

# The H<sub>2</sub>V Value Chain In Ceará: A Brief Analysis Of The Contributions Of The International Marketing Mix In The Context Of The Energy Transition In Europe

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## Abstract:

**Background:** This study examines the role of green hydrogen (H<sub>2</sub>V) in the global energy transition as part of the solution to global warming. It defines the H<sub>2</sub>V value chain to be developed in Ceará and explores the application of international marketing mix concepts to this value chain for export to Europe. The study also highlights the benefits for high-level decision-makers in the process of integrating H<sub>2</sub>V into the European market.

**Materials and Methods:** A qualitative research approach was adopted, essential for an in-depth exploration of the planning and management of the H<sub>2</sub>V value chain from the perspective of the marketing mix. The study employed a literature review methodology, consulting sources categorized into three groups: (1) sources on H<sub>2</sub>V and the energy transition, (2) sources on the H<sub>2</sub>V value chain in Ceará, and (3) sources on the international marketing mix, enabling its application to the energy vector's value chain in Ceará.

**Results:** The findings indicate that high-level managers can benefit from applying these marketing concepts to strengthen Ceará's position as an energy supplier to Europe.

**Conclusion:** The study underscores the strategic relevance of incorporating international marketing principles into the H<sub>2</sub>V value chain, reinforcing Ceará's potential as a key player in Europe's energy transition.

**Keywords:** Green Hydrogen; Energy Transition; Ceará; Value Chain; Marketing Mix.

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## I. Introduction

The state of Ceará has demonstrated its potential as an energy solutions provider to mitigate the effects of climate change and global warming, contributing to the global industry's decarbonization process. In this context, various strategies can be employed to communicate its capabilities and potential to the international community, particularly in the production and export of green hydrogen (H<sub>2</sub>V). One such strategy involves leveraging international marketing contributions to identify markets for distributing this energy vector.

Regarding the methodology, a qualitative approach was selected. As for the research methods, the study was bibliographic and documentary, drawing on publications (both national and international), reports from international organizations, and online sources. The consultation and consolidation of these materials enabled the identification of the key issues related to the study. Thus, the general objective of this study is to present the contributions of the international marketing mix applicable to the H<sub>2</sub>V value chain in Ceará.

As a result of this analysis, the study aims to provide high-level decision-makers with tools that facilitate the decision-making process in consolidating Ceará as an exporter to the European market. The specific objectives established are as follows: to examine the landscape of H<sub>2</sub>V and its role as a global solution for the energy transition and the decarbonization of the world economy; to define the current state of the H<sub>2</sub>V value chain in Ceará, assessing its scope and complexity; and to describe the international marketing mix, applying its principles to the ongoing development of Ceará's H<sub>2</sub>V industrial sector.

This article is structured into four sections, providing a comprehensive analysis of the international marketing mix applicable to the H<sub>2</sub>V value chain. The first section, Introduction, presents the central theme of the study. The second section, Methodology, outlines the research approach, including data collection and analysis strategies. The third section, Theoretical Framework, explores H<sub>2</sub>V and its significance for the global energy transition, describes the current configuration of the H<sub>2</sub>V value chain in Ceará, and defines the international marketing mix and its applications within this context. Finally, the Final Considerations section

synthesizes the study's key findings, highlighting the advantages of understanding the marketing mix for high-level decision-makers involved in H<sub>2</sub>V production and export to Europe.

## **II. Material And Methods**

The research adopted a qualitative approach, as the primary objective was to apply marketing mix concepts to the complex H<sub>2</sub>V value chain in the state of Ceará. The qualitative approach is widely recognized in the scientific community for its ability to provide contextual analyses, allowing for an assessment of the dynamics surrounding the energy transition, renewable energy sources, and industrial hubs. Qualitative research focuses on interpreting and understanding complex phenomena, making it particularly relevant in fields involving the production chain of an energy vector derived from renewable sources, where variables are extensive and dynamic.

Regarding the qualitative approach, Lösch, Rambo, and Ferreira (2023, p. 04) emphasize that:

The qualitative approach [...] is a type of research that seeks to understand social, cultural, and educational phenomena through the analysis of subjective data, such as interviews, observations, life reports, among others. Its scope is to achieve a deep and detailed understanding of the subject in question, rather than quantitatively measuring the phenomenon. It is often used in case studies, exploratory research, action research, ethnographic studies, and investigations of pedagogical practices, as well as in research on students' or teachers' perspectives on educational issues.

The research method adopted was a literature review, an essential methodology for constructing scientific knowledge, as it enables a critical and integrated analysis of existing information on a given topic (Carvalho, 2020).

For this review, research sources were carefully selected and classified into three main categories: (1) specific sources on H<sub>2</sub>V, addressing its essential role as the fuel of the future in the energy transition and global economic decarbonization; (2) specific sources on the H<sub>2</sub>V value chain in global, national, and local contexts; and (3) sources on the marketing mix (commonly known as the 4Ps), which serve as a foundation for decision-making processes related to the consolidation of the industrial hub, production in Ceará, and export to Europe.

The classification of these sources enabled a more precise and contextualized analysis, fostering the development of a robust discussion on the benefits of the marketing mix in the H<sub>2</sub>V value chain in Ceará. The literature review was conducted through the examination of reports from international organizations, publications from Brazilian federal agencies, recent scientific articles, and books, ensuring a broad and comprehensive reflection of the most relevant and up-to-date contributions in the field.

## **III. Literature Review**

This theoretical framework was structured into three subtopics. The first discusses H<sub>2</sub>V and its potential as a global solution for the energy transition. The second provides a brief overview of the hydrogen value chain in Ceará, highlighting its key characteristics. The third examines the application of the marketing mix (product, price, promotion, and place/distribution chain) to the H<sub>2</sub>V value chain and its potential contributions within the context of the energy transition in Europe.

### **Hydrogen**

Hydrogen is a lightweight fuel with a higher energy content per unit of mass than any other known fuel, capable of storing and delivering large amounts of energy (Oliveira, 2022). In the context of economic decarbonization and the fight against global warming, hydrogen is considered a cornerstone of the energy transformation. It has been proven to play a crucial role in the transition strategies currently being implemented by various countries, particularly as an alternative for highly carbon-intensive sectors (MME, 2023).

Among the numerous applications of hydrogen, "green hydrogen" stands out. It is produced from renewable sources such as solar, wind, and hydropower. The Policy Report in Support of the United Nations High-Level Political Forum identifies green hydrogen as a key solution for hard-to-decarbonize sectors (Santos & Gandara, 2022).

"Governments worldwide have set decarbonization targets, striving for energy independence. Many countries have developed national strategies, and Europe, in particular, has established ambitious goals to introduce it as an energy carrier" (Berger, 2023, p. 4).

Studies by the International Energy Agency (IEA) estimate that H<sub>2</sub>V production will increase from 90 million tons in 2020 to over 200 million tons by 2030. Additionally, the Hydrogen Council Report highlights Brazil's potential to become a major player in H<sub>2</sub>V production and export. The global hydrogen market is expected to reach USD 2.5 trillion by 2050, representing approximately 20% of the world's total energy demand (Martins, 2021).

The Hydrogen Council justifies Brazil's strategic position based on its unparalleled attributes for H<sub>2</sub>V and green product production, including abundant low-cost renewable energy, complementary energy sources, an interconnected power grid, and an attractive domestic market. "Additionally, Brazil is one of the few countries

worldwide capable of decarbonizing its own economy while also contributing to other nations, given its vast resource availability" (Oliveira, 2024, p. 39).

For Brazil's National Hydrogen Program (PNH<sub>2</sub>), led by the Ministry of Mines and Energy (MME), the inclusion of hydrogen in the national energy agenda is a priority for investment in research, development, and innovation, as outlined in National Energy Policy Council Resolution No. 2, dated February 10, 2021.

As noted by Bezerra (2023), in the industrial sector, manufacturing "green products" without greenhouse gas (GHG) emissions will represent a highly promising market in the coming years, given the likelihood of carbon taxation in various countries. Additionally, companies are increasingly adopting Environmental, Social, and Governance (ESG) initiatives to obtain certifications and enhance their public image.

How Can the State of Ceará Capitalize on the Energy Transition? Given this global shift, how can the State of Ceará position itself as a provider of energy solutions to mitigate global warming? How can it leverage international marketing concepts to enhance its H2V value chain and consolidate its role in the energy transition?

### **Hydrogen Value Chain in Ceará**

The value chain is understood as a way to break down the entire production cycle (logistics, operations, infrastructure, etc.) into parts, so that by analyzing the pathways and stages of the process (inputs and outputs), it becomes possible to identify and add value to the product or service, benefiting the company, the customer, and the market.

According to Porter (2004), it is a method that enables the organization of processes by examining the links between each stage and how each can generate value for the customer, allowing the organization to understand the systemic functioning of production. In other words, it is a flowchart detailing the paths taken during the production process, addressing the nuances of the business. Considered essential in the production environment, the proper definition of the value chain enables companies to implement improvements that strengthen market delivery. The World Energy Council (WEC) highlights that, in the context of a hydrogen hub, the presence of multiple users from different sectors could make its infrastructure (such as pipelines, storage stations, and refueling stations) more cost-effective by promoting economies of scale and synergies among these sectors, thus fostering the development of the value chain (WEC, 2021).

According to the International Energy Agency (IEA), the development of hydrogen infrastructures and technologies is frequently linked to economic development, especially within the context of the energy transition. For this reason, hydrogen value chains contribute to different technological fields and manufacturing sectors (IEA, 2019).

Meanwhile, the International Renewable Energy Agency (IRENA) asserts that a well-structured value chain could enhance economic competitiveness. In the long term, countries with renewable potential could become centers of green industrialization, leveraging their resources to attract energy-intensive industries (IRENA, 2022).

According to the Brazilian Ministry of Mines and Energy (MME, 2021), the hydrogen market experienced significant global momentum following post-pandemic energy policies aimed at economic recovery and accelerating the energy transition. Many governments recognize that the decarbonization of the global economy is directly proportional to the hydrogen value chain, encompassing renewable energy (wind and solar), production, storage, transportation, distribution, and consumption.

In an article published by the Getúlio Vargas Foundation – Europe, Raccichini, Contardi, and Ristuccia (2022) presented an overview of strategies, experiences, and market issues related to hydrogen in Brazil, with emphasis on Ceará. The state was highlighted as the "First Green Hydrogen Valley of Brazil" due to its extensive investment portfolio, covering the entire value chain (production, transformation, transportation, and end uses).

Due to its strategically privileged location in northeastern Brazil—featuring low latitudes, an Atlantic coastline near key commercial maritime routes to Europe, and favorable wind and solar irradiation conditions—Ceará has become a significant global player in green hydrogen production and export (Barbosa & Gomes, 2024b).

In Ceará, with an average annual solar radiation of 5.5 kWh/m<sup>2</sup> per day and wind speeds reaching up to 36 km/h, the state secures a competitive advantage from the very outset of the production process (FIEC, 2024).

The state government asserts that Ceará is among the frontrunners in developing the hydrogen value chain due to its wind, solar, and logistical potential, positioning itself as a key player in both national and international markets. By December 2023, the state had already signed thirty-five memoranda of understanding for the development of the H2V Hub (Ceará, 2023). T

o better understand the green hydrogen production cycle at the Pecém Industrial and Port Complex (CIPP) in Ceará, the analysis will focus on Flowchart 1. As can be observed, the value chain is extensive and complex, which is why supply chain management is diversified, involving numerous suppliers.

**Flowchart 1: Green Hydrogen Value Chain in the Pecém Complex.**



Source: Nunes, & Picanço (2021, p.47).

Taking the aforementioned flowchart as a reference, senior management and other hierarchical levels within the company would be able to identify and analyze opportunities for improvement at each stage of the green hydrogen (H<sub>2</sub>V) production cycle, thereby adding value. Consequently, the benefits derived from these improvements would further enhance Ceará’s competitive advantages, such as cost reduction or decreased lead time in the commercialization of this energy vector.

**International Marketing Mix**

In the context of international marketing, the production and export of green hydrogen (H<sub>2</sub>V) from the Pecém Industrial and Port Complex (CIPP) to the European market would involve trade exchanges between two key players: Ceará (as the supplier and producer) and Europe (as the demander and consumer market). For these relationships to be stable, long-term, and solid in a "win-win" environment, the former must meet the expectations, preferences, and needs of the latter (Carioni, & Neves, 2008).

Marketing emerges in this scenario as a managerial process through which demanders obtain what they need and desire by creating, offering, and exchanging products with a supplier (Kotler, 1994). It is noteworthy that the supplier's strategic planning should focus on attracting, convincing, and persuading the demander by identifying, understanding, and interpreting its expectations, which would then translate into commercial exchanges. This approach aims to transform the offer into full satisfaction for the consumer (Carioni, & Neves, 2008).

In the European energy landscape, marked by efforts to decarbonize economies in the post-pandemic period and amid the Russia-Ukraine war, the "Old World" is actively seeking solutions to diversify its energy matrix as part of a race to mitigate the various climate effects of global warming. Consequently, this market requires partnerships and international cooperation with global H<sub>2</sub>V suppliers that demonstrate technical, commercial, and technological expertise. It is important to highlight that this race includes several countries that view H<sub>2</sub>V as a key solution for energy transition.

Thus, Ceará, not being alone in this transition, faces competition from other global producers, leading to intense international competition. Given these circumstances, international marketing, when applied strategically by decision-makers in Ceará, could enable the state to offer H<sub>2</sub>V with competitive differentiators, thereby making the product more attractive to European buyers by providing them with perceived value in the North Atlantic market.

To achieve the desired outcomes in the production and export of this energy vector, the following section explores the four "P's" of the marketing mix, a concept developed by Jerome McCarthy in the 1960s: Product, Price, Promotion, and Place (Carioni, 2006).

**Product**

At a fundamental level, a product is defined as something a company offers to meet the desires of consumers (buyers), providing them with benefits in exchange for their demand. According to Kuazaqui (2018), a product must meet the needs of a specific market while offering a competitive advantage over rival products. Madruga et al. (2006) argue that the product is the core element of marketing strategy, representing much more than just a physical good; it embodies the benefits and advantages perceived by the user.

Although various energy generation alternatives exist through hydrogen as a substitute for fossil fuels (oil, coal, and natural gas), Brazil—alongside Australia, Japan, South Korea, Saudi Arabia, and Chile—has opted for green hydrogen, which emits zero CO<sub>2</sub> into the atmosphere compared to other hydrogen-based generation methods (Table 1). This choice reinforces the principle of energy sustainability (Nunes, & Picanço, 2021).

**Table 1: Energy Generation from Hydrogen**

Type of Hydrogen	Fuel Source / Process	Carbon Emission (Kg of CO <sub>2</sub> / Kg of H <sub>2</sub> )
Brown	Coal / Gasification	18 - 20
Gray	Natural Gas / Steam Reforming	8 - 12
Turquoise	Natural Gas / Pyrolysis	5 - 11
Blue	Natural Gas / CO <sub>2</sub> Capture	0.6 - 1
Yellow	Electricity Grid / Electrolysis	0 - 9
Green	Renewable Energy / Electrolysis	0
Pink	Heat / Nuclear Energy / Electrolysis	0 - 0.4

Source: Nunes, & Picanço (2021, p.05).

According to Oliveira (2022), the Northeast region of Brazil is positioning itself as a production hub due to its high potential for wind and solar energy generation, along with its ports being geographically well located in relation to key European markets, with the state of Ceará standing out for having the largest number of projects announced in Brazil. In the state, this option is facilitated by the natural conditions for generating renewable energy at competitive prices compared to other regions of the world. Thus, defining H<sub>2</sub>V as the product in the marketing mix, it is important to highlight the creation of the Hydrogen Hub in 2021, in partnership with the State Government, the Federal University of Ceará, and the Pecém Industrial and Port Complex (CIPP). At that time, the activity included the signing of a memorandum of understanding (MoU) with the Australian company Energyx Energy for the construction of a plant at CIPP (FIEC, 2021).

The competitive differentiators sought by marketing professionals are found in CIPP, considering that the future H<sub>2</sub>V industries will be located in a state surrounded by an ocean of high economic importance in the globalized world (the Atlantic), which facilitates commercial exchange with Europe. In addition, CIPP has an Export Processing Zone (ZPE), contributing to competitiveness in the export process (Barbosa & Gomes, 2024a).

In the H<sub>2</sub>V value chain, another competitive advantage would be logistics, as the optimization of transport, storage, industrial, and commercial operations would likely reduce the order cycle time (lead time) (purchase, processing, acquisition of inputs, production, dispatch, and delivery) at the Pecém port. What stands out is that H<sub>2</sub>V is not just a product with its physical-chemical characteristics traded on the international market; it is actually an energy vector that promotes sustainability, contributing to the reduction of greenhouse gas emissions.

Therefore, in this article, it is interpreted that the benefits, attributes, and utilities of H<sub>2</sub>V are directly contributing to environmental preservation and the decarbonization of industries, making it essential for the global energy transition. Subsequently, for transportation purposes, H<sub>2</sub> would be converted into NH<sub>3</sub> (ammonia), considered the most plausible strategy for Ceará, as it has been consolidated as the primary product in most of the studied clusters and has a mass market that would mitigate the risk of failure (FIEC, 2024).

From the considerations above, Ceará seeks to achieve a leading role in the international arena, supported by the aforementioned competitive advantages and the growing global demand for clean energy sources. "The production and export of H<sub>2</sub>V could position the country as a provider of decarbonization solutions for other nations" (MME, 2023, p. 6).

However, there are key considerations in the value chain that require due attention and priority from high-level decision-makers. First, attention should be given to water (H<sub>2</sub>O), considered a critical primary resource for H<sub>2</sub>V production, from which hydrogen will be extracted and requiring a significant amount for its production (approximately 15L/kg of H<sub>2</sub>). For reference, in a scenario where an economy produces 2.3Gt of H<sub>2</sub>/year at 15L/kg, the demand would be 34,500 Gt/year (FIEC, 2024).

Second, electrolyzers, considered the most relevant component in H<sub>2</sub>V production, are responsible for breaking the H<sub>2</sub>O molecule, separating hydrogen from oxygen (FIEC, 2024).

### Price

In the Marketing Mix, price refers to the amount the customer (buyer, consumer, or market) is willing to pay to meet their needs, desires, or expectations. Conceptually, it represents the financial amount required to acquire the offering, and should be calculated based on factors such as production costs, taxation, and sales expenses. Price becomes a complex competitive factor in an environment where competitors strive daily to optimize their costs, effectively reducing their profit margins (Arbache et al., 2006).

In the product value chain, the adequate and fair formulation of price can result in a range of advantages, especially for the primary business objectives: sales, productivity, and profitability. It is the only element in the mix that generates revenue and is considered one of the most critical and complex aspects faced by global companies (Carioni & Neves, 2008).

Within the H<sub>2</sub>V context, this aspect becomes highly important. It is estimated that Brazil has the potential to competitively capture a share of the import markets of the United States and the European Union, generating approximately two billion dollars by 2030 and exporting between four and six billion dollars by 2040 (McKinsey, 2021).

Ceará would certainly capture a portion of these export revenues. Another important consideration was made by Santos and Gandara (2022, p. 13), who pointed out that Brazil holds

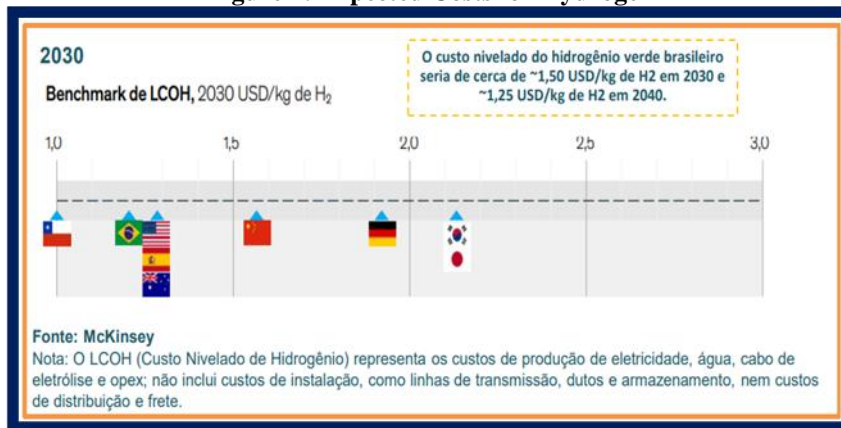
A great opportunity to play a significant international role by offering H<sub>2</sub>V at a lower price and in high quantities, enabling the supply of the domestic market and the possible export of surplus to Europe (a potential consumer market for the hydrogen produced in the country).

It is also essential to recognize Brazil's global competitiveness in renewable energy, which provides a significant advantage in H<sub>2</sub>V production. The country could become one of the largest global producers due to the low cost of its natural resources, requiring less investment in capital goods (McKinsey, 2022).

“It is expected that production costs for H<sub>2</sub>V will continue to decrease over the coming decades due to advancements in electrolyzer technology and improvements in the development of business models and creative project finance structures” (FIEC, 2024, p. 109).

In the studies of Santos et al. (2022), Brazil would play a significant international role by offering H<sub>2</sub>V at lower prices and in large quantities, facilitating access to external markets in Europe. Again, Ceará emerges as a potential global supplier of the fuel of the future. In a lecture given at the Energy Transition and H<sub>2</sub>V Production Seminar, the CEO of CIPP informed that the levelized cost of Brazilian H<sub>2</sub>V would be approximately USD 1.50/kg of H<sub>2</sub> by 2030 and approximately USD 1.25/kg of H<sub>2</sub> by 2040 (Figure 1).

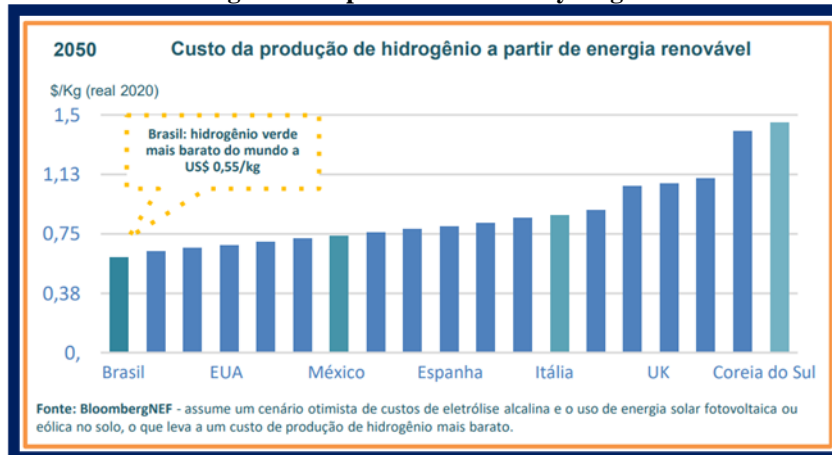
Figure 1: Expected Costs for Hydrogen



Source: Figueirêdo (2023, p. 04).

According to Figueirêdo, H<sub>2</sub>V could achieve the status of the cheapest in the world by 2050, compared to the estimated costs for the product produced in the USA, Mexico, Spain, Italy, the United Kingdom, and South Korea (Figure 2).

Figure 2: Expected Costs for Hydrogen



Source: Figueirêdo (2023, p. 4).

In a way, the aforementioned price estimates indirectly reflect the synergy between Ceará's high solar irradiation and coastal winds, positioning it as a potential producer of green hydrogen (H<sub>2</sub>V). Thus, the production costs could contribute to making Ceará a global player in the hydrogen economy, given its electricity matrix based on renewable energy sources. These characteristics align with the International Renewable Energy Agency (IRENA) report, which states that H<sub>2</sub>V production is more economically viable in regions with abundant renewable resources, available land, access to water, and the capacity to transport hydrogen to major importing countries (Barbosa & Gomes, 2024b).

For the H<sub>2</sub>V value chain in Ceará, another competitive edge lies in the Export Processing Zone (free zone) located in the Pecém Industrial and Port Complex (CIPP), offering differentiated tax incentives, such as the suspension of federal, state, and municipal taxes. The benefits granted to companies established there would last up to 20 years, with the possibility of extension (Barbosa & Gomes, 2024b).

However, a word of caution for high-level decision-makers: despite Ceará's cost structure for H<sub>2</sub>V production being highly competitive globally (due to natural resources and climatic conditions leading to efficient, low-cost renewable energy sources), Brazilian taxes are the only component of the structured cost that could undermine Ceará's competitiveness (FIEC, 2024, p. 108).

### **Promotion**

Promotion refers to the strategies used by a company to communicate and promote its product or service, seizing the opportunity to add value. "Traditionally, these strategies involve investments in advertising, publicity, and sales promotions" (Kuzaqui, 2018, p. 54).

Given that the product and price have already been defined in the strategic planning, the next step is to outline communication and dissemination strategies to the market (target audience), aiming to enhance its value through its characteristics and benefits, persuading customers to make a purchase.

For H<sub>2</sub>V produced in the Pecém Industrial and Port Complex (CIPP), the promotion of this energy vector has been continuously carried out by the FIEC (Federation of Industries of the State of Ceará). Some of the actions undertaken by the Federation to promote the potential and competitive advantages of Ceará regarding the production and exportation of H<sub>2</sub>V are highlighted below. At the United Nations Climate Change Conference (COP 26) in Glasgow, Scotland, FIEC presented a lecture titled Green Hydrogen: Investment Opportunities in Northeast Brazil to delegations from more than one hundred countries (FIEC NOTÍCIAS, 2021).

The immense potential of H<sub>2</sub>V produced in Ceará was discussed, alongside the significant investment opportunities in the Northeast. In another instance, FIEC hosted a visit from the German Embassy delegation (FIEC NOTÍCIAS, 2023), led by the Director of the Division for Hydrogen Projects in Developing Countries from the German Ministry of Economic Affairs and Climate Protection; the delegation also included the Deputy Director of the German Agency for International Cooperation (GIZ Brasil). During this visit, FIEC presented the H<sub>2</sub>V industry chain in Ceará, focusing on wind and solar matrices, while sharing information that positioned Ceará in a privileged zone for foreign direct investments, as well as the shared management of the Pecém Port with the Port of Rotterdam. Another significant visit was from a delegation of Siemens (a German company specializing in industrial automation, software, infrastructure, building technology, and transport) to the H<sub>2</sub>V Hub (Pecém Port and ZPE) and the FIEC Industry Observatory (FIEC online, 2023).

In March 2024, FIEC also hosted a visit from the Belgian Embassy delegation. During this visit, the Belgian consul explained that the purpose of the visit was related to the energy and port sectors, facilitating future strategic ties between Ceará and Belgium. The FIEC presentation highlighted the advantages of Ceará for the development of the renewable energy industry, with an emphasis on H<sub>2</sub>V (FIEC online, 2024a).

A delegation from Voltalia, a French company operating in twenty countries as an energy producer, also visited Ceará to explore the region's capabilities and potential. Following this, the state government signed a preliminary contract with the company for the installation of a green H<sub>2</sub>V and ammonia production unit at CIPP, a project valued at US\$3 billion and expected to generate 5,000 jobs during the implementation phase (FIEC online, 2024b).

Another opportunity to promote Ceará as a provider of H<sub>2</sub>V was the participation of FIEC and CIPP in the World Hydrogen 2024 Summit & Exhibition, the largest global event on H<sub>2</sub>V, held in Rotterdam, the Netherlands. The international mission aimed to promote and attract participants for the FIEC Summit 2024, as well as to prospect and finalize potential business deals (FIEC online, 2024c).

In June 2024, FIEC and the State Government of Ceará presented the results of the H<sub>2</sub>V Masterplan for Ceará, a mapping of the opportunities expected to arise from production projects in the state. The study was conducted by the American consultancy IXL Center, involving specialists from Harvard University and MIT (Massachusetts Institute of Technology), researchers from over 15 different countries, senior consultants specializing in innovation, and representatives from various public and private organizations in Ceará (FIEC online, 2024d).

In August 2024, the third edition of the FIEC SUMMIT began. It is one of the largest events in Brazil related to the H<sub>2</sub>V chain, innovation, and technology. This event positioned Ceará as the focal point for discussions on energy transition, renewable energy, and the potential of H<sub>2</sub>V for socio-economic and industrial development (FIEC online, 2024e).

In the month of September alone, four significant activities and initiatives were carried out under the coordination of FIEC:

a. Reception of the Australian Ambassador to Brazil, during which ongoing projects focusing on renewable energy and green hydrogen (H<sub>2</sub>V) were presented, among other topics (FIEC online, 2024f);

b. Reception of a delegation from Mecklenburg-Vorpommern (Germany).

The meeting, organized by the Brazil-Germany Chamber of Commerce and Industry in Rio de Janeiro, aimed primarily at strengthening ties between the regions and exploring potential partnerships in industrial and energy projects in the state of Ceará (FIEC online, 2024g);

c. Reception of the Director of the Organization for Economic Cooperation and Development (OECD) Centre, during which projects on renewable energy, technology, and innovation were presented, alongside the state's potential for establishing global partnerships (FIEC online, 2024h);

d. Signing of a letter of intent with TÜV Rheinland Akademie GmbH (Germany), aimed at developing technical training for safety and health in the management and handling of H<sub>2</sub>V in Brazilian port areas. The event took place during the Brazil-Germany Economic Meeting, part of the International Hydrogen Ramp-Up Programme by GIZ (FIEC online, 2024i).

In October 2024, FIEC hosted a delegation of researchers from universities and representatives from Dutch companies working in innovation and energy transition fields. During this occasion, the H<sub>2</sub>V value chain was presented (ranging from renewable energy activities to advanced technological infrastructure at the Port of Pecém) along with renewable energy innovation projects within the Ceará industry (FIEC online, 2024j).

In December 2024, FIEC supported the World Summit on Energy Transition (WSOET), which brought together representatives from over 25 countries to discuss the challenges and opportunities of the future energy landscape. The event was organized by the Winds for Future Institute (IW4F) in partnership with the Global Institute for the Future of Tourism (GIFT) (FIEC online, 2024k).

As observed, FIEC has been fulfilling its role in promoting, publicizing, and fostering the H<sub>2</sub>V value chain in Ceará, both for national entities such as governments and foreign institutions. These actions and initiatives have the potential to attract investments and international partnerships, contributing to the consolidation of the state as a global player in the world's energy transition. Thus, aware of its commitments to the global energy transition, Ceará has been drawing closer to the international community, strengthening political, economic, and technological ties related to the development of the hydrogen economy (international cooperation).

### **Place (Distribution Chain)**

The term "place" refers to the point of sale or the location where a product or service is distributed to the end consumer (i.e., where the product is ultimately sold). According to Kuazaqui (2018, p. 54), it represents "the ways to physically distribute the product, involving both internal and external logistics structures."

For SEBRAE, whether physical or virtual, it refers to the location where a business is established to compete, attract customers, and achieve significant results, adding that the better the location, the easier it is to gain customers.

Madruga et al. (2006) highlight it as one of the most important marketing activities, considering that it can represent effective service, making the customer's purchase more convenient—a crucial factor in a competitive market. A well-structured distribution channel ensures product availability in the market, contributing to an improvement in customer retention rates (Arbache et al., 2006).

In international commerce, the seller/producer must adequately identify the market entry strategy through a set of actions organized by the relevant actors with the purpose of exporting (Kuazaqui, 2018).

In this context, the National Energy Policy Council (CNPE) Resolution No. 6/2022 is cited, which established the National Hydrogen Program (PNH2), highlighting the need to develop and consolidate the hydrogen market in Brazil and the country's international insertion on economically competitive bases, in addition to studying the export potential in the context of energy transition (MME, 2021).

To better understand this marketing element within the context of international commercialization of Ceará's green hydrogen (H<sub>2</sub>V), the starting point was the launch of the Hydrogen Hub in 2021 at the Pecém Industrial and Port Complex (CIPP). This initiative has the potential to generate renewable energy with a location close to strategic global ports, contributing to the development of the market and technology for the national industry, and positioning Ceará as an international reference and a platform for other countries (Oliveira, 2022).

Not by coincidence, in 2023, through a bilateral agreement (joint venture), the state governments of Ceará and the Netherlands established the Pecém (production and export) - Rotterdam (import and distribution) maritime corridor, thus creating a shipping route for the commercialization of H<sub>2</sub>V to Europe (Vasileva, 2023).



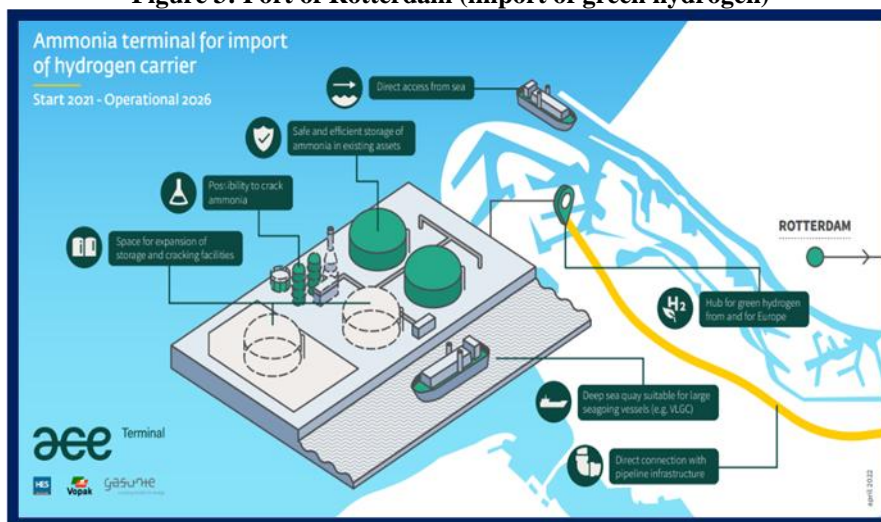
This strategic effort in international business was essential to build distribution channels for H<sub>2</sub>V in Europe, as Rotterdam is well-positioned in the European market, being a port complex that combines production and consumption, infrastructure for distribution to other European countries (with pipelines to Belgium and Germany), import terminals, and electrolyzers (FKA, 2022; Oliveira, 2022).

Technically and operationally, the advantages of Rotterdam lie in the port infrastructure, which is capable of unloading ships from all parts of the world, with storage tanks and other facilities equipped to convert green ammonia into H<sub>2</sub>V when necessary. It is also expected that a pipeline network will be developed for the transport of gaseous hydrogen, especially in regions like Europe, which is expected to become a major market (McKinsey, 2021).

The Port of Rotterdam is in contact with several European companies to explore potential buyers of hydrogen, mainly located in the Chemelot industrial center (southeast of the Netherlands) and in the surrounding areas of North Rhine-Westphalia (chemical industries, refineries, and steel mills) (FKA, 2022).

Thus, Rotterdam, considered the largest seaport in Europe, would be the primary gateway for Ceará's green hydrogen (H<sub>2</sub>V). After the departure of this energy vector from the Port of Pecém and crossing the Atlantic, one can envision its arrival in the "Old World" (Figure 3), thus illustrating part of the distribution channel in the European market.

**Figure 3: Port of Rotterdam (import of green hydrogen)**



Source: Port of Rotterdam (2024a).

From theory to practice, the logistical planning resulting from the Pecém-Rotterdam route would directly influence the reduction of costs (receipt, storage, sorting, and distribution) of hydrogen and the meeting of European market demands, confirming that, once again, the Pecém-Rotterdam agreement provides a significant competitive advantage over other exporting ports. For reference, demand for green hydrogen (H<sub>2</sub>V) from Rotterdam to Germany may reach 20 Gt per year by 2050, of which 18 Gt would come from imports (Figueirêdo, 2023).

For Rotterdam's administration, the goal of this partnership is to strengthen bilateral cooperation and promote initiatives between the Netherlands and Brazil in port development, port logistics, inland connectivity, and energy-related projects with ports (offshore wind energy and green hydrogen production) (Port of Rotterdam, 2023).

In general terms, is it possible to delineate part of the hydrogen consumer market in Europe? The answer is yes! Aligned with the European Union's climate goals, the industrial complex located in Northwestern Europe is committed to a significant reduction in greenhouse gas emissions by 2030, which would require maximizing energy efficiency and making large investments, such as in hydrogen (Port of Rotterdam, 2022).

Specifically, the Port Authority of Rotterdam clarifies that hydrogen distribution channels in Europe would take three different forms: a. Through the Delta Rhine Corridor, via pipeline networks linking Rotterdam to industrial complexes in the Netherlands, Germany, and Belgium. It is expected that the completion of this corridor will occur by 2031/2032, when several companies plan to import and distribute hydrogen (and derivatives) to their respective industrial complexes, thus consolidating a value chain for European decarbonization (Port of Rotterdam, 2024b); b. Through RH2INE/CONDOR H<sub>2</sub> transported by barges along European waterways; c. Through ammonia (NH<sub>3</sub>) and methanol (CH<sub>3</sub>OH) along the Texas-Rotterdam-Duisport-Worms route.

**Map 1: Hydrogen Supply Logistics in Europe.**

Source: Port of Rotterdam (URIBE, 2024, p. 23).

The good news is that the year 2024 concluded very promisingly for the distribution channel of Ceará's green hydrogen (H<sub>2</sub>V) in the international market. In November, the ports of Pecém (Brazil), Rotterdam (Netherlands), and Duisport (Germany) signed a Memorandum of Understanding (MoU) aimed at consolidating Europe's future decarbonization through this "green corridor" (Uribe, 2024).

In general terms, the relevance of this agreement:

- Would strengthen the central role of the Netherlands in connecting Brazilian fuel to Germany, as the Port of Rotterdam expects to import about 18 Gt of H<sub>2</sub> (and derivatives) by 2050. Part of this quantity would be sent to Germany via pipelines, waterways, and maritime transport;
- Would highlight the Port of Duisport, as it would not only support the development of Pecém but also contribute to the expansion of H<sub>2</sub>V distribution channels within Europe, strengthening the European green industry through the creation of new supply chains;
- Would develop North Rhine-Westphalia, considered the largest industrial hub in Germany, making it the first climate-neutral industrial region in Europe. Thus, under the aforementioned circumstances, decision-makers for the H<sub>2</sub>V produced in Pecém would be better positioned to formulate strategic plans, conduct market research, develop internationalization plans, and execute the export process.

#### IV. Conclusion

In this complex environment involving the global energy transition, where international markets tend to be highly competitive, it has been characterized that proper planning (short, medium, and long-term) has the potential to generate competitive advantages for businesses that engage in it. Therefore, the importance of developing strategies for positioning the green hydrogen (H<sub>2</sub>V) produced in Ceará in the international market. Thus, this article aimed to present the contributions of the international marketing mix applicable to the value chain of H<sub>2</sub>V in Ceará.

As a result of this analysis, it contributes to high-level decision-makers with tools that support the decision-making process in consolidating the state as a provider of energy to the "Old World." The research achieved its objectives as it enabled a better understanding of aspects of the business environment within the complex and dynamic energy sector, which could be used by government bodies, companies, and industries involved in the entire H<sub>2</sub>V production cycle. The research demonstrated how the marketing mix, in light of the "4Ps," would contribute to the planning, management, and decision-making process of stakeholders from the government of the State of Ceará, the FIEC System, and CIPP. In this way, it would strengthen Ceará's well-known competitive advantages in managing the H<sub>2</sub>V value chain.

Furthermore, the qualitative approach, through the literature review, was essential for understanding the complexity of H<sub>2</sub>V production and, from there, applying the marketing mix concepts in favor of production and exportation. The study revealed that it is feasible and practical to apply the "4Ps" concepts to deepen the knowledge related to the insertion of Ceará's H<sub>2</sub>V into the European continent. In this regard, the article demonstrated that high-level decision-makers could benefit from these insights in better defining the strategic planning of the entire production and export cycle of the fuel of the future.

For future research, it is recommended to monitor the evolution of H<sub>2</sub>V prices in both national and international markets and to identify, in more detail, after its delivery at the Port of Rotterdam, the distribution channels in Europe that may be of interest to FIEC and CIPP. Additionally, it would be essential to assess the consistency of promotional and publicity activities related to H<sub>2</sub>V to entities, companies, institutions, and international governments, in a way that aligns with Ceará's strategic stature as a global player in the energy transition, further stimulating the European market's interest in partnering with the state in this global energy transition.

### References

- [1]. Arbache Et Al. (2006). *Logistics Management, Distribution, And Trade Marketing* (3rd Ed.). Fundação Getúlio Vargas, Editora FGV.
- [2]. Barbosa, M. C., & Gomes, R. L. R. (2024a). 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. Retrieved From <Http://Www.Iosrjournals.Org> (Accessed: December 21, 2024).
- [3]. Barbosa, M. C., & Gomes, R. L. R. (2024b). Ceará, The Federation Of Industries Of The State Of Ceará (FIEC), And Green Hydrogen Production: A Global Benchmark In Energy Transition And Economy Decarbonization. Retrieved From <Http://Www.Iosrjournals.Org> (Accessed: December 21, 2024).
- [4]. Berger, R. (2023). *How To Capture Value In The Emerging Hydrogen Market*. France. Retrieved From <Https://Shre.Ink/Bz2l> (Accessed: October 20, 2024).
- [5]. Bezerra, F. D. (2023). Green Hydrogen: An Opportunity For The Northeast. *Banco Do Nordeste. ETENE Sectoral Notebook*, 8(320).
- [6]. Brasil. Ministério De Minas E Energia (MME). (2021). *National Hydrogen Program: Proposal Of Guidelines*. Brasília.
- [7]. Brasil. Ministério De Minas E Energia (MME). (2023). *National Hydrogen Program: Three-Year Work Plan 2023-2025*. Brasília.
- [8]. Carioni, R. (2006). *Marketing Management I*. UNISUL.
- [9]. Carioni, R., & Neves, J. B. (2008). *International Marketing Management* (2nd Ed.). UNISUL.
- [10]. Carvalho, Y. M. (2020). From The Old To The New: Literature Review As A Method Of Doing Science. *Thema Journal*, 16(4), 913–928. <Https://Doi.Org/10.15536/Thema>
- [11]. Ceará. (2023). The Green Hydrogen Chain Predicts A Series Of Actions To Ensure Professional Qualification In Ceará. Retrieved From <Https://Shre.Ink/Bfcl> (Accessed: December 28, 2024).
- [12]. FIEC. (2021). The Green Hydrogen Hub Is Launched In Ceará In Partnership With FIEC. Retrieved From <Https://Www1.Sfiee.Org.Br/Sites/Numa/?St=Noticia&Id=139592> (Accessed: September 31, 2024).
- [13]. FIEC. (2024). Master Plan Green Hydrogen Ceará: Building Ceará's Green Hydrogen Hub. Final Report. Fortaleza.
- [14]. FIEC Notícias. (2021, November 2). FIEC Participates In COP 26 With A Lecture On Green Hydrogen. Retrieved From <Https://Www1.Sfiee.Org.Br/Sites/Numa/?St=Noticia&Id=145584> (Accessed: September 13, 2024).
- [15]. FIEC Notícias. (2023). FIEC President Welcomes A Delegation From The German Ministry Of Economic Affairs And Climate Protection At The Industry House. Retrieved From <Https://Shre.Ink/Bfex> (Accessed: October 13, 2024).
- [16]. FIEC Online. (2023). Ricardo Cavalcante And Paulo André Holanda Welcome A Siemens Delegation At FIEC, Focusing On The Green Hydrogen HUB. Available At: <Https://Shre.Ink/Bfce>. Accessed November 16, 2024.
- [17]. FIEC Online. (2024a). FIEC Hosts The Belgian Embassy Delegation. Published March 15, 2024. Available At: <Https://Shre.Ink/Bfcm>. Accessed November 13, 2024.
- [18]. FIEC Online. (2024b). Ricardo Cavalcante And Carlos Prado Welcome The French Renewable Energy Producer Voltalia Delegation. Published April 11, 2024. Available At: <Https://Shre.Ink/Bfcg>. Accessed October 16, 2024.
- [19]. FIEC Online. (2024c). FIEC Participates In The World's Largest H2V Event, The World Hydrogen 2024 Summit & Exhibition, In Rotterdam. Published May 13, 2024. Available At: <Https://Shre.Ink/Bfcd>. Accessed October 13, 2024.
- [20]. FIEC Online. (2024d). FIEC And The State Government Present The Masterplan, Mapping Opportunities In The Green Hydrogen Value Chain In Ceará. Available At: <Https://Shre.Ink/Bfc8>. Accessed October 20, 2024.
- [21]. FIEC Online. (2024e). FIEC Summit 2024 Starts In Fortaleza, With The Presence Of Authorities And Entrepreneurs Debating H2V And Energy Transition. Available At: <Https://Shre.Ink/Bfcr>. Accessed October 19, 2024.
- [22]. FIEC Online. (2024f). Ricardo Cavalcante Welcomes The Australian Ambassador To Brazil At The Casa Da Indústria. Available At: <Https://Shre.Ink/Bfci>. Accessed December 10, 2024.
- [23]. FIEC Online. (2024g). FIEC And The German Delegation Hold A Networking Meeting To Discuss Potential Energy Projects In Ceará. Available At: <Https://Shre.Ink/Bfcf>. Accessed December 17, 2024.
- [24]. FIEC Online. (2024h). FIEC Hosts A Visit From The OECD Director To Showcase Ceará's Industry Potential In Renewable Energies, Technology, And Innovation. Available At: <Https://Shre.Ink/Bfcp>. Accessed December 15, 2024.
- [25]. FIEC Online. (2024i). Germany: FIEC, Through SENAI, Signs A Letter Of Intent To Develop And Ensure Safety Standards For H2V Handling. Available At: <Https://Shre.Ink/Bfcb>. Accessed December 27, 2024.
- [26]. FIEC Online. (2024j). FIEC Welcomes The Dutch Delegation To Showcase Opportunities In The Green Hydrogen Value Chain And Innovation Actions In Ceará's Industry. Available At: <Https://Shre.Ink/Bfcw>. Accessed December 23, 2024.
- [27]. FIEC Online. (2024k). FIEC Participates In A Global Event On Energy Transition. Available At: <Https://Shre.Ink/Bfct>. Accessed December 20, 2024.
- [28]. Figueirêdo, H. (2024). CIPP. Energy Transition And Green Hydrogen Production Seminar: Transforming Ceará And Brazil's Economy Through The Green Hydrogen Hub In Pecém. Available At: <Https://Shre.Ink/Bv2f>. Accessed December 13, 2024.
- [29]. KAS. Konrad Adenauer Foundation. (2022). *Cooperation Between Brazil And Europe: Geopolitical Importance And Innovation Prospects*. Brazil-Europe Relations Series No. 12. Rio De Janeiro, Brazil.
- [30]. International Energy Agency (IEA). (2019). *The Future Of Hydrogen*. Paris, France. Available At: <Https://Bit.Ly/3omzx0m>. Accessed December 6, 2024.
- [31]. International Renewable Energy Agency (IRENA). (2022). *Geopolitics Of The Energy Transformation: The Hydrogen Factor*. Abu Dhabi, UAE.
- [32]. Kotler, P. (1994). *Marketing Management: Analysis, Planning, Implementation, And Control* (4th Ed.). São Paulo, Brazil: Atlas.
- [33]. Kuazaqui, E., & Others. (2018). *International Relations: Challenges And Business Opportunities For Brazil*. Federal And Regional Councils Of Administration Of São Paulo. São Paulo, Brazil: Literate Books.
- [34]. Lösch, S., Rambo, C. A., & Ferreira, J. De L. (2023). Exploratory Research In The Qualitative Approach In Education. *Revista Ibero-Americana De Estudos Em Educação*, 18(00), E023141. E-ISSN: 1982-5587. <Https://Doi.Org/10.21723/Riaee.V18i00.17958>

- [35]. Madruga, R. P., & Others. (2006). *Marketing Management In The Contemporary World* (3rd Revised Ed.). Rio De Janeiro, Brazil: Fundação Getúlio Vargas.
- [36]. Martins, T. (2021). Green Hydrogen Places Brazil On The Radar Of Investors. *Revista Brasil-Alemanha*, 29(1).
- [37]. Mckinsey & Company. (2021, November 25). Green Hydrogen: An Opportunity To Generate Wealth With Sustainability For Brazil And The World. Retrieved From <https://shre.ink/Bv2j>
- [38]. Mckinsey & Company. (2022, November 9). A Hidden Treasure: The Opportunity For Brazil To Become A Leader In The New Green Economy. Retrieved From <https://shre.ink/Bv2o>
- [39]. Nunes, F., & Picanço, J. (2021). *Academia Cearense De Engenharia. Green Hydrogen: A Pathway To Ceará's Development*. Fortaleza, Brazil. Oliveira, R. C. De. (2022). *Overview Of Hydrogen In Brazil*. Discussion Paper 2787. Brasília, Brazil: Instituto De Pesquisa Econômica Aplicada (IPEA).
- [40]. Oliveira, J. C. R. De. (2024). *Renewable Energies And Green Hydrogen: Pillars Of The Energy Transition And Brazil's Opportunity*. Course Completion Work, Lato Sensu Postgraduate In Electricity Sector Regulation, Federal University Of Rio De Janeiro.
- [41]. UN Policy Briefs In Support Of The High-Level Political Forum. (2022). *Addressing Energy's Interlinkages With Other Sdgs*. Retrieved From [2022-UN\\_SDG7 Brief-060122.Pdf](https://www.un.org/development/desa/policy/2022-UN_SDG7_Brief-060122.Pdf) Porter, M. E. (2004). *Competitive Strategy: Techniques For Analyzing Industries And Competitors* (2nd Ed.). Rio De Janeiro, Brazil: Elsevier.
- [42]. Port Of Rotterdam. (2024a). *Ammonia Terminal For The Import Of Hydrogen Carrier*. Retrieved From <https://shre.ink/Bfcq> Port Of Rotterdam. (2024b). *Green Energy From Brazil For Germany*. Retrieved From <https://shre.ink/Bfxx>
- [43]. Port Of Rotterdam. (2023, May 11). *Ports Of Rotterdam And Pecém (Brazil) Join Brazilian-Dutch Cooperation*. Retrieved From <https://shre.ink/Bfc2>
- [44]. Port Of Rotterdam. (2022, April 6). *Broad Industry Support For Delta Corridor Project*. Retrieved From <https://shre.ink/Bfcc>
- [45]. Raccichini, A., Contardi, M., & Ristuccia, M. S. (2022). *Innovative Energy Climate Action: Part 4: The Brazilian Hydrogen Move*. Fundação Getúlio Vargas (FGV), FGV Europe. Retrieved From <https://shre.ink/Bv2v>
- [46]. Santos, P. R. Dos, & Gandara, S. Da S. S. (2022). *Mapping Of Patents Filed In Brazil On Technologies Related To Hydrogen Production With A Focus On Green Hydrogen*. Instituto Nacional Da Propriedade Industrial. Rio De Janeiro, Brazil. Retrieved From <https://shre.ink/Bv2z>
- [47]. Uribe, D. (2024). *Port Of Rotterdam As A Gateway To Northwest Europe For The Brazilian H2 Market*. World Hydrogen Summit.
- [48]. Vasileva, A. (2023). *Hydrogen Market Updates From Across Latin America*. Intelligence Report, World Hydrogen Leaders. Chile.
- [49]. World Energy Council (WEC). (2021). *National Hydrogen Strategies: Hydrogen On The Horizon: Ready, Almost Set, Go?*