

# The Projection Of The State Of Ceará On The International Stage Through FIEC In The Production And Exportation Of Green Hydrogen And Its Impact On Socioeconomic Development In Ceará

Márcio Carneiro Barbosa, Rickardo Léo Ramos Gomes

(Bachelor's Degree In Foreign Trade Technology – UNISUL; Postgraduate MBA In Renewable Energy Management – Fbuni/IEL; Postgraduate Degree In Higher Education Teaching – UFRJ; MBA In Business Logistics – FGV; M.Sc. In Military Sciences – Brazilian Army Command And General Staff College.), (Honorary Doctorate In Biological Sciences; M. Sc. In Phytotechnics – Federal University Of Ceará – UFC; Specialist In Science Teaching Methodology – State University Of Ceará - UECE). Corresponding Author: Rickardo Léo Ramos Gomes

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## Abstract:

**Background:** The beginning of the 21st century presents the international community with a tumultuous global environment characterized by instability and uncertainty. Global warming and the decarbonization of the economy are among the challenges that many countries have prioritized by increasing renewable energy sources in their energy matrices. Strengthening international relations, Ceará, due to its geographical location and favorable natural conditions of sun and wind, emerges as a promising player to contribute to global energy demands through hydrogen production and exportation.

**Materials and Methods:** This research focuses on examining the initiatives led by the Federation of Industries of the State of Ceará (FIEC) in the production and exportation of green hydrogen, aiming to understand their potential impact on the state's position in the international arena and the associated benefits.

**Results:** The research evaluates the socioeconomic effects of these initiatives on Ceará, revealing that the ongoing actions have the potential to strengthen the state's economic and social structures. These improvements could contribute to a more equitable, sustainable, and inclusive society.

**Conclusion:** The initiatives related to green hydrogen production and exportation under FIEC's leadership promise not only to support national energy security but also to elevate the quality of life for the people of Ceará, enhance the educational system, and secure the state's role in the global energy transition.

**Keywords:** International Relations; Renewable Energies; Energy Transition; Green Hydrogen.

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## I. Introduction

According to analyses of the international scenario, the early 21st century has been marked by a tumultuous, multipolar global environment, characterized by instability and uncertainty. Contributing factors to this scenario include the global financial crisis (2008), the COVID-19 pandemic (2020), the war between Russia and Ukraine (2022), and the conflict between Israel and Hamas (2023).

Alongside these events, climate crises have also emerged, evidenced by rising global average temperatures (due to greenhouse gas emissions), droughts in arable regions, urban flooding, polar ice melt, and rising ocean levels. To address these challenges, various countries have prioritized, for instance, decarbonizing their economies and increasing the use of renewable energy sources. As a result, new global policies have arisen to accelerate the energy transition, with green hydrogen as a key fuel. In this global context, the state of Ceará emerges as a potential solution in the race for worldwide energy transition.

The region's favorable physiographic factors, such as optimal climate conditions, contribute to this potential. Its coastal area has a continental shelf that offers advantageous land-sea connections, and its location in the most eastern part of South America, known as the Northeastern Promontory, shortens distances to Europe, Africa, and North America. Additionally, the Federation of Industries of the State of Ceará (FIEC) stands out as an essential player in promoting and strengthening energy transition policies and decarbonizing the economy on the international stage.

The concept of International Relations is crucial to Ceará's projection on the world stage, and cooperation between FIEC, foreign institutions, and governments will be necessary by 2050 to overcome the challenges and uncertainties of the global energy transition. Thus, the primary objective of this research article is to demonstrate the benefits Ceará gains at both national and international levels from green hydrogen production and export under

FIEC's leadership. This study also aims to measure the socioeconomic development impacts in Ceará resulting from these management efforts. For the methodology, a qualitative approach was chosen.

The research was bibliographic and documental, involving publications, reports (national and international), scientific articles, FIEC presentations, and websites. From the consultation and consolidation of these materials, it was possible to identify key issues related to the topic. The specific objectives established are as follows: to characterize the importance of the Northeastern Promontory as a geopolitical advantage for the state of Ceará in the context of international trade; to distinguish the solar and wind conditions in Ceará as a geoeconomic advantage within the energy transition context; to review current and future international agreements and protocols, managed by FIEC, regarding green hydrogen production and export; to identify the countries with which FIEC has signed or is in the process of signing memoranda of understanding (MoU) in the context of economic decarbonization; and to assess the socioeconomic impacts in Ceará resulting from FIEC's green hydrogen production and export initiatives. This article is structured into four sections: an introduction, the methodology, the theoretical framework, and the final considerations.

## **II. Material And Methods**

Considering that the present project focuses on the potential socioeconomic outcomes resulting from the production and export of green hydrogen by the state of Ceará, through FIEC, a qualitative approach was chosen to understand the results that may be intended.

Regarding the qualitative approach, González (2020, p. 03) emphasizes that "in Qualitative Research, the Epistemological Place is highlighted and occupied by the researchers, thus assuming cognitive commitments to the quality of the research<sup>1</sup>."

As for the research methods, the study is bibliographic and documental, comprising the following techniques: a. literature and document survey; b. selection of bibliography and documents; c. analytical reading of the selected bibliography and documents; d. data collection survey; e. annotation: during which bibliographic citation, summary, and analytical notes will be made; f. critical analysis, data tabulation, and consolidation of the study questions.

Carvalho (2022, p. 13) states that: "Bibliographic research is an essential part of scientific work, as it contextualizes the current research landscape, points out conceptual inconsistencies, and encourages the undertaking of new studies, all through the summary and synthesis of existing works<sup>2</sup>."

For the elaboration of the theoretical framework, bibliographic research was conducted through publications, national and international reports, scientific articles from academic institutions, FIEC presentations on renewable energies and green hydrogen, and websites. From the consultation, combination, and consolidation of these materials, it was possible to identify the most important issues related to the topic.

## **III. Literature Review**

This framework has been organized into five subsections. The first discusses the Northeastern Promontory as a geopolitical advantage for Ceará. The second addresses the solar and wind conditions in the state as geoeconomic advantages in the energy transition. The third focuses on the international agreements with FIEC involving the production and export of green hydrogen. The fourth examines the countries and memorandums of understanding signed by FIEC in the decarbonization of the economy. Lastly, the fifth subsection explores the impact of FIEC's actions on the socioeconomic development of Ceará.

### **The Northeastern Promontory as a Geopolitical Advantage for the State of Ceará**

Following the outbreak of the Russia-Ukraine war (2022) and the Israel-Hamas conflict (2023), the study of geopolitics has gained renewed attention in political, military, and academic spheres. Geopolitics involves understanding territorial spaces, as geographic location influences political, economic, and social interests<sup>3</sup>.

Several concepts have been developed by the Munich Geopolitical Institute (Germany), among which two stand out: "Geopolitics is the geographical awareness of the state" and "Geopolitics is the science of the relationships between land and political processes." For the German geographer Karl Haushofer, "Geopolitics is the science that deals with the dependence of political facts on the land"<sup>4</sup>.

Therezinha de Castro, in her work *Geopolitics: Principles, Means, and Ends*, defines the term as the science linking geographical aspects to political events, with the main objective of rationally utilizing all branches of geography in the planning of state activities, aiming for both immediate and long-term results<sup>5</sup>.

Mafra (2002, p. 8) defines geopolitics as "when geographical conditions influence political studies, decisions, and planning<sup>6</sup>." The definitions above help to better understand how the geographical positioning and physiographic conditions of a territory can influence the formulation of public and foreign policies, national development, and international relations.

According to Mattos (1977, p. 18), a country's position is analyzed from a geopolitical perspective based on the following aspects: latitude, proximity or distance from the sea (maritimity or continentality), and altitude

(plains, plateaus, or mountains). In the specific case of Ceará, the state occupies the northeastern part of Brazil and South America, at a latitude of 4°46'30" South. Being close to the Equator, the incidence of sunlight is almost perpendicular to the surface, resulting in higher temperatures (normally above 20°C) compared to higher latitudes (further south). These conditions provide permanent advantages for the technical exploitation and economic use of photovoltaic solar energy.

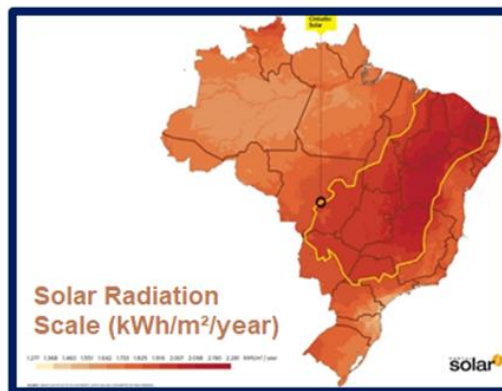
Regarding maritimity, Ceará is bordered by the Atlantic Ocean (an ocean of high economic importance in the globalized world), facilitating overseas interests through commercial exchange<sup>6, 7, 8</sup>, as well as access to the international community. Additionally, the state's continental shelf provides favorable conditions for land-sea interaction, particularly for the establishment and construction of ports, such as the Port of Pecém, home to the Pecém Industrial and Port Complex (CIPP), including the ZPE (Export Processing Zone) and the Green Hydrogen Hub. Regarding altitude, Mattos (1977) notes that it creates favorable or unfavorable conditions for socioeconomic development, with plains always facilitating human movement and land exploration<sup>7</sup>.

In Ceará, the coastal plains to the north extend along the Atlantic, with elevations ranging from 30 to 100 meters, increasing as one moves inland. Thus, Ceará's strategic positioning within the Northeastern Promontory is crucial, as it shortens the distance to Europe, is close to important maritime export routes, and is near consumer markets<sup>9</sup>. This geographical advantage facilitates access to the main international trade flows of goods, products, and services.

### **The Solar and Wind Conditions of the State of Ceará as Goeconomic Advantages in the Energy Transition**

The Brazilian Solar Energy Atlas defines an area stretching from the Northeast to the Pantanal, called the "solar belt." The best radiation rates are found between the hinterland of Bahia and part of Minas Gerais. As shown in Map 1, the state of Ceará is fully located within the Brazilian solar belt.

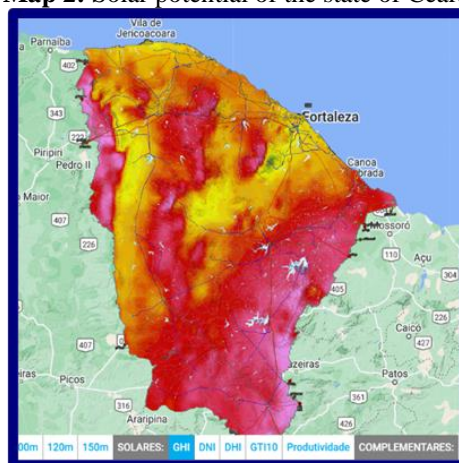
**Map 1: Solar Radiation in Brazil**



Source: Solar Portal

In turn, the Wind and Solar Atlas of Ceará (Map 2) demonstrates how the geographical position of the state allows for the economic exploitation of solar energy, generating a photovoltaic potential of 643 GW<sup>10</sup>.

**Map 2: Solar potential of the state of Ceará.**

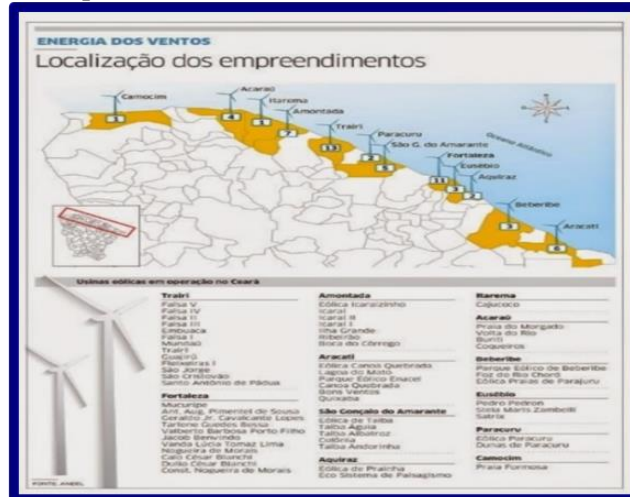


Source: Wind and Solar Atlas of Ceará<sup>9</sup>

In the wind energy context, various studies favor the installation of wind farms in Ceará. One such conclusion comes from a study by Silva et al. (2020), which applied the Weibull probability distribution, a tool used in studies involving wind potential estimation<sup>11</sup>. Another key study is the publication of the Brazilian Wind Energy Potential Atlas, which covers the entire national territory. Its objective is to provide information that enables decision-makers to identify suitable areas for wind energy utilization.

The atlas is intended for government authorities, electric sector planners, national and international financing agencies, development institutions, and investors. Notably, the combination of location and wind factors in the Ceará plains has enabled the installation and operation of several wind farms (Map 3). Being located on coastal plains, access conditions facilitate both construction and, subsequently, operation and maintenance (O&M) of these farms.

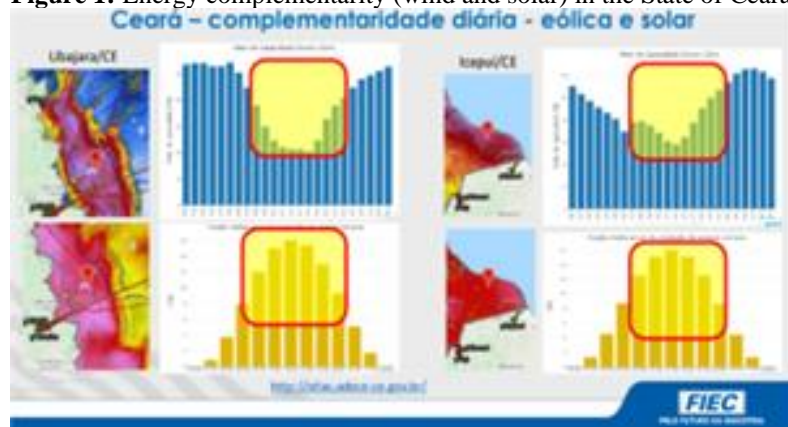
**Map 3:** Location of wind farms in the state of Ceará.



Source: Revista Litoral Leste (2014)<sup>12</sup>.

The above characteristics align with the report from the International Renewable Energy Agency (IRENA), which states that H<sub>2</sub>V will be economically best produced in areas with a combination of abundant renewable resources, available land, access to water, and the capacity to transport it to large importing countries<sup>13</sup>. Therefore, the state's location (within the solar belt) combined with wind conditions offers a promising potential for both solar photovoltaic and wind energy, due to what is called energy complementarity (Fig. 1), even benefiting from energy security in H<sub>2</sub>V production.

**Figure 1:** Energy complementarity (wind and solar) in the State of Ceará.



Source: FIEC (2023)<sup>14</sup>

Thus, Ceará's production of H<sub>2</sub>V would bring with it more attractive and competitive operational, logistical, and commercial advantages, positioning the state as a provider of renewable energy to Europe, for example, over other producing countries. It is noteworthy that, as analyzed by Oliveira (2022, p. 8), Europe is more focused on the use of green hydrogen to decarbonize the industrial and heavy transport sectors (buses and trucks), and is expected to remain the largest market in the short term<sup>15</sup>.

### International Agreements with FIEC Involving the Production and Export of Green Hydrogen

FIEC has undertaken a series of initiatives with foreign governments and companies aimed at developing the hydrogen economy in the state. Among the bilateral relationships, notable agreements include collaborations with GIZ (German Agency for International Cooperation) and the Fraunhofer Institute, both based in Germany.

In 2023 alone, two significant international missions were conducted. The first, held in June, was called the International Technical Mission and took place in Germany with a delegation from SENAI and Sindienergia-CE. The second mission, also in Germany, occurred in October, when members of SENAI participated in activities within the scope of the bilateral cooperation program "H<sub>2</sub>Brasil" between Germany and Brazil, an initiative of the Ministry of Mines and Energy (MME) and GIZ. These agreements have the potential to maintain the state's competitiveness and prominence on the international stage, particularly in Europe.

Also noteworthy is the international partnership between FIEC/SENAI and the Australian multinational Fortescue, with the goal of establishing a working group to develop initiatives supporting employment, sectors, and sustainable economies, including workforce training for the green hydrogen (H<sub>2</sub>V) supply chain. Another partnership involved organizing the "NRW HYway2 Brasil: Networking Brazil-Germany: Green Hydrogen."

In 2021, FIEC, the State Government, and UFC signed a letter of intent for the construction of a hydrogen fuel plant at the Pecém Industrial and Port Complex (CIPP)<sup>16</sup>. Not coincidentally, this decision aligned with the global trend of creating hubs, as described by Oliveira (2022, p. 17):

The potential for renewable energy generation and its location near strategic ports worldwide stimulated the creation of hydrogen innovation hubs, aimed at contributing to the development of the market and technology for the national industry, becoming an international reference, and serving as an access platform for other countries<sup>15</sup>.

On that occasion, a Memorandum of Understanding (MoU) was signed with the Australian company Energyx, which is expected to invest US\$ 5.4 billion in the project. "Since its launch, thirty-five MoUs have been signed with the State Government and FIEC with national and international institutions interested in developing their projects in the State<sup>16</sup>".

This convergence of efforts not only demonstrates the importance of FIEC in the energy transition but also strengthens the companies and respective countries in areas related to investments, R&D, and human resource development.

### FIEC and Partner Countries in the Decarbonization of the Economy

International Relations (IR) is the field that, above all, represents the interests of the State on the international stage, whether for its survival or for the satisfaction of the demands of its members<sup>15</sup>. In the economic and energy sectors, a new expression has emerged among countries and institutions: "hydrogen diplomacy." "Governments of potentially exporting countries are implementing political-diplomatic strategies concerning hydrogen<sup>13</sup>".

FIEC has been conducting its actions, programs, initiatives, and development plans (within the hydrogen economy context) in close collaboration with countries and multinational companies, solidified through various agreements, taking a leading role in Ceará and projecting the state onto the global stage. In terms of countries, Table 1 presents the investments already made in the Pecém Industrial and Port Complex (CIPP). These studies were conducted by the International Consultancy McKinsey, which notes that since Brazil has an energy matrix composed of 85% renewable energy (hydropower, wind, solar, and biomass), investments for national H<sub>2</sub>V production could benefit from the existing electrical grid, as 70% of the cost of hydrogen production is the energy cost<sup>17</sup>.

**Table 1:** Projects and Confirmed Investments in the Pecém Port (in H<sub>2</sub>V)

Country	Company	Projected Values (US\$)	Investment Location
Austrália	Fortescue Future Industries	6 bilhões	Porto do Pecém, Ceará
Holanda	Transhydrogen Alliance	2 bilhões	Porto do Pecém, Ceará
Austrália	Energix Energy	5,4 bilhões	Porto do Pecém, Ceará
França	Qair	6,95 bilhões	Porto do Pecém, Ceará
Portugal	EDP do Brasil	8 milhões	Porto do Pecém, Ceará
França	Engie	-	Porto do Pecém, Ceará
Espanha	Neoenergia	-	Porto do Pecém, Ceará
Alemanha	White Martins	-	Porto do Pecém, Ceará
Alemanha	Linde	-	Porto do Pecém, Ceará
França	TotalEnergies	-	Porto do Pecém, Ceará
Brasil	Eneva	-	Porto do Pecém, Ceará
Brasil	Diferencial Energia	-	Porto do Pecém, Ceará
Alemanha	Hytron	-	Porto do Pecém, Ceará
Brasil	H2helium Energia	-	Porto do Pecém, Ceará

Source: Oliveira (2022, p. 31)<sup>15</sup>.



In these circumstances, under the premises of paradiplomacy, FIEC emerges as a key global player in the H<sub>2</sub>V international market, as a result of the Hydrogen Hub at the CIPP. The complex has been attracting significant public and private investments and receiving large energy projects, whose producers will benefit from the tax incentives offered by the ZPE.

### The Impact of FIEC's Actions on the Socioeconomic Development of Ceará

In the report World Employment and Social Outlook 2018: Greening with Jobs, the International Labour Organization (ILO) stated that 24 million new jobs would be created worldwide by 2030 if policies promoting a greener economy were correctly implemented.

In 2023, the Brazilian government, through the Ministry of Mines and Energy (MME), launched the National Plan for a Just and Inclusive Energy Transition (PLANTE) during the 78th UN General Assembly in New York, declaring that the current opportunity was to "make energy a driving force for the country's sustainable development." As a result of PLANTE, Brazil would achieve the following gains: "employment and income, social inclusion, reduction of socioeconomic inequalities, economic growth, reindustrialization, combating climate change, and improved quality of life."

It would not be socially just or environmentally responsible for the energy transition, bringing with it technological benefits and large capital investments, if it did not benefit the societies it belongs to. The effectiveness of economic transformations would be better characterized when it was able to meet human needs and address social aspirations<sup>3</sup>.

"Bringing the above premises to the reality of Ceará, the benefits of H<sub>2</sub>V production and exportation would allow the development of the state's industry, making companies more competitive and attractive to Foreign Direct Investments<sup>18</sup>". Therefore, the activities related to H<sub>2</sub>V in the state of Ceará have the potential to improve the living conditions of the Ceará population.

Thus, the gains for Ceará's society, resulting from the hydrogen economy, would be evident in the anticipated socioeconomic development, as already predicted by Souza Filho (2019, p. 88), who states:

The Energy Sector already plays a significant role in Ceará's economic dynamics, especially due to the differentiated potential provided by wind and solar sources. Every day, new investments are announced across various regions of the state, which brings about a convergence of interests from public and private actors to ensure conditions for rapid development of this industry, ensuring the necessary agility in the business environment and attracting new ventures in its production chain<sup>19</sup>.

During the launch of the Green Hydrogen Masterplan in Ceará, in June 2024, Patel (2024) presented the numerous opportunities of the H<sub>2</sub>V economy (Fig. 2). Economic sectors such as energy, construction, heavy industry, and metal mechanics would emerge as essential industries in the development of the hydrogen value chain and, consequently, benefiting the economic and social dimensions of Ceará's population<sup>20</sup>.

Another aspect highlighted by Pavel was the hydrogen legacy in the educational field, given the need to train and educate specialized human resources for the present, ensuring a more promising future for Ceará's citizens. Installers and maintainers of Electrolysis Systems, logistics operators for gas transportation, and specialists in Green Hydrogen Systems are currently the main workforce demands. To this end, the FIEC System already includes SENAI and IEL in this mission to strengthen the human dimension of the hydrogen economy for the benefit of Ceará's society.

Recently, the Renewable Energy Research and Innovation Network of Ceará (Rede Verdes) was created, demonstrating a firm commitment to the development of the human and technological dimensions of the hydrogen value chain in the state of Ceará.

Figure 2: Socioeconomic opportunities arising from H<sub>2</sub>V in Ceará.



Source: Patel (2024, p. 25)<sup>20</sup>

From an economic perspective, the development of the H<sub>2</sub>V production chain in Ceará would bring about the reindustrialization of the state's manufacturing complex through industry decarbonization, including opportunities in the state's economic structure arising from the new energy matrix based on renewable sources.

Ceará's leadership in hydrogen production and export would open opportunities for the development of an export market and the strengthening of international partnerships based on shared interests. In turn, the strengthening of the production chain would contribute to the decarbonization of industry and transportation, while the development of a hydrogen ecosystem in Ceará would enhance energy security<sup>21</sup>.

Thus, as demonstrated, the energy transition in Ceará would have the potential to generate socioeconomic value, create local jobs, enable technology transfer, develop local suppliers and industries, and reduce electricity costs for consumers.

#### IV. Conclusion

The present study is justified by the importance and relevance of the adverse effects that nature has exhibited across all continents as a result of global warming, the impacts on global ecosystems, and the environmental uncertainties caused by excess CO<sub>2</sub> in the atmosphere. Numerous countries have been increasing renewable energy production within their matrices through policies, programs, agreements, treaties, and international partnerships.

In this period, when environmental circumstances demand commitment, cooperation, and integration among interstate actors, FIEC emerges as a potential provider of solutions to global climate issues, fostering Ceará's industrial sector as a supplier of renewable energies used in the production of the fuel of the future (green hydrogen) at lower costs compared to other countries, thereby enabling a competitive advantage in the global market.

The study demonstrated that part of this success stems from Ceará's geopolitical conditions, a strategic advantage derived from leveraging the state's geographical assets, facilitating better international integration and the generation of business opportunities within the context of the energy transition. Ceará is positioned as a potential H<sub>2</sub>V supplier for the European market, becoming an important global player.

The research fully met its objectives, as it demonstrated that the success of ongoing actions and initiatives has the potential to strengthen the state's socioeconomic structure, making it more equitable, sustainable, and inclusive, with positive effects on the quality of life of the people of Ceará, the educational system, and ensuring national energy security.

Ceará is now presented with the opportunity to integrate itself into a new global value chain, given its natural aptitude for H<sub>2</sub>V production, thus confirming the project's central problem. Finally, it is recommended that FIEC continue to strengthen negotiations with the government of the State of Ceará and with foreign countries and institutions to consolidate the H<sub>2</sub>V value chain.

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