logistics integration and export, and innovation.

In the prospective analysis and economic and social impacts, the potential effects of the H2V chain on green reindustrialization and the role of the Camaçari Petrochemical Complex, the generation of qualified jobs and workforce training, and the strengthening of the green economy of exports from the state of Bahia were considered.

Finally, based on the analysis of the collected data, the integrated and well-founded writing phase was completed, with the preparation of a technical and structured text, integrating regulatory, economic, logistical and environmental aspects, in order to present a strategic vision of Bahia as a protagonist in the development of the Green Hydrogen chain.

3. The Development of Renewable Energy in Brazil and the Challenge and Opportunities of the Energy Transition – A Brief Analysis of this Process in the State of Bahia.

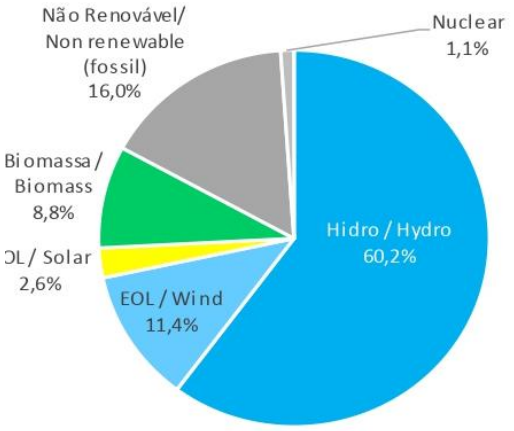
Currently, one of the greatest global challenges involves reducing CO2 emissions into the atmosphere until a global carbon-zero policy is achieved. To achieve this goal, it is necessary to change the way the planet consumes energy.

In this sense, developing and implementing energy transition policies, in order to migrate consumption from fossil fuels to renewable sources, has proven to be an effective path adopted by some developed countries to enable the decarbonization of the economy.

Germany has proven to be a country committed to this purpose, not only doing its homework[1], but also supporting developing countries in this agenda, by investing funds in decarbonization solutions to be adopted in the industrialization process of these countries, and in the conservation of their natural resources.

In this context, the Brazilian industrial market, in recent years, connected with global trends, has begun to demand investments in renewable energy infrastructure, such as photovoltaic, wind, and more recently, green hydrogen.

According to data from the National Energy Balance of 2022 / Base Year 2021, from the Ministry of Mines and Energy[2], the Brazilian electricity matrix is composed of more than 80% (eighty percent) of energy from renewable sources:



The northeastern region of Brazil, due to its natural characteristics marked by long periods of sunshine and strong and constant winds, has become the largest renewable energy generating hub in the country.

According to the National System Operator (ONS), the unprecedented generation of 16,656MW of wind energy was verified in the northeast region on October 19, 2022, and on July 21, 2022, and on February 12, 2023, the unprecedented generation of 3,726MW of solar energy was verified[3]:

Recordes de Geração Eólica e Solar

Data de referência do recorde
01/01/2026

Fonte	Subsistema	Período	Instante	Recorde de Geração (MWmed)	% da carga atendida pela fonte	Fator de Capacidade
Eólica	SIN	Horário	15/10/2022 23:00	18.458	27,54%	80,06%
		Diário	15/10/2022	16.045	24,48%	69,59%
		Mensal	Outubro/2022	13.062	19,02%	55,95%
	Norte	Horário	22/08/2021 08:00	424	7,51%	99,54%
		Diário	04/09/2021	413	6,70%	96,97%
		Mensal	Novembro/2019	335	5,88%	78,72%
	Nordeste	Horário	19/10/2022 22:00	16.656	124,65%	80,53%
		Diário	11/10/2022	14.722	120,51%	71,18%
		Mensal	Outubro/2022	11.898	102,38%	56,73%
	Sul	Horário	07/09/2021 19:00	1.875	14,15%	96,34%
		Diário	07/09/2021	1.796	16,96%	92,29%
		Mensal	Abril/2020	845	8,23%	43,40%
Solar	SIN	Horário	02/06/2023 11:00	17.543	22,79%	181,69%
		Diário	02/06/2023	5.445	7,45%	56,39%
		Mensal	Maio/2023	4.855	6,84%	50,29%
	Nordeste	Horário	09/05/2023 10:00	6.041	47,57%	109,42%
		Diário	08/05/2023	2.055	16,78%	37,23%
		Mensal	Maio/2023	1.732	14,48%	31,37%
	Sudeste/Centro-Oeste	Horário	05/05/2023 11:00	8.540	18,42%	214,51%
		Diário	05/05/2023	2.631	6,11%	66,08%
		Mensal	Maio/2023	2.324	5,84%	57,24%

In this scenario, the state of Bahia, in turn, leads the generation of renewable energy in Brazil. According to data from the Electric Energy Commercialization Chamber (CCEE), whose information is contained in the Executive Report of the Secretariat of Economic Development, the State of Bahia has led the national generation of wind and solar energy since 2017.[4]

This fact places this State as a great potential recipient of investments for the production of green hydrogen, considering that for obtaining the green seal for this type of energy to be viable, its production must be supported by a renewable energy source.

However, for the State of Bahia to be able to induce the efficient allocation of resources arising from investments in the production of green hydrogen, it is necessary to develop a strategic plan capable of taking advantage of this new economic cycle that shows promise in favor of generating economic growth with income distribution, that is, the economic and social development of the regions that will receive these investments.

This strategic planning must be based on concrete actions that enable the following factors: 1) Stimulating the implementation of the complete green hydrogen production chain; 2) Promoting the logistical and industrial infrastructure necessary to enable the production and distribution of green hydrogen and its value-added derivatives; 3) Stimulating competition among companies operating in the green hydrogen production chain; 4) Training and valuing the local workforce; 5) Implementing a carbon credit market; 6) Policy for access to green credit; 7) Stimulating research, development, and innovation; 8) International cooperation with technology transfer; 9) Integration between the government, companies, academia, organized civil society, and communities impacted by the green hydrogen industry; and 10) Regulation that provides legal certainty for investments and fosters the green hydrogen industry based on the factors listed above.

In this sense, on March 3, 2022, the State of Bahia issued Decree No. 21,200[5], which institutes the State Plan for the Green Hydrogen Economy - PLEH2V, "aiming to promote, strengthen and consolidate the production, processing and use, as well as scientific-technological research and innovation associated with these, of green hydrogen as a raw material in industrial processes and as an energy input in the various sectors of the economy, in particular in industry, urban mobility and transport, aiming at the implementation, modernization and diversification of enterprises and the consolidation of the green hydrogen production chain in the State."

This legislation therefore created the State Plan for the Green Hydrogen Economy (PLEH2V),

providing legal certainty, strategic guidelines, and incentives to attract investment in this new energy sector. It is worth noting that the Plan aims not only to promote the production and use of H2V in the industrial and logistics sectors, but also to foster research, development, and innovation, with direct support from science and technology institutions.

In this context, the State of Bahia entered into a partnership with Senai Cimatec University to develop the H2V Bahia Atlas, published in 2023[6]. This document is a milestone in the state's strategic territorial planning, identifying priority areas suited to the production of green hydrogen based on technical criteria such as: (i) wind potential greater than 7 m/s at an altitude of 150 m; (ii) high global horizontal solar irradiation (>2,000 kWh/m2/year); (iii) surface and groundwater availability; (iv) proximity to electrical, logistical, and industrial infrastructure; (v) low overlap with protected or restricted areas.

Based on multi-criteria modeling (AHP), the Atlas estimated that Bahia has the potential to produce more than 60 million tons of H2V per year, placing the state among the most competitive in the world in this emerging sector.

Stimulated by this favorable scenario for the implementation of the green hydrogen chain in the state of Bahia, a partnership signed between Senai Cimatec University and the company Galp, through its affiliate Petrogal Brasil, promoted by resources from the National Petroleum Agency (ANP) and the Brazilian Company for Industrial Research and Innovation (EMBRAPII), will enable the implementation of a green hydrogen pilot plant for research and innovation in Bahia, involving the green hydrogen value chain.[7]

It is no coincidence that Bahia has been the scene of interest from national and foreign investors who are evaluating the installation of green hydrogen production plants, as demonstrated by the partnership signed between the petrochemical company Unigel and the German group Thyssenkrupp, for the installation of the first plant producing this type of energy in Brazil, in the Camaçari Industrial Complex - Bahia, an initiative that, due to the financial crisis in which the company Unigel ended up being involved later, in 2024, and which led to its request for judicial recovery, has not yet been implemented [8] [9].

Regarding the logistical infrastructure required to handle the flow of green hydrogen production and its value-added derivatives, Bahia has some consolidated assets and others in the design, construction, and consolidation phase.

The port infrastructure is composed of the public ports of Aratu-Candeias with direct road connection to the Camaçari Petrochemical Complex, the Port of Salvador which is connected by the BR-324 highway, and the Port of Ilhéus located in the south of Bahia, whose

main highway is the BR-415, which moved in the year 2024 cargoes of the order of 6,564,648 (six million, five hundred and sixty-four thousand, six hundred and forty-eight) tons, 6,997,113 (six million, nine hundred and ninety-seven thousand, one hundred and thirteen) tons, and 232,287 (two hundred and thirty-two thousand, two hundred and eighty-seven) tons, respectively, adding up to a total cargo movement of the order of 13,794,048 (thirteen million, seven hundred and ninety-four thousand, and forty-eight) tons[10], without the capacity being exhausted.

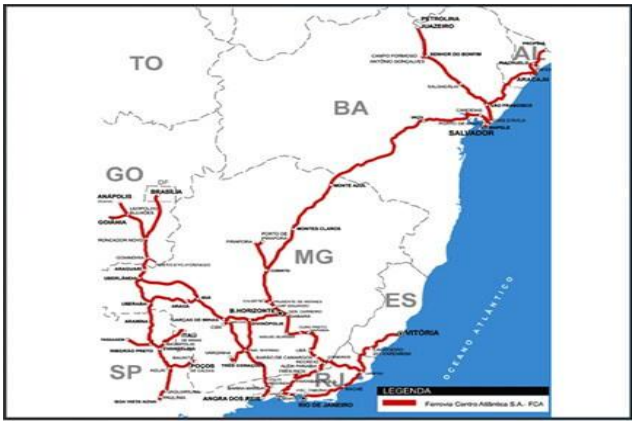
In fact, a new sea route was recently launched that will connect the Port of Gaolan located in the city of Zhuhai in China, to the Port of Salvador, reducing travel time by up to 30 days and, consequently, reducing freight by more than 30% (thirty percent).[11]

In addition, Bahia still has seven Private Use Terminals (TUPs) that in 2023 handled around 28.8 million tons of cargo, namely: (i) Gerdau Aços Longos TUP; (ii) Cotegipe Port Terminal (TPC); (iii) Dow Aratu Bahia Maritime Terminal; (iv) Miguel de Oliveira Port Terminal (former Ford port); (v) Bahia LNG Regasification Terminal (TRBA); (vi) Madre de Deus Waterway Terminal (TEMADRE), and (vii) Enseada Shipyard[12].

Regarding road infrastructure, Bahia has an extensive network, with emphasis on BRs-324, 101, 116 and 407, which connect industrial hubs, production areas and the aforementioned port terminals.

Bahia's railway infrastructure, however, lacks investment in its modernization and expansion.

The Ferrovia Centro Atlântica (FCA)[13], despite being an important logistics hub connecting the Southeast, Northeast, and Central-West regions of Brazil, with a significant section in Bahia that runs from the city of Corinto in Minas Gerais to the Port of Aratu-Candeias in Bahia, is outdated. This railway is operated through a concession operated by the company VLI that expires in August 2026. The renewal process is currently underway, and it foresees investments of nearly R$24 billion in refurbishment and the acquisition of new locomotives, aiming to improve safety and increase capacity. Therefore, the expectation is that by 2026 a definition will be made regarding the investments that will be made in this railway network.



Furthermore, construction is underway on the approximately 1,527-km West-East Integration Railway (FIOL), which will connect the future Porto Sul in Ilhéus, Bahia, to the city of Figueirópolis in the state of Tocantins, where it will connect with the North-South Railway. This project has significant potential to expand the Brazilian railway network, directly impacting the Bahian economy, given that approximately two-thirds of its route runs through the state of Bahia. Construction on the 537-km section between Ilhéus and Caetité, which is approximately 75% (seventy-five percent) complete, was halted in March 2025 by Bahia Mineração (BAMIN), the concessionaire for this section. The second section between the city of Caetité and the city of Barreiras, 485 km long, which is under the responsibility of the state-owned company Infra S.A., is currently approximately 66% (sixty-six percent) complete[14], while the third section, which connects the city of Barreiras to the city of Figueirópolis in the state of Tocantins, is in the study and design phase. The completion of this project is essential to expand the route for the flow of green hydrogen production in Bahia.

Finally, regarding industrial infrastructure, the Camaçari Industrial Complex represents a strategic asset for the H2V chain in Bahia. It is the largest integrated refining and petrochemical hub in Latin America, with chemical, fertilizer, fuel, and plastics industries, many of which could replace fossil fuels with H2V and green derivatives, such as green ammonia, green methanol, and SAF (Sustainable Aviation Fuel). This hub already has an interconnected pipeline infrastructure for transporting and processing energy inputs that can be adapted for green hydrogen.

According to data from COFIC – Camaçari Industrial Development Committee, the Camaçari Industrial Hub accounts for 22% of the GDP of the manufacturing industry in the State of Bahia, with an installed capacity of over 12 million tons/year of basic, intermediate and final chemical and petrochemical products, and an installed capacity for 240,000 tons/year of electrolytic copper, in the copper metallurgy segment, and 250,000 vehicles/year in the automotive segment, accounting for 15% of the total exported by the state of Bahia[15].

Therefore, the synergy with the Camaçari Industrial Hub can add value to the production chain, enable the use of H2V as a raw material and contribute to the so-called green neo-industrialization with a focus on decarbonization, competitiveness, innovation and export.

4. Conclusion

As demonstrated in this work, the need to migrate energy consumption based on fossil fuels to renewable sources is a global challenge in favor of reducing greenhouse gas emissions and controlling the phenomenon of global warming.

Brazil, with its energy matrix predominantly composed of renewable energy sources, is becoming an important global player in this energy transition process and should seek to adopt strategic public policies, especially in the Northeast states, with the aim of taking advantage of national and foreign investments in this sector of the economy, aiming to generate sustainable economic and social development in these regions.

One sector that is proving promising is the green hydrogen production chain, in which the state of Bahia has been standing out in the development and implementation of a strategic plan based on the promotion of regulation, research, development and workforce training, and logistical and industrial infrastructure, aiming to enable the emergence and structuring of this economic chain.

The enactment of Decree 21,200/2022, which establishes the State Plan for the Green Hydrogen Economy – PLEH2V, even before the enactment of national legislation on this matter (Law 14,948/2024), the partnership signed with Senai Cimatec University for the preparation of the Green Hydrogen Atlas, among other technological and workforce training projects, the use of federal investments already underway in the West-East Integration Railway (FIOL), and the upcoming Centro Atlantic Railway, and the existence of the Camaçari Industrial Hub, are factors that place the State of Bahia as a potential candidate to lead the production of green hydrogen in Brazil, and thus, be the main stage for attracting national and foreign investments from companies that will operate in this promising economic sector.

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