

The Contributions of Michael Eugene Porter's Five Competitive Forces in the Strategic Planning of Green Hydrogen Production in Ceará and Its Export to Europe

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Abstract:

Background: This paper addresses Michael Porter's contributions to the current business environment in which the State of Ceará is inserted due to the production of green hydrogen and its export to Europe. It describes the general principles of strategic planning applied in the context of the energy transition, in addition to applying the concepts of Porter's Competitive Forces in the current business environment.

Materials and Methods: This research adopted a qualitative approach, essential to explore the planning and applicability of Porter's concepts in the H₂V value chain. The procedure used was a literature review, which involved consulting sources classified into two categories: (1) sources on strategic planning and (2) sources on Porter's Competitive Forces, allowing them to be applied in this energy vector.

Results: The studies indicate that it is possible for high-level managers to benefit from these concepts in order to strengthen Ceará as an energy supplier to Europe.

Conclusion: The research highlights the potential for the application of Porter's Competitive Forces in the strategic planning of green hydrogen production in Ceará, offering insights for high-level managers involved in decision-making processes regarding the state's insertion in the European market.

Keywords: Ceará; Europe; Green Hydrogen; Porter; Production.

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I. Introduction

Those responsible for high-level decision-making possess a range of tools at their disposal that allow for the analysis of the business environment. After the correct application of these tools and methodologies, decisions are substantiated in favor of strengthening productive activities. The current scenario in which the State of Ceará finds itself is promising regarding the production of green hydrogen (H₂V), thanks to the competitive advantages derived from its strategic location in northeastern Brazil and its ease of generating wind and solar energy.

These circumstances are reflected in Ceará's strategic planning, which is part of a longer-term timeline. Therefore, it is crucial to continuously monitor current and future trends related to energy transition, as well as to assess national and international contexts related to H₂V production, in order to contribute to the state's goal of participating in the global economy's decarbonization process.

One such tool is Michael Porter's Five Competitive Forces, which helps identify limitations, threats, and business opportunities within the main actors involved in the H₂V market, particularly with Europe. Regarding the methodology used, a qualitative approach was chosen. The research methods included a bibliographic and documentary study conducted through publications (both national and international), reports from international organizations, and websites. By consulting and consolidating these materials, it was possible to raise the most important issues addressed in this study.

Thus, the general objective of this paper is to present the contributions of Porter's Five Competitive Forces in the current H₂V production scenario in Ceará. As a result of this analysis, the aim is to provide high-level decision-makers with information that supports the business model, contributing to the state's role as a producer and exporter of this energy vector (fuel of the future) to the European market.

The specific objectives are: to describe the general principles of strategic planning applied in the current business environment of Ceará, and to characterize how Porter's Five Forces would contribute to studies, analyses, and assessments of Ceará's competitiveness in producing and exporting H₂V to Europe.

This paper is structured in four sections that aim to provide a comprehensive analysis of the applicable Porter's Forces within the H₂V value chain. The first section, Introduction, presents the central theme of the study.

The second section, Methodology, describes the approach adopted for the research, including data collection and analysis strategies. The third section, Theoretical Foundation, provides an explanation of the general principles of strategic planning and its importance for the State of Ceará, as well as the application of Porter's Forces concepts in the context of the H₂V value chain. Finally, the Conclusion section summarizes the main findings of the research, highlighting the advantages of understanding Porter's Forces for high-level decision-makers when it comes to H₂V production and export to Europe.

II. Material And Methods

The approach adopted in this research was qualitative in nature, as the main objective was to apply the concepts of Porter's Five Forces to the current scenarios of the H₂V production chain in Ceará. The qualitative approach is widely recognized in the scientific community for its ability to provide contextual analyses, allowing for an evaluation of the H₂V situation in Ceará for Europe. Qualitative research focuses on interpreting and understanding complex phenomena, making it essential in fields that involve a production chain for an energy vector, where variables are broad and dynamic.

Regarding the qualitative approach, González (2020, p. 03) highlights that in Qualitative Research, “the Epistemological Place is emphasized and occupied by researchers, thus assuming cognitive commitments to the quality of the research”.

The research procedure adopted was a literature review, an essential methodology in the construction of scientific knowledge, as it allows for a critical and integrated analysis of existing information on a given topic. According to Lakatos and Marconi (2017), a literature review contributes to an expanded understanding of the object of study, in addition to promoting the consolidation of well-founded approaches.

For the implementation of this review, the research sources were selected and classified into two main categories: (1) specific sources on the general principles of strategic planning, and (2) Porter's Five Forces and their applicability in the current context of H₂V production in Ceará and its export to Europe.

The classification of these sources allowed for a more precise and contextualized analysis, enabling the construction of a robust discussion on the applicability of Porter's Forces in the H₂V value chain in Ceará. The review was conducted through consulting reports from international organizations, recent articles, websites, and books, ensuring a comprehensive scope that reflected the most relevant and current contributions in the field.

III. Literature Review

The theoretical foundation of this study is organized into two main subsections: 3.1 General Principles of Strategic Planning and 3.2 Porter's Five Competitive Forces.

Section 3.1, General Principles of Strategic Planning, explores the fundamental concepts and methodologies that underpin the formulation of strategic plans within organizations. This section provides a comprehensive review of the key theories and frameworks that guide strategic decision-making, emphasizing the importance of long-term vision, resource allocation, and competitive positioning. By understanding these principles, organizations are better equipped to navigate complex and dynamic business environments, ensuring their sustainability and growth.

Section 3.2, Porter's Five Competitive Forces, delves into Michael Porter's influential framework for analyzing the competitive dynamics within an industry. This section outlines the five forces—competitive rivalry, the threat of new entrants, the threat of substitute products or services, bargaining power of suppliers, and bargaining power of buyers—and examines how these forces shape the strategic landscape of businesses. The application of this model is essential for understanding market competition and developing strategies that can effectively address the challenges posed by these forces.

Together, these two subsections provide a robust theoretical foundation for the study, enabling a thorough understanding of the strategic planning processes and the competitive forces at play within the context of the H₂V production and exportation scenario in Ceará.

General Principles of Strategic Planning

The execution of international operations inherently involves uncertainties and risks. Such uncertainties arise from operating in markets distinct from the domestic one, with political-legal and socio-economic systems that may differ significantly (Rocha & Almeida, 2006). The production of green hydrogen (H₂V) in Ceará and its subsequent export to Europe is no exception. It requires meticulous planning from high-level managers to navigate these challenges effectively. Moreover, planning is a quintessential human activity, deeply embedded in rational nature, which allows individuals to reflect on current circumstances and anticipate possible future outcomes. One of its main purposes is to evaluate the potential implications of present decisions, thereby fostering a decision-making process that considers their impact on the desired future (Martignago, 2011).

In the context of the global economic decarbonization process, the strategic planning process is particularly significant, as it provides long-term direction for organizations. At this juncture, setting organizational

objectives and establishing a strategy to achieve them becomes paramount (Robbins, DeCenzo, & Wolter, 2012). Through strategic planning, managers are able to conduct diagnostics, define strategies, plan execution, allocate resources, generate innovation, enhance competitiveness, and ultimately add value to the business (Chiavenato, 2013).

According to Albuquerque et al. (2021), strategic planning is essential for identifying organizational objectives, analyzing the external environment, and aligning the company's goals with its long-term vision. To guide these processes effectively, managers must possess conceptual competence, defined as the ability to analyze and diagnose complex situations, work with ideas, and view the business as a system of interrelated parts. This competence allows them to make better decisions and anticipate potential business challenges (Robbins, DeCenzo, & Wolter, 2012; Rebouças, 2018).

Furthermore, it is essential to analyze and assess situations clearly, gather accurate data, and critically evaluate facts to make well-informed decisions (Rebouças, 2018). The formulation and implementation of appropriate strategies, based on a comprehensive understanding of both internal and external environments, signify the strategic management of an organization (Toni, 2021). In a competitive business model, it is a well-established notion that any organization aiming to enter an increasingly competitive and dynamic market must innovate, develop effective negotiation strategies, and offer high-quality products and services at competitive prices to surpass competitors, retain customers, and create efficient metrics for their operations and processes (Araújo, 2021, p. 11).

The absence of strategic planning exposes an organization to future uncertainties and the various internal and external forces that influence its competitiveness in the industrial sector (Martignago, 2011). This highlights the necessity for strategic planning to guide business decisions effectively. Given these considerations, stakeholders involved in the H₂V value chain in Ceará, particularly within the Pecém Industrial and Port Complex (CIPP), can benefit from Porter's Five Competitive Forces. This framework would provide valuable insights, helping them make informed decisions when it comes to exporting H₂V to Europe. In this context, strategic planning, underpinned by Porter's concepts, would enable a more efficient decision-making process, fostering innovation, aligning efforts with organizational goals, and identifying potential political, economic, social, and technological changes that could impact competitiveness.

This proactive approach ensures that Ceará's competitiveness remains robust in the international arena, where the state is already gaining recognition (Vidal Jr & Vidal, 2022). By leveraging strategic planning and Porter's model, Ceará's position as a key energy supplier in the global market will be further reinforced, allowing it to thrive in the evolving global economy.

The Five Competitive Forces of Porter

In order to assist companies in analyzing their business environment, Michael Eugene Porter, a professor at Harvard Business School, suggested a model in 1979 to track competition in the industry. The more knowledge a company possesses, the greater its chances of gaining competitive advantages over other competitors, increasing the company's profits. In fact, understanding market competitiveness would be crucial for defining the best strategies for the company. Thus, Porter's Forces are a set of ways to analyze the business model with a holistic view of the market, enabling diagnostics for decision-making. When considered together, they help to determine whether a particular industry is attractive or not, aiding in the identification of opportunities or threats (Martignago, 2011). This study, widely applied in strategic planning, influences the development of efficient business strategies. Furthermore, it would offer the opportunity to understand the macro-business environment in which Ceará's H₂V (Hydrogen) could be inserted within Europe, with the advantage of identifying its positioning in relation to international competitors.

Rivalry Among Competitors

Globalization has intensified competition in most markets by increasing the number of competitors. The greater the number of companies in a particular sector, the higher the competition in that market (Porter, 2004). The aforementioned assertions fit perfectly with the current international scenario of energy transformation, where several countries have implemented policies aimed at decarbonizing their industries due to the international commitment to reduce greenhouse gas emissions and mitigate the effects of global warming. This raises a question: what would make the market more competitive? How could producers differentiate themselves to gain a larger market share in the global market? Part of these answers can be found in Ceará, as the state's territorial extension, with areas suitable for wind and photovoltaic energy generation, would provide the capability to be a strong global producer and potential exporter of H₂V, contributing to a greater global supply of H₂V (Barbosa & Gomes, 2024).

In Porter's studies, when a product or service is considered a basic necessity, homogeneous, consumers tend to choose it based on price, which intensifies the rivalry among competitors (Martignago, 2011). Since H₂V is considered an energy vector with commodity characteristics, produced through a physical-chemical process

(electrolysis), it would not have any differentiation in terms of quality between one producing country and another. At the national level, it is anticipated that the competitive differential of H₂V in Cear a's CIPP (Hydrogen Production and Industrial Complex) would be strongly influenced by the already established competitive advantages in Cear a. It is important to highlight that part of this competitiveness would stem from delivery time to Europe and production costs. The former would be due to the proximity of the Northeast to the European continent, and the latter would result from the low costs of generating wind and solar photovoltaic energy in the state (Barbosa & Gomes, 2024).

However, a report by the International Renewable Energy Agency (IRENA) states that having access to abundant renewable energy is an advantage in the energy race, but it is not enough, as other factors such as infrastructure, capital cost, access to technologies, government support, investments, and political stability are also important (IRENA, 2022). In the same direction, Uribe (2024, p. 8), at the World Hydrogen Summit 2024, highlighted the key criteria for analysis for potential hydrogen producers and exporters, such as the availability of infrastructure, electrical grid, political stability, public policies, legislation, transportation and storage, renewable energy sources, and workforce. Thus, the state of Cear a, when positioning itself as a global player in the offer of H₂V worldwide, should certainly base itself on the criteria identified above in terms of competitive advantages. Regarding global competitors, there are countries with high-quality resources for hydrogen production, widely dispersed around the globe. Many exporting countries are also endowed with renewable resources that could produce hydrogen (Oliveira, 2022). An analysis of potential competitors of Cear a (and Brazil) would reference the same IRENA report, which states that countries in Africa, the Americas, the Middle East, and Oceania would have greater technical potential for production, with their ability to produce large volumes varying according to the strategies of each country (IRENA, 2022). In South America, Chile would stand out; in Oceania, Australia; and in Africa, Morocco (Map 1).

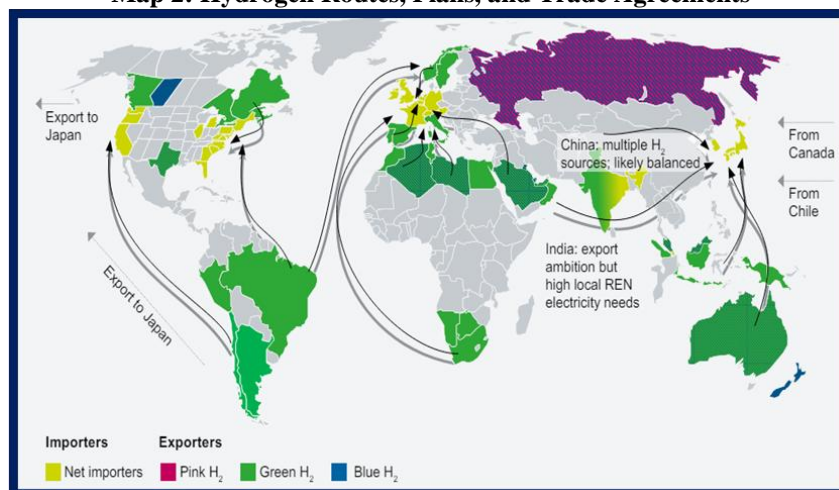
Map 1: Hydrogen Routes, Plans, and Trade Agreements (IRENA).



Source: IRENA (2022, p. 13).

In another study, Roland Berger identifies the largest hydrogen importing and exporting regions. In South America, Chile, for example, would have the west coast of the United States and Japan as export markets, while Brazil would target Europe and the Atlantic coast of the United States (Map 2).

Map 2: Hydrogen Routes, Plans, and Trade Agreements



Source: Berger (2023, p. 6).

For the Port of Rotterdam, the potential hydrogen-producing and exporting countries were identified in Map 3.

Map 3: Potential H₂V Exporting Countries



Source: Uribe (2024, p. 7).

Among the main regions that would operate in the H₂V sector, Latin America, the Middle East, Australia, and Chile stand out as major exporters, with China being the largest producer in the world, aiming to “produce between 100,000 and 200,000 tons annually by 2025” (Oliveira, 2022, p. 8).

In the H₂V Masterplan, launched in 2024 in Ceará, studies conducted by the U.S. consultancy IXL Center, with the participation of the Massachusetts Institute of Technology, Harvard University, senior researchers, and consultants, indicated that Ceará's main competitors would be Spain, Morocco, and Canada (FIEC, 2024, p. 32).

Regarding Europe, the Port of Rotterdam (Netherlands), considered the largest port for H₂V importation in the world, has already established partnerships with many countries, totaling over 30 Memoranda of Understanding (MoU) signed with Morocco, Portugal, Iceland, Oman, Uruguay, Chile, Australia, South Africa, Brazil, Scotland, Canada, Egypt, Spain, Argentina, Saudi Arabia, the United Arab Emirates, and Norway. Approximately one-third of the 20 million tons of hydrogen and derivatives imported would remain in the Netherlands, while two-thirds would be sent to Germany and other countries (FKA, 2022, p. 83).

In any case, it is estimated that cross-border trade would gain momentum in the 2030s due to the maturity and competitiveness of the technology (Lima, 2023, p. 47). It is, therefore, up to the managers in Ceará to continually analyze and assess potential competing countries or companies for the H₂V produced in CIPP, identifying threats or partnership opportunities.

Bargaining Power of Buyers

In general terms, in the second competitive force of Porter, buyers push prices down and bargain for higher quality (Martignago, 2011). In this article, the buyers (clients or consumers) are potential importing countries of H₂V located in Europe, seeking to replace fossil fuels with cheaper and less polluting energy sources, in line with the decarbonization of industries due to global warming (Barbosa & Gomes, 2024).

The aspects that may pose a threat to the energy industry in Ceará, as related to the buyers, could include the following:

a. Ability to Acquire Large Volumes

According to IRENA, hydrogen is likely to influence the shift in energy trade geography. With renewable energy costs decreasing, the geopolitical map will show increasing regionalization in energy relations. For the International Energy Agency (IEA), production is expected to increase from 90 million tons in 2020 to over 200 million tons by 2030. Estimates from the Hydrogen Council indicate that Brazil has the potential to become a key player (both in production and export) in the H₂V market, which is expected to reach \$2.5 trillion globally by 2050, accounting for about 20% of the global energy demand (Martins, 2021, p. 31). As a reference, Rotterdam's demand to Germany could reach 20 million tons per year by 2050, with 18 million tons being imported. “From Ceará's side, with an estimated production of 1.3 million tons per year in 2030, CIPP could meet 25% of Rotterdam's import demand” (Figueirêdo, 2023, p. 7). In summary, the above figures indicate the projected production of extremely large volumes of H₂V both globally and locally, which could be used by buyers to push down prices in Ceará.

b. Standardized and Little Differentiated Products

H₂V is produced from renewable energy sources without carbon emissions. This production is based on electrolysis, an electrochemical process that splits water into H₂ and O₂. With decreasing renewable electricity

costs, interest in electrolytic hydrogen is increasing, requiring about 9 liters of water to produce 1 kg of H₂ and 8 kg of oxygen (Oliveira, 2022, p. 15). Since this energy vector is considered a commodity, with no technical differentiation, European consumers would opt for the most competitive product, i.e., the cheapest or the one with other advantages for the buyer (e.g., shorter delivery time). Despite Ceará's privileged location and low renewable energy production costs, European buyers could exert pressure on pricing. As seen, production relies on chemical processes, with no distinction between production in Ceará or another country. In such circumstances, the European buyer would have the ability to bargain for a lower price, and if negotiations fail, would have the freedom to seek another competing supplier outside of Ceará.

c. Buyer Has Full Information About the Market

International institutions like IEA and IRENA have published detailed studies and reports on H₂V, and several countries have developed their own national policies. All of this information about demand, market prices, and supplier costs gives the buyer more bargaining power (Martignago, 2011). It has been mapped that large-scale hydrogen development could create a new industrial sector for producing high-tech equipment. "Regional supply chains for manufacturing equipment (such as electrolyzers) could create opportunities and jobs beyond large economies" (IEA, 2021, p. 9). In addition, governments of potential exporting countries are implementing political strategies with many other countries at the highest levels of diplomacy. Over time, these agreements would likely give way to new commercial relations, new maritime routes, and new trade corridors (IRENA, 2022). The H₂V Masterplan itself is a comprehensive publication that presents detailed and meticulous studies on H₂V market prospects, allowing various national and international stakeholders to gain insight into the hydrogen economy. Thus, it is possible that Ceará, during the sales negotiation process, could be pressured by European buyers to lower prices due to their knowledge of important information about the CIPP.

d. High Market Competitiveness

The bargaining power of buyers is directly related to the degree of competitiveness among companies. As the customer is the ultimate decision-maker in the purchase (product, goods, and services), they hold part of the bargaining process, always seeking, obviously, their own economic benefit—lower prices, for example. In light of the war in Ukraine, European countries were forced to reduce their dependence on Russian gas and diversify their energy matrices by increasing renewable energy sources. Thus, Ceará, leveraging the competitive advantages already mentioned, would have a significant opportunity to export to Europe via the Port of Rotterdam (Barbosa & Gomes, 2024). Given the global race in H₂V production, the sooner this product is available for export, the faster the European market would purchase it.

Bargaining Power of Suppliers

Suppliers can diminish an industry's profitability when they exercise their bargaining power over buyers, potentially threatening to raise prices or reduce the quality of the supplied products (Martignago, 2011). In this way, such power could determine how dependent a company becomes on the suppliers of its products, goods, and services.

Conceptually, according to the Brazilian Service of Support to Micro and Small Enterprises (SEBRAE), if a company relies on a few suppliers, it is likely to become dependent on decisions regarding prices, deadlines, and quality levels. Another possibility is that the same suppliers may decide to supply competitors as well, a situation that would increase the risks and vulnerabilities related to the fulfillment of the company's strategic planning. For a better understanding of the suppliers in the H₂V production chain at CIPP, the analysis will focus on Figure 1.

Figure 1: Green Hydrogen Value Chain at Pecém Complex



Source: Nunes, Picanço (2021, 47).

As observed, the chain is complex, highlighting a diversity of suppliers, circumstances in which suppliers would be strong in negotiations when: a. The offered product is a crucial input for the buyer. This increases the supplier's bargaining power when the input is in high demand in the market, allowing for a higher price. Consequently, the company is forced to pay more to avoid losing its suppliers (Araújo, 2021). Among the activities in Figure 1, one was identified that could potentially increase the bargaining power of international suppliers. In the context of the energy transition, the most relevant component in H2V production is the electrolyzer, which could be of the ALK (alkaline) or PEM (proton exchange membrane) type. Globally, it is expected that PEM will surpass ALK by 2030, as production expands with a greater number of patents and investments in R&D (FIEC, 2024). According to the report "Global Electrolyzer Market: Growth, Trends, and Forecast for 2029" (Blackridge Research, 2024), China, Europe, and North America have grown and emerged as important players in the electrolyzer market using advanced technology (Table 1).

Table 1: Main Global Hydrogen Electrolyzer Manufacturers, 2024

S.No.	Owner Company	Location of the Plant	Current Electrolyzer Production Capacity (MW)
1	LONGi Hydrogen Technology Co., Ltd.	China	5,000
2	Plug Power, Inc.	Woodbine, Georgia, U.S.	2,500
3	Hygreen Energy	Shandong, China	2,000
4	Bloom Energy Corporation	Newark, New Jersey, United States of America (U.S.A.)	2,000
5	ITM Power Plc	Sheffield, U.K.	1,500
6	PERIC Hydrogen Technologies Co., Ltd.	Handan City, Hebei Province, China	1,500
7	McPhy Energy S.A.	San Miniato, Italy	1,300
8	Electric Hydrogen Co.	Devens, Massachusetts, U.S.A.	1,200
9	Thyssenkrupp Nucera AG & Co. KGaA	Germany	1,000
10	John Cockerill S.A.	Suzhou, China	1,000
11	Cummins, Inc.	Fridley, Minnesota, U.S.A.	1,000
12	Nel ASA	Heroya, Norway	500
13	HydrogenPro ASA	Heroya, Porsgrunn, Norway	500
14	Sunfire GmbH	Solingen, Germany	500
15	Ohmium International, Inc.	Bengaluru, India	500

Fonte: *Blackridge Research*¹

China is the world's largest low-cost electrolyzer producer, with three major manufacturers controlling the Chinese industry. Due to trade disputes, Europe and North America are unlikely to purchase their electrolyzers, creating an opportunity for neutral countries like Brazil (FIEC, 2024). The same country accounts for about 40% of global production capacity, and several economies, including India, the European Union, and the United States, have launched policies to support electrolyzer production capacity (Muniz, Carvalho & Junior, 2024). Numerous large-scale Chinese orders may have delivery times exceeding two years (FIEC, 2024, p. 118).

a. The industry is not an important client for the supplier group: When the industry is not a significant client, the supplier's performance is less dependent on the industry's outcomes (Martignago, 2011). In this case, losing the client would not substantially impact the supplier, but the reverse is true for the industry: losing a supplier would impact the quality and sales of products. Thus, managing supplier relationships carefully, particularly with electrolyzer manufacturers, is critical. Companies should avoid depending on just one or two suppliers.

Threat of New Entrants (Barriers to Entry)

The threat of new entrants depends on existing barriers and the reaction expected from competitors. If barriers are high, entry is discouraged; if they are low, new entrants can easily access the market (Martignago, 2011). New entrants could lead to lower profits, price reductions, and difficulties in negotiating with suppliers (Porter, 2004). The following situations could create obstacles, hindrances, and disincentives for establishing new businesses in a specific economic sector: a. Economies of Scale: Economies of scale refer to the reduction in unit costs as the volume of production increases over time. In this case, the company is forced to enter the market on a large scale or face a cost disadvantage if it enters on a small scale, both of which are undesirable options for new entrants (Martignago, 2011). The H₂V market from Ceará would target Europe, accessing the market via the port of Rotterdam. Studies estimate a production of 1.3 million tons/year by 2030, with potential to supply 25% of the

¹ Top 15 Hydrogen Electrolyzer Manufacturers in the World. Disponível em: <https://www.blackridgeresearch.com/blog/list-of-global-top-hydrogen-electrolyzer-manufacturers-companies-makers-suppliers-in-the-world>. Acesso em 03 fev. 2025.

port's import demand (Figueirêdo, 2023). Since European hydrogen production is insufficient to meet demand, importing from countries where hydrogen can be produced more economically, such as the Middle East, North Africa, and Latin America, becomes crucial (WEC, 2021, p. 9). The European Union cannot produce the required quantity, hence the solution is to source from countries with production and export capacity, including Brazil, due to its solar and wind energy potential (Oliveira, 2022). Given this, Ceará is expected to face no difficulties in entering the European market.

b. Need for Capital: The need for substantial financial investment to compete in a market creates a barrier to entry, as operating globally demands a large capital base (Martignago, 2011). For instance, the World Bank and the Ministry of Development, Industry, and Trade financed infrastructure for the hydrogen hub at Pecém port (Ceará) with US\$ 100 million (Vasileva, 2023). Additionally, Pecém port plans investments of R\$ 2.2 billion until 2028 to modernize further. After launching the hub, Ceará signed over 35 MoUs with national and international companies, announcing investments of around US\$ 20 billion (Muniz, Carvalho & Junior, 2024). Hence, Ceará is not expected to face capital constraints in H₂V production and entry into the European market.

c. Access to Distribution Channels: A barrier to entry can arise from the need to secure product distribution channels. Given that established companies already serve distribution channels, a new entrant would need to convince these channels to accept their product (Martignago, 2011). However, in 2023, the Ceará and Netherlands governments established the Pecém-Rotterdam maritime corridor (production and export - import and distribution), creating a shipping route for H₂V commercialization in Europe (Vasileva, 2023). Rotterdam (Netherlands) is the largest port in Europe, making it the primary entry point for Ceará's H₂V. Currently, there are feasibility studies in the Netherlands for the construction of four pipelines covering Rotterdam, Chemelot Limburg, North Brabant, North Rhine-Westphalia, under the Delta Corridor initiative. This venture will contribute to the energy transition in the region, especially in Rotterdam and Chemelot, allowing their industries to transition to a more sustainable form of production. Once this maritime corridor is established, it will provide access to a market in a continent focused on the energy transition and dependent on imports in the coming years. Thus, access to distribution channels is not seen as a restrictive barrier for Ceará's H₂V entering Europe.

d. Government Policy: Governments can be a significant barrier to entry in their markets due to mechanisms that could hinder foreign companies' operations. Licensing, access restrictions to raw materials, tariffs, taxes, quotas, and preferential fiscal treatment for local companies are some examples of entry barriers (Martignago, 2011). However, in the global race to mitigate the effects of climate change, international cooperation has been prominent. Since launching the hub at Pecém, the Ceará government has signed over thirty-five MoUs with national and international institutions interested in developing projects in the state, particularly at CIPP (see Table 1).

Table 1: Companies that Signed MoU with the Government of Ceará (H₂V Hub of Pecém)

1. Enegix Energy	19. HDF
2. White Martins/Linde	20. Mitsui
3. Qair	21. ABB
4. Fortescue (Pré-contrato)	22. Gold Wind
5. Eneva	23. Alupar
6. Diferencial	24. Mingyang Smart Energy
7. Hytron	25. Spic
8. H2helium	26. Gansu Science & Technology Investment
9. Neoenergia	27. PowerChina
10. Engie	28. Platform Zero (Complexo do Pecém + 13 instituições de cinco países)
11. Transhydrogen Alliance	29. Green Hydrogen Corridor (Complexo do Pecém, AES Brasil, Casa dos Ventos, Comerc Eficiência, Havenbedrijf Rotterdam, Fortescue e EDP)
12. Total Eren	30. Voltalia
13. AES Brasil (Pré-contrato)	31. Lightsource bp
14. Cactus Energia Verde (Pré-contrato)	32. EDF Renewables
15. Casa dos Ventos (Pré-contrato)	33. GoVerde
16. H2 Green Power	34. Hitachi
17. Comerc Eficiência	35. Jepri
18. Enel Green Power	

Source: Bezerra (2023, p. 11).

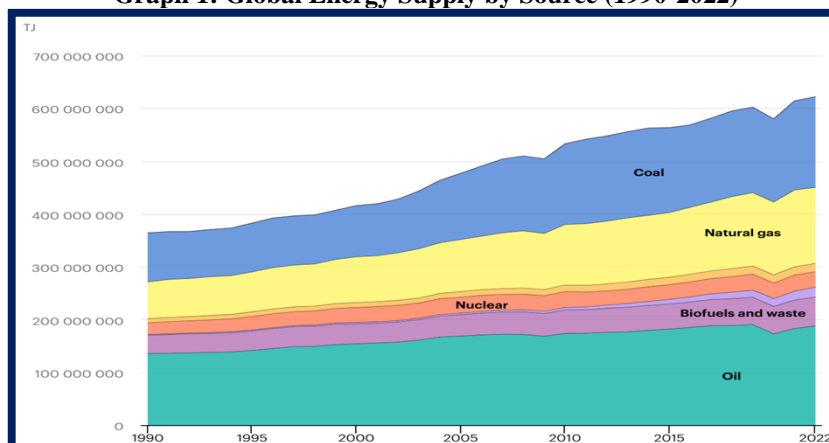
These MoUs align with Article 7 of the Paris Agreement by emphasizing international cooperation on climate issues, promoting the reduction of technological and financial inequalities between Global South and North countries, and including actions such as the sharing of information, institutional arrangements, strengthening of R&D, and exchange of best practices (FKA, 2022). Therefore, up to the present moment, there is no indication of entry barriers for the H₂V from Pecém into Europe, which would provide better negotiation conditions for producers in the CIPP when conducting bilateral and international agreements.

Pressure from Substitute Products

In addition to direct competitors, every industry competes with substitute products: tea can replace coffee; juice can replace soda (Martignago, 2011). Under these conditions, the pressure from substitute products can

reduce the profitability and profit margin of a company when the market opts for something different but with similar functionalities or the same objectives. This perspective suggests that once another product (substitute) is more attractive to the consumer, the market share that was previously held by another company may be compromised. To sustain the industrial complex, transportation systems, and societal needs, countries rely on energy matrices: fossil fuels (oil, gas, and coal); renewable energies (hydroelectric, wind, solar photovoltaic, and geothermal); nuclear energy; and biofuels (biomass and bioenergy). By analyzing Graph 1, one understands the origins of greenhouse gases, the causes of global warming, the need for energy transition, and the decarbonization of the global economy. This raises awareness in the international community to increase the use of renewable energies in their energy matrices.

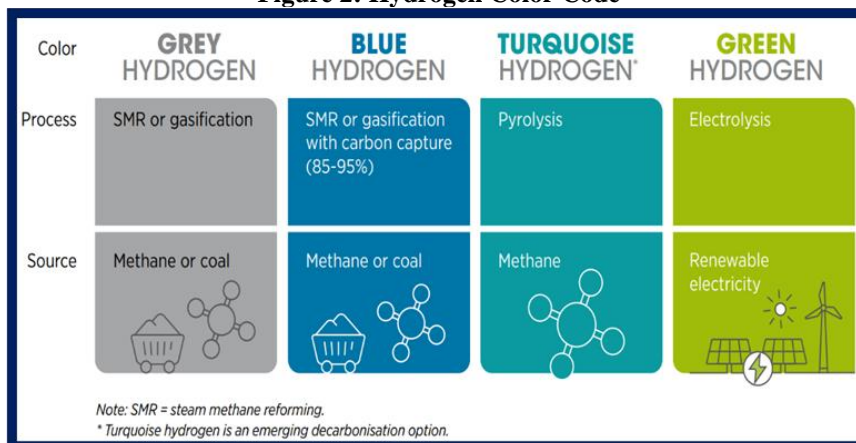
Graph 1: Global Energy Supply by Source (1990-2022)



Source: Agência Internacional de Energia (IEA)²

And what would be the substitute products for Green Hydrogen (H₂V)? Part of the answer is found in Chart 1 itself, and other alternatives also come from hydrogen itself. It can be produced through multiple processes and energy sources; in fact, a color-coding nomenclature (Figure 2) is becoming commonly used to facilitate the discussion (IRENA, 2020).

Figure 2: Hydrogen Color Code



Source: IRENA (2020, p. 8).

However, in the long term, the global energy matrix is expected to change due to the increased production of renewable energy. The process of energy transition is irreversible, thanks to the awareness of the international community regarding what has been referred to as the Sustainability Trilemma. This concept suggests that, to be sustainable, a company must be financially viable, socially equitable, and environmentally responsible, always seeking a balance among these three pillars.

² IEA. Energy Statistics Data Browser. Disponível em: <https://www.iea.org/data-and-statistics/data-tools/energy-statistics-data-browser?country=WORLD&fuel=Energy%20supply&indicator=TESbySource> Acesso em 04 fev. 2025.

IV. Conclusion

In this complex environment of global energy transition, where international markets tend to be highly competitive, it has been established that proper planning (short, medium, and long-term) has the potential to generate competitive advantages for businesses. Hence, the importance of developing strategic plans to be used for positioning the H₂V produced in Ceará within the international market (Europe).

Thus, this article aimed to present the contributions of Porter's Competitive Forces applicable to the value chain of H₂V in Ceará. As a result of this analysis, it aimed to contribute to high-level decision-makers with tools that favor the decision-making process in consolidating the State as an energy provider to the "Old World."

The research achieved its objectives by providing insights into the complex and dynamic energy environment that can be utilized by government bodies, multinational companies, and Brazilian industries involved in the entire H₂V production cycle in the CIPP.

The research demonstrated how Porter's tools could contribute to planning, management, and decision-making processes for stakeholders in the Ceará market. By doing so, it would strengthen the well-established competitive advantages of the State over other global competitors.

The qualitative approach, through literature and documentary review, was essential to understanding the heterogeneity of the H₂V value chain in CIPP, the challenges faced by negotiators in Ceará with suppliers and potential buyers, the complexity of distribution channels in the European consumer market, and understanding the competitive pressures within the global energy sector.

The research revealed that it is feasible to apply the "5P" concepts to deepen knowledge related to the insertion of Ceará's H₂V in the European continent. In this regard, the article demonstrated that high-level decision-makers could benefit from this knowledge by defining efficient strategic plans for the entire production and export cycle of the fuel of the future, thereby ensuring the success of Ceará in the energy field under better conditions.

For future research, considering the evolution of market variables, it is recommended to monitor the behavior of the "5P" in both the national and international scenarios, the conduct of potential customers in Ceará, and the stance of H₂V value chain suppliers in order to strengthen the State as a global player in the energy transition, stimulating interest in the European market as a strategic partner in this global energy transition.

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