

**GREEN HYDROGEN INTEGRATION INTO NATIONAL ENERGY POLICY:
OPPORTUNITIES AND CHALLENGES FOR PT PLN'S SUSTAINABLE
GROWTH**

**PENERAPAN HIDROGEN HIJAU DALAM KEBIJAKAN ENERGI
NASIONAL: PELUANG DAN TANTANGAN BAGI PERTUMBUHAN
BERKELANJUTAN PT PLN**

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ABSTRACT

This research aims to explore the integration of green hydrogen in Indonesia's national energy policy, focusing on the role of PT PLN (Persero) in supporting the sustainable energy transition. Green hydrogen, which is produced using renewable energy, is expected to be an important solution for the decarbonization of the industrial and transportation sectors. This study adopts a qualitative method through a case study of PT PLN, investigating internal elements such as PLN's renewable energy infrastructure, as well as external elements such as the government policies and international demand for green energy. The results of the research using the SWOT analysis method show that although PLN has strengths in terms of renewable energy infrastructure, the main challenges in the development of green hydrogen include high production costs, global competition, and immature regulatory policies. This study recommends that PLN must enhance strategic collaborations, pioneer hydrogen production technology, and conform to pro-green energy policies to guarantee green hydrogen market growth sustainably. In summary, PLN has enormous potential to dominate green hydrogen development in Indonesia, but the above challenges should be addressed through cooperation, pro-green policies, and effective technology development.

Keywords: Green Hydrogen, PT PLN, National Energy Policy, Sustainable Growth, Decarbonization, Renewable Energy, Indonesia, Energy Transition, Policy Integration.

ABSTRAK

Penelitian ini bertujuan untuk mengkaji integrasi hidrogen hijau dalam kebijakan energi nasional Indonesia, dengan fokus pada peran PT PLN (Persero) dalam mendukung transisi energi berkelanjutan. Hidrogen hijau, yang diproduksi menggunakan energi terbarukan, diharapkan menjadi solusi penting untuk mendekarbonisasi sektor industri dan transportasi. Penelitian ini menggunakan metode kualitatif melalui studi kasus PT PLN, menganalisis unsur internal seperti infrastruktur energi terbarukan PLN, serta unsur eksternal seperti kebijakan pemerintah dan permintaan internasional terhadap energi hijau. Hasil penelitian menggunakan metode analisis SWOT menunjukkan bahwa meskipun PLN memiliki keunggulan dalam infrastruktur energi terbarukan, tantangan utama dalam pengembangan hidrogen hijau meliputi biaya produksi yang tinggi, persaingan global, dan kebijakan regulasi yang belum matang. Studi ini merekomendasikan agar PLN meningkatkan kolaborasi strategis, mengadopsi teknologi produksi hidrogen terdepan, dan mematuhi kebijakan pro-energi hijau untuk menjamin pertumbuhan pasar hidrogen hijau secara berkelanjutan. Secara ringkas, PLN memiliki potensi besar untuk mendominasi pengembangan hidrogen hijau di Indonesia, namun tantangan di atas harus diatasi melalui kerja sama, kebijakan pro-hijau, dan pengembangan teknologi yang efektif.

Kata kunci: Hidrogen Hijau, PT PLN, Kebijakan Energi Nasional, Pertumbuhan Berkelanjutan, Dekarbonisasi, Energi Terbarukan, Indonesia, Transisi Energi, Integrasi Kebijakan.

INTRODUCTION

Given the increasing effect of climate change, the worldwide shift to sustainable energy alternatives must be given top importance. Green hydrogen, which may decarbonise energy-intensive

industries including transportation, industry, and power generation [18], is among the most exciting substitutes for fossil fuels. Green hydrogen offers Indonesia a chance to diversify its energy mix, lower reliance on fossil fuels, and

assist in decarbonisation targets for the country. But the inclusion of green hydrogen into Indonesia's national energy plan, especially via PT PLN (Persero), offers both major advantages and difficulties.

1.1 Company profile

PT PLN (Persero) is Indonesia's state-owned electricity company, tasked with providing reliable and sustainable energy throughout the archipelago. As a critical player in Indonesia's energy transition, PT PLN operates across various segments, including electricity generation, transmission, distribution, and retail. PT PLN has ventured into new and renewable energy solutions, including Green hydrogen, to address the country's growing energy demands and align with global sustainability goals. PT PLN In running its company, has a vision, mission, and Motto, consisting of the;

Vision:

To be a Global Top 500 Company and #1 Customer Choice for Energy Solutions.

Mission:

1. Conducting electricity business and other related fields, oriented to customer satisfaction, company members and shareholders.
2. Making electricity as a medium to improve the quality of people's lives.
3. Keeping electricity as driving economic activity.
4. Conducting environmentally sound business activities.

Motto: Electricity for a Better Life

PLN drives inclusive and sustainable growth through "The Next Chapter of Transformation" to become a global Top 500 company and the top energy choice. This initiative, through the "Moonshots" Program, focuses on Growth, Digitalization, and Net Zero Emission, continuing Transformation 2.0

with key aspirations and launchpads for success.

The Transformation 2.0 program focuses on three main aspirations and Moonshot Launchpad as an enabler. Part of that enabler is the development of the hydrogen business as part of the acceleration of Moonshots' growth, which has a potential additional revenue of more than 23.7 trillion in 2028 and will continue to grow.

The company's efforts align closely with Indonesia's national energy policies and sustainability commitments. PT PLN works to ensure that its hydrogen initiatives comply with regulations while advocating for policies that support renewable energy adoption.

1.2 Green Hydrogen

Green hydrogen has emerged as a pivotal technology in the global transition towards sustainable energy systems. It is produced through the electrolysis of water, utilizing renewable energy sources such as solar, wind, and hydropower, which distinguishes it from conventional hydrogen production methods that rely on fossil fuels [13]. The electrolysis process splits water into hydrogen and oxygen, producing a clean energy carrier that can decarbonize various sectors, including transportation, industry, and energy production [10]. As the global energy landscape shifts towards sustainability, green hydrogen is increasingly recognized for its potential to provide energy storage solutions, thereby addressing the intermittency of renewable energy sources [9].

The energy transition of Indonesia revolves mostly around PT PLN, the state-owned electricity provider. Currently running a large renewable energy infrastructure, the company is excellently positioned to lead the integration of green hydrogen into the national grid [38]. High production costs,

inadequate infrastructure, and legislative uncertainty are among the various obstacles green hydrogen must overcome [15]. Although earlier research had looked at the technical and financial sides of green hydrogen generation, little is known about how green hydrogen might be strategically included into the business models of energy corporations, especially about Indonesia [1].

1.3 The Symptom (GAP)

This work attempts to close this gap by examining PT PLN's influence on Indonesian green hydrogen development. The study focuses on how the business may use policy frameworks to attain sustainable development while also overcoming internal and external obstacles in applying green hydrogen. Given the infrastructure, legal environment, and market needs of the company, the study will investigate the prospects that green hydrogen offers for PT PLN. Moreover, the study will offer suggestions for the green hydrogen business development plan of PLN in line with the national energy policy of Indonesia and world sustainability objectives.

1.4 Research Question and Research Objective

Research Questions (RQ)

1. How can green hydrogen be integrated into Indonesia's national energy policy, and what role does PT PLN play in this integration?
2. What are the external challenges faced by PT PLN in integrating green hydrogen into its business model?
3. What internal capabilities does PT PLN have that enable it to integrate green hydrogen into its business model?
4. How can PT PLN align its green hydrogen strategy with national

energy policy goals and achieve sustainable growth in this sector?

Research Objectives (RO)

1. To examine the integration of green hydrogen into Indonesia's national energy policy and identify the role of PT PLN in this process.
2. To assess the external challenges that PT PLN faces in integrating green hydrogen into its operations and business model
3. To evaluate the internal capabilities of PT PLN, including infrastructure, expertise, and resources, for supporting green hydrogen development and integration.
4. To propose strategies for PT PLN to align its green hydrogen development with Indonesia's national energy policy and ensure long-term, sustainable growth in this sector.

LITERATURE REVIEW

1.1 External Analysis

In strategic management, external factor analysis is crucial for assessing opportunities and dangers that impact an organization's decision-making. External analysis encompasses three fundamental dimensions that consist of the general environment, the industrial environment, and the competitive environment [16 ;17]. In the Indonesian setting, external strategic management must account for regulatory dynamics, national energy policies, and cultural factors [51]. Moreover, comprehending The Five Competitive Forces That Shape Strategy [48] is essential for evaluating the competitive landscape and commercial feasibility in the green hydrogen industry.

External analysis is an essential aspect of strategic management since it enables organizations to recognize external factors that influence their competitive standing. Hitt, Ireland, and

Hoskisson [16 ;17] identify three principal domains of external analysis.

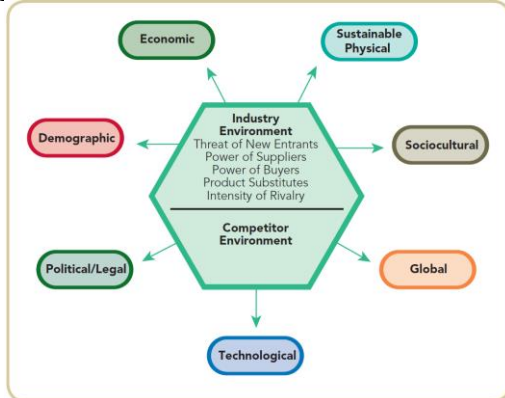


Figure 1. External Environment [16;17]

Understanding the general environment is essential for businesses to navigate both opportunities and risks. Economic, political, demographic, technological, sociocultural, global, and sustainable physical factors all influence a company's ability to succeed in a competitive and ever-changing market landscape. In the case of PT PLN and the renewable energy sector, these factors are critical to shaping its strategy and ensuring long-term sustainability. By aligning with national and global trends, PT PLN can capitalize on the growing demand for green hydrogen and other renewable energy solutions.

Industry environment analysis examines the competitive forces that shape an industry's profitability and strategic opportunities. According to Hitt, Ireland, and Hoskisson [16 ;17]. the industry environment is primarily analyzed using Porter's Five Forces Model, which includes the threat of new entrants, the bargaining power of suppliers, the bargaining power of buyers, the threat of substitute products or services, and the intensity of competitive rivalry. Understanding these forces enables firms to develop strategies that enhance their competitive advantage.

The competitive environment constitutes the concluding aspect of the

external environment. Competitor analysis concentrates on each company with which a corporation directly competes [16 ;17] An analysis covering 4 Factors such as future objective, assumption, current strategy and capabilities [16 ;17] and these factors to shape responses to competitor. This analysis is a necessity to perform due to similarity within the industry within the context of what drives competitors, what the competitor is doing and can do, what the competitor believes about the industry, and what the competitor's capabilities are.

1.2 Regulatory, Policy, and Culture Analysis

Government regulations, such as the Renewable Energy Law (UU No. 30/2007) and Presidential Regulation No. 112/2022 on Renewable Energy Pricing, set the framework for green hydrogen investment in Indonesia [51]. Indonesia's regulatory framework plays a pivotal role in shaping the development of green hydrogen.

Indonesia's National Energy Policy (KEN) aims for a 23% renewable energy mix by 2025, with a call for state-owned enterprises like PLN to view hydrogen as a green energy resource [51]. Indonesia's National Energy Policy (KEN) is the government policy for managing energy resources to attain national energy independence and security. KEN plays a substantial role in inspiring state-owned enterprises (SOEs), such as PLN, to pursue hydrogen as a sustainable energy source. Amid Indonesia's commitment to transforming the energy sector, hydrogen is recognized as a promising alternative fuel to support decarbonization efforts [39]. PLN has initiated green hydrogen projects, supported by the government through regulatory policies, infrastructure investments, and conducive policies [29].

The regulatory environment in Indonesia, such as KEN, directly affects green hydrogen production through setting definitive energy transition goals, promoting investment, and offering long-term policy stability [18]. The attempts are aligned with global action to boost hydrogen as a key component of an orderly energy transition [10].

1.3 Internal Analysis

Internal analysis is the study of the internal environment of an organization, its resources, capabilities, and overall structural alignment. It is a critical process in identifying the strengths and weaknesses that will affect a firm's capacity to realize its strategic goals. Internal analysis entails the study of critical factors, such as the resources of the organization, both tangible and intangible, and the capabilities and core competencies of the organization.

Resource-Based View (RBV)

The Resource-Based View (RBV) theory emphasizes that a firm's resources and capabilities are fundamental to achieving sustainable competitive advantages. According to this perspective, the possession of valuable, rare, inimitable, and non-substitutable (VRIN) resources provides a foundation for long-term success [5]. Resources can be both tangible (such as capital, equipment, and infrastructure) and intangible (such as intellectual property, brand reputation, and organizational culture). The integration of these resources into organizational capabilities enables firms to outperform competitors. Successful firms leverage their capabilities, combining both tangible and intangible assets, to develop core competencies, which set them apart from rivals [16 ;17]. Thus, RBV highlights the critical role of resources and capabilities

in shaping a company's strategy and competitive position in the market.

Competitive Advantage

A competitive advantage refers to a firm's ability to provide superior value to its customers compared to its competitors, often resulting in higher profitability and market share [48]. This advantage can arise from various factors, including core competencies, unique skills, and strategic resources that are difficult for competitors to replicate. A firm can achieve competitive advantage through strategies such as cost leadership becoming the lowest-cost producer or differentiation offering unique products or services valued by customers. The VRIN framework is often used to evaluate whether a firm's resources can deliver a lasting competitive edge. Resources and capabilities that meet the VRIN criteria valuable, rare, costly to imitate, and non-substitutable allow firms to sustain their competitive advantage over time [16 ;17]. This strategic advantage is crucial for companies seeking to maintain long-term leadership in their industries.

Value Chain Analysis

Aiming to improve operational efficiency, lower costs, and maximize the value supplied to consumers, supply chain analysis is the study of the whole supply chain process from procurement to final delivery. This study concentrates on the way important activities including procurement, manufacturing, logistics, and distribution are combined to evaluate how each element enhances the competitive advantage and general performance of the company. Through improved supply chain capabilities, a well-executed supply chain analysis points up possible inefficiencies, possibilities for cost cuts, and chances to

improve the market position of the company.

Support functions are essential since they guarantee the efficiency of value chain operations by means of the required tools and resources. Although they are not directly involved in manufacturing or distribution of goods, they enable the company to maximize its capacity for conducting main operations

The whole competitive advantage of the business depends on the value generated by both main operations and support roles. Effective management of value chain activities and strong support functions can help a company to improve its capacity to provide value to consumers and beat its rivals. Maintaining long-term success depends on these activities and functions being included into a coherent strategy. All these actions should lead to value for the client. This implies the company should concentrate on providing premium goods or services that satisfy consumer wants thereby raising customer satisfaction.

2.4 SWOT Analysis

Strategic planning tool SWOT analysis evaluates Strengths (S), weaknesses (W), opportunities (O), and threats (T) of a business. This structure enables companies to better grasp their strategic posture and create plans to reach competitive advantages [16 ;17]. The analysis is divided into two main components: internal factors (strengths and weaknesses) and external factors (opportunities and threats) [16 ;17].

The first stage, strategy formulation, begins with an internal and external analysis to identify an organization's strengths, weaknesses, opportunities, and threats [16 ;17]. Internal analysis evaluates key competences, resources, and capacities to ascertain the strengths and shortcomings

of a company [16 ;17]. External analysis, on the other hand, entails keeping an eye on the whole surroundings and industry conditions to spot chances and hazards influencing corporate performance [16 ;17]. By balancing internal and external elements, this strategy lets companies create successful plans [16 ;17]. This approach allows businesses to develop effective strategies by balancing internal and external factors [16 ;17].

2.5 TOWS Matrix

Heinz Weihrich created the TOWS Matrix in 1982 as a strategic management tool based on the conventional SWOT Analysis (strengths, weaknesses, opportunities, and threats) by emphasizing on matching the internal and external factors found in the SWOT analysis to create strategic options. TOWS stands for Threats, Opportunities, Weaknesses, and Strengths, but it is structured differently from the SWOT analysis to help managers develop specific strategies.

The TOWS Matrix is a tool for generating strategic options by identifying the relationship between internal and external factors. The internal factors are the strengths and vulnerabilities of the company, while the external factors are the opportunities and threats in the business environment.

RESEARCH METHODOLOGY

This study adopts a qualitative research methodology to explore the integration of green hydrogen into Indonesia's national energy policy, focusing specifically on PT PLN's role in fostering sustainable growth within the renewable energy sector. The research aims to identify the opportunities and challenges PT PLN faces in integrating green hydrogen into its operations and how these efforts align with Indonesia's broader energy transition goals. The

qualitative approach is ideal for gaining in-depth insights into the regulatory, economic, and strategic factors influencing the development of green hydrogen.

This study employs a case study approach, which is particularly well-suited for understanding complex phenomena in their real-world context [52]. By examining PT PLN's existing practices, resources, and strategic initiatives, the case study will provide a detailed understanding of how the company is positioned within Indonesia's energy policy framework and what challenges it faces in integrating green hydrogen into its business model.

Conceptual Framework

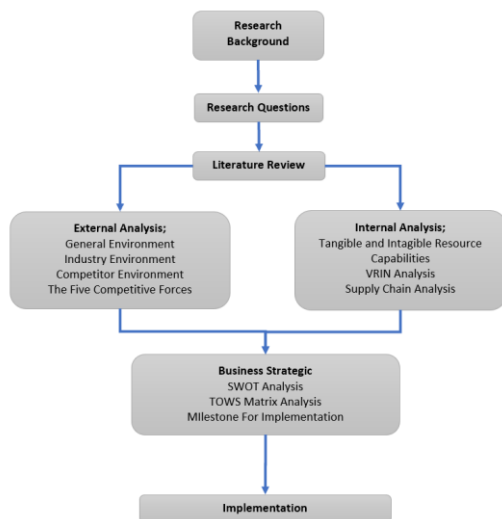


Figure 2. Conceptual Framework

The author employs a framework to conduct this research to work on the Problem statement and perform an analysis market for green hydrogen and development business strategy for maintaining PLN's competitiveness in a rapidly evolving energy market.

This research methodology is designed to comprehensively address the integration of green hydrogen into PT PLN's business strategy, considering both internal capabilities and external policy and market factors. Through qualitative data collection and thematic

analysis, the study will offer insights into the opportunities and challenges faced by PT PLN, contributing to a better understanding of the role of green hydrogen in Indonesia's energy transition.

RESULTS AND DISCUSSIONS

4.1 External Analysis

These general environmental aspects need to be determined to conduct the external analysis.

Economic Factor

This analysis will give an outlook how interlinked economic segments with economic condition and its direction where the company took place. Economical aspect to the topik are;

1. Indonesia Gross Domestic Product (GDP). Indonesia's economy in 2024 grew by 5.03%. the grew accorred in all industries. Within a specific aspect of electricity and gas provision, Indonesia scored around 4,77 % growth from 2023 [4]
2. Indonesia Rupiah Exchange Rate. In 2024, Indonesia's exchange rate experienced high volatility, with the Rupiah averaging around IDR 15,864 per USD. This put financial pressure on Indonesia's electricity sector, especially for companies with global supply chains or USD-based debt. This affected project budgets, particularly for renewable energy and infrastructure development. Currency fluctuations also impacted foreign investor confidence, making financing large-scale electricity projects more challenging.
3. The scalability of green hydrogen is closely linked to economic expansion. During phases of strong expansion, industrial demand escalates and the inclination for investment intensifies. Conversely, during economic downturns, capital-intensive projects

may encounter postponements or terminations.

Political and Legal Factor

This aspect will describe how Companies could influence Government to accommodate Business Green Hydrogen, and how the government could regulate Businesses Green Hydrogen. For this study, Political/ Legal aspect related to the issue are;

1. National Energy Policy (REUN) state target 23% renewable energy in national energy mix by 2025. Hydrogen is positioned as a future renewable energy carrier.
2. Presidential Regulation No.112/2022 states the acceleration of renewable energy development for power plants. Prioritizes clean energy , including hydrogen potential.
3. Roadmap for green and blue hydrogen from Draft of the Ministerial Regulation (ESDM) Including technical standards and fiscal incentives.
4. Government Regulation No. 98/ 2021 states implementation of carbon economic value (NEK). Opens Pathways for hydrogen as a tool for decarbonization.
5. The transformation 2.0 Program from PT PLN (persero) focuses on three main aspirations and moonshot launchpad as an enabler. Part of that enabler is the development of the hydrogen business as part of the acceleration of moonshot growth.

Demographic Factors

Urban areas are centres of industrial energy demand and transport innovation. With over 57% of Indonesians living in urban areas, cities have become key markets for hydrogen applications such as fuel-cell public transport or decarbonized electricity. They are strategic indicators for the

hydrogen business. In countries like Indonesia, where the population is large, youthful, increasingly urbanized, and progressively educated, the long-term outlook for hydrogen as a sustainable energy solution is promising. Companies that align their product offerings, workforce development, and infrastructure deployment with these demographic trends will be better positioned to lead the hydrogen transition.

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Technological Factors

Technologies are the key to developing green hydrogen to be more affordable for implementation. The production of green hydrogen is gaining traction globally, driven by technological advancements and decreasing costs of renewable energy [41] Green hydrogen production costs are expected to decline significantly as economies of scale are achieved through the widespread deployment of electrolyzers and renewable energy technologies [41].

Sociocultural Factors

Sociocultural factors such as cultural values, lifestyle trends, and consumer environmental awareness strongly influence the adoption of hydrogen technologies. Public consciousness on climate change is rising globally. a recent UNDP-Peoples' Climate Vote survey found that 89% of people across 125 countries support stronger government actions against climate change [50]. This societal shift fosters a favorable environment for green energy adoption, including hydrogen. Furthermore, public acceptance of hydrogen is closely linked to perceptions of its environmental benefits, safety, and affordability [46].

Global Factors

Global factors such as international trade dynamics, economic crises, geopolitical tensions, and supply chain disruptions significantly influence the hydrogen industry's expansion and stability. Establishing international hydrogen trade corridors is vital for creating a global market for clean hydrogen, necessitating cross-border collaboration and policy alignment . Geopolitical developments, including competition over technological leadership and resource access, can reshape energy alliances and affect investment flows in the hydrogen sector [22]. Moreover, supply chain vulnerabilities, as evidenced by concerns over dependence on specific countries for electrolyser components, highlight the need for diversified and resilient supply networks.

The sustainable physical Factor

Sustainable physical factors such as climate change, resource availability, and environmental regulations are critical drivers in the development of the hydrogen industry. The urgency to

combat climate change has positioned hydrogen as a crucial solution for decarbonizing hard-to-abate sectors, as "hydrogen can play a key role in achieving net-zero targets by replacing fossil fuels in industrial and transport sectors" [22]. However, the scalability of hydrogen projects is highly dependent on the availability of renewable resources like water and solar energy, which vary significantly across regions and affect production costs [29]. Furthermore, implementing environmental regulations and green energy policies accelerates investment in hydrogen technologies, providing long-term advantages for companies that align with sustainability standards [47].

4.2 Industry Analysis/ Porter 5 Forces Threat of New Entrants

The green hydrogen industry in Indonesia requires substantial capital investment, advanced technology (e.g., electrolyzers), and compliance with strict environmental regulations. PT PLN, as a state-owned utility company, benefits from government backing and existing energy infrastructure, which creates significant entry barriers for new players. However, the sector's growth potential and the Indonesian government's push for energy transition through hydrogen roadmaps may attract new domestic and international competitors [22].

Bargaining Power of Suppliers

The supply of hydrogen production technology, particularly electrolyzers and related components, is still dominated by a few global providers. This limited supplier base, combined with high product specialization, increases supplier power and can raise input costs. Indonesia's dependency on imported technology further strengthens supplier influence in the early stages of industry development [53].

Bargaining Power Of Buyers

Currently, the hydrogen market in Indonesia is nascent, with few large-scale buyers, resulting in relatively low bargaining power. However, as industrial sectors such as transportation, fertilizer, Petrochemicals, Oil Refineries, steel, Cement, Ceramics, Paper, and heavy industry begin to adopt hydrogen, their influence is likely to grow. For now, PLN faces little downward pricing pressure from buyers [20].

Threat of Substitutes

Green hydrogen competes with other clean energy sources such as batteries, biofuels, and conventional fossil fuels. For sectors like heavy transport and industrial processes, hydrogen offers unique decarbonization potential, which limits direct substitution. Nonetheless, the presence of cheaper energy alternatives can pose a threat if cost parity is not achieved [22].

Industry Rivalry

Competition in Indonesia's green hydrogen industry is currently limited, with PLN and Pertamina as the primary stakeholders. However, rivalry is expected to increase with international interest and private sector participation, especially as Indonesia opens its hydrogen market to foreign investment and innovation [37].

4.2 Competitor Analysis

In order to determine PT. PLN (Persero) competitor and analyze its capability, we need to determine 4 aspects;

- *Future Objectives*

PLN's future objectives in green hydrogen are ambitious but still in the early stages compared to regional and global competitors. The company will emphasize renewable-based hydrogen production, infrastructure development, and strategic

partnerships while managing risks through gradual scaling and policy alignment. To stay competitive, PLN must accelerate technology adoption, enhance financial support, and secure early market adoption to establish itself as a key player in Indonesia's hydrogen economy.

- *Current Strategy*

PLN is currently focusing utilizing excess production of 128 tons/year of green hydrogen for as a cooling engine in 22 locations and but also serves as a training facility for PLN's internal human resources in operating and maintaining the facility. However also PLN building on pilot projects, infrastructure development, and strategic partnerships to build a competitive advantage. PLN, as a state-owned enterprise (SOE), PLN's strategy is also influenced by government policies and regulatory frameworks. PT PLN (Persero) wants to reduce Fossil fuel by switching to hydrogen, the pilot project that is currently being carried out is the installation of a Fuel Cell Generator on Gili Ketapang Island, East Java. PLTD Gili Ketapang has 2 units of diesel power generation engines with each engine capacity of 656 kW with a capacity of 470 kW per unit. Installation of Fuel Cell Generator in Gili Ketapang with testing for 8x24 hours.

- *Assumption*

PLN assumes the green hydrogen market will be volatile, requiring strategic flexibility and investment diversification. The company is moving away from the fossil fuel-based status quo, recognizing the need for a low-carbon transition. Meanwhile, PLN's competitors assume that cost, policy, and demand

uncertainty will shape market development. These assumptions influence PLN's investment decisions, risk management strategies, and market positioning.

- *Capabilities*

PLN has significant strengths in infrastructure, renewable energy integration, and government backing, making it a key player in Indonesia's

hydrogen transition. However, it faces high production costs, slower technological adoption, and competition from both domestic and international firms. To stay competitive, PLN must accelerate its R&D, reduce production costs, and explore export opportunities.

4.3 Internal Analysis

Tangible & Intangible Resources

Characteristic	Physical Assets	Renewable Energy	Financial Resources	Technological Assets	Organizational Assets
Capacity	72,976 MW installed power	8.8 GW installed, 18 GW target	IDR 1.670,64 T Tot Assets	Smart Grids, IoT monitoring	Subsidiaries exist
Network	70,933 kms transmission	Biomass Co-firing at 43 PLTU	IDR 1.015,63 T Tot Equity	Digital substations	PLN Indonesia Power
Other	7,036 unit Tot Power Plant	BESS 0,35 GWh in 94 Location	IDR 487,38 T Revenue	Green hydrogen & RE projects	PLN Nusantara Power
Other	1,048,183 GWh Length of Distribution Network	22 Location (Total Number of GHP)	IDR 47,2 T (Operation Profit)	App PLN Mobile 47 Million Users Rate 4.8	PLN Icon Plus
Other	323.321 GWh Electricity Production	Sensyan HRS (1st H2 Refuel Station)	IDR 22,07 T (Net Profit)	None	PLN Energy Primer Indonesia

Table 1. Tangible Resource of PT PLN (Persero) (Resource: Author analysis & LK PLN,2023)

Characteristic	Description
Brand Reputation	Strong image, trusted provider
Regulatory Advantage	Government support, monopoly status
Intellectual Property	Smart grid, renewable innovations
Human Capital	Skilled experts, deep knowledge
Strategic Partnerships	Collaborations with global entities
Organizational Knowledge	Understanding of infrastructure, policy
Vision and Mission	World-class, customer-focused growth
Transformation Program 2.0	Growth, digital, net-zero focus

Table 2. Intangible Resource of PT PLN (Persero) (Resource: Author analysis & LK PLN,2023)

As far as online presence is concerned, PLN has an Advanced Online Presence through its official website and mobile apps, focusing on enhancing customer experience and transparency. It also undertakes an active engagement with the public through social media platforms and digital services.

Furthermore, PLN has set its ambitious Transformation Program 2.0 Moonshot with four main pillars: Growth, Digital, Net Zero Emissions, and the Moonshot Launchpad. This is in line with its

ultimate goal of being a world-class, trusted, and sustainable energy company

Capabilities

A company's capabilities are built from the combination of both tangible and intangible resources. These resources

are used to complete organizational tasks that are necessary for the company to produce, distribute, and service its products or services in order to create value for customers. For PT PLN (Persero), its strengths lie at the core of its ability to provide energy services enabling Indonesia's economic and sustainable growth. Mixing of inner assets such as human capital, technology, and organizational structure enables PLN to innovate and stay competitive in the rapidly evolving energy sector.

As an SOE and Indonesia's largest energy utility, PLN's capabilities take significant roles in ensuring that energy is distributed soundly and renewable energy solutions are being established within the national grid of the country. These capacities are renewable energy production and electricity distribution, technological innovation, human capacity development, and management systems. All of these functional areas are contributory to PLN's general aim of spearheading Indonesia's energy shift to more sustainable and green energy solutions, of which the green hydrogen development is one of its clean energy initiatives. The strengths that belong to PT PLN (Persero) are the following:

1. Renewable Energy Production

PT PLN is capable of constructing and operating renewable power plants, such as solar, wind, hydroelectric, and biomass. Such ability encompasses the technical expertise to produce renewable energy as well as technical capability to balance various renewable power sources into the national grid of the country (smart grid). Green hydrogen is produced by water electrolysis, which will have substantial electricity consumption. With the growing capacity of PLN's renewable energy, particularly in solar (109 GW), wind (73 GW), and geothermal (23 GW), it will be able to

provide the volume of electricity needed to mass-produce green hydrogen. Locations where green hydrogen is to be produced (e.g., Jawa Barat, Gresik, Sulawesi, and Sumatra Selatan) are strategically positioned near areas with high renewable energy resources.

2. Energy Distribution

PLN's distribution infrastructure accumulated over the years provides a solid competitive advantage in delivering green hydrogen to major industries, including heavy industries and transport, where hydrogen is a viable substitute. PLN can leverage its distribution networks to supply hydrogen economically at competitive rates, further fortifying its market share.

3. Human Capital

PLN's highly skilled human resources will also be crucial to effective technology deployment and upscaling of green hydrogen technologies. Training and employee development investment to gain expertise in hydrogen technologies and energy transition strategies will ensure PLN remains competitive in terms of innovation and operational efficiency

4. Management Information Systems (MIS)

PLN has a robust management information system (MIS) that supports real-time decision-making for energy grid management and operational efficiency. The use of SCADA systems, IoT-based systems, digital substations, and control centers to monitor and control the operations of power plants and distribution networks, as well as the use of big data technologies to predict energy demand

and optimize renewable energy distribution.

5. Marketing and Public Relations

PLN can also sell renewable energy and tell consumers about its benefits. Effective marketing creates consumer awareness of green energy technology and achieves public acceptance of renewable energy technology.

6. Research and Development (R&D)

PLN has a solid research and development (R&D) capacity that is significant in developing and applying new clean renewable energy technologies, such as green hydrogen storage equipment for renewable energy. Such a capacity helps PLN innovate in clean energy alternatives and stay abreast with emerging technologies.

PT PLN (Persero) can be capable of applying a cost leadership strategy and achieving business diversification through its innovation in green hydrogen. Its long history of capabilities in renewable energy production, distribution, technology innovation, HR, and management systems positions it well to compete and lead the transition towards an Indonesia sustainable energy future. As the market for green hydrogen is expanding, PLN's ability to capitalize on its strengths and offer low-cost innovative solutions will be the key in maintaining its competitive edge in the evolving energy sector.

VRIN Analysis

Based on the provided functional areas for PT PLN (Persero), I will analyze each area's capabilities using the VRIN framework (Value, Rarity, Imitability, Non-substitutability) to determine the core competencies of PLN. This analysis will provide insights into how these capabilities can help PLN become a

leader in the energy transition, especially through the diversification into green hydrogen.

Functional Area	Value (V)	Rarity (R)	Imitability (I)	Non-substitutability (N)
Renewable Energy Production	✓	✓		✓
Energy Distribution	✓	✓		✓
Human Capital	✓	✓		✓
Management Informasi System (MIS)	✓			✓
Marketing	✓			✓
Technology and Innovation (R&D)	✓	✓		✓

Table 3. VRIN Analysis (Resource: Author analysis)

The author conducted an analysis based on the table above. From the above analysis, PT PLN's core competencies areas are as follows;

1. Production of Renewable Energy

PLN's large-scale production of renewable energy is a key strength since it forms the foundation of green hydrogen development. This strength allows PLN to generate and supply clean energy at scale, a key component in the generation of green hydrogen. This scarcity matters since there are few companies within the energy sector that have the scale and infrastructure to generate renewable energy at this level.

2. Energy Distribution

PLN's distribution infrastructure is crucial to provide renewable energy, e.g., green hydrogen, to significant sectors (industry, transport, etc.). This is to establish a competitive edge in the business of green energy. The uniqueness is that PLN's distribution infrastructure is national, which is a first in Indonesia.

3. Human Capital

PLN human capital is a critical asset, given that well-qualified staff will need to be deployed in the design, implementation, and management of the green energy ventures like green hydrogen production. PLN, through their local experience and industry-specific expertise, are leaders in

energy innovation. They invest in training programs and development initiatives to acquire skills in renewable energy technology, green hydrogen, and energy management.

4. Technology and Innovation (R&D)

Green hydrogen and energy system innovation R&D capabilities give PLN a sustainable competitive advantage. Through continued investments in green hydrogen technologies, PLN will be at the forefront of the energy transition.

These fundamental competencies will position PLN to successfully grow its business in green hydrogen by leveraging its track record and assets in renewable power generation, transmission, and R&D. Green hydrogen, produced from clean power, can be a significant part of PLN's business, allowing the company to become a low-carbon energy player and maintain dominance in Indonesia's energy transition.

Value Chain Analysis

PT PLN (Persero), Indonesia's biggest state-owned electricity company, is the central figure in the energy business of Indonesia for electricity generation, transmission, and distribution. In order to stay competitive and drive growth, PLN must strive to continuously improve its value chain activities and support functions that are the backbone of creating value and enabling the green energy transition. Value creation theory in the supply chain is based on the premise that each level of the chain must add more value to the final product or service, in this case, the guaranteed supply of green hydrogen and green energy.

PLN's value chain activities and support functions may be analyzed applying A Model value chain model, in which activities that create value within

an organization are categorized into primary activities and support activities.

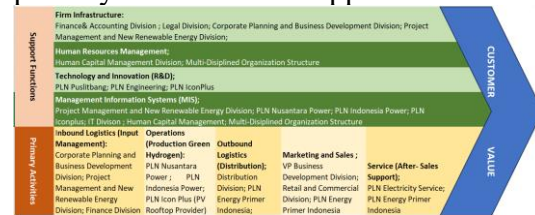


Figure 3. Value Chain Analysis Model for PT PLN Business Green Hydrogen

4.4 SWOT Analysis

The SWOT analysis enables the strategist to assess the company's present circumstances and future potential by concurrently evaluating internal and external elements. The SWOT analysis allows managers to examine internal and external surroundings, identifying pertinent aspects that may affect the company's present or future competitive advantage. The focus is on internal and external elements that may positively or negatively influence the company's capacity to attain and maintain a competitive advantage.

Concerning the PLN situation, The following is a SWOT analysis related to the development of the green hydrogen business by PT PLN (Persero), supported by the latest information and references.

Tabel 4. SWOT Analysis

Strengths <ul style="list-style-type: none"> • Extensive renewable Energy Infrastructure • Experience in Energy Management • Established National Grid • Government Support 	Weaknesses <ul style="list-style-type: none"> • Dependency on Fossil Based Infrastructure • Limited Green Hydrogen Production Capacity • Technology Gaps • Management of Large Scale Green Hydrogen Projects
Opportunities <ul style="list-style-type: none"> • Increasing Global Demand for Green Hydrogen • Government Support and Regulation • Technological advancement in Green Hydrogen production • Strategic Location for Export 	Threats <ul style="list-style-type: none"> • Global Competition • Fluctuations in Renewable Energy Prices • Regulatory and Policy Uncertainty • Infrastructure Challenges

At Strengths Quadrant, PT PLN (Persero) possesses significant strengths in terms of big renewable energy infrastructure, i.e., solar power, wind power, and geothermal power, setting a strong base in the production of green hydrogen. Subsequently, working experience of PLN in energy management and possessing well-established national grid enable efficient

integration and distribution of energy, and governmental support promotes its place in producing green hydrogen based on national sustainability goals.

In the Weaknesses Quadrant, While it has strengths, PLN possesses weaknesses such as its dependence on fossil-based infrastructure, which has restricted the scalability of green hydrogen output. The company also possesses low green hydrogen production capacity and huge technology gaps in hydrogen production and storage that need to be bridged to increase efficiency. Moreover, PLN's ability to implement large-scale green hydrogen projects is still in the process of being developed.

In Opportunities, PT PLN has numerous opportunities, some of which include the increasing global demand for green hydrogen that opens up new export markets and is complemented by government support for renewable energy projects. Better technology in green hydrogen production and sites for exporting improve PT PLN's position to be capable of profiting from the expanding global market, particularly in places like Japan and South Korea.

In Threats, PLN will have to contend with global competition from other countries heavily investing in green hydrogen. Price volatility of renewable energy, regulatory risks, and challenges to establishing hydrogen infrastructure also pose threats to PLN's ability to produce green hydrogen at scale and continue to be competitive in a rapidly changing market.

4.5 TOWS Matrix Analysis

The TOWS matrix analysis is an essential tool for PT PLN to evaluate its Strengths, Weaknesses, Opportunities, and Threats in the green hydrogen sector. By analyzing these factors, PLN can identify strategic actions to leverage its internal strengths, address its weaknesses,

capitalize on external opportunities, and mitigate the threats posed by a rapidly evolving energy landscape.

The following is an analysis of internal strengths, and weaknesses, as well as capitalize on external opportunities, and the threats.

Table 5. TOWS Matrix Analysis

Internal factors External factors	Strengths (S)	Weakness (W)
	<ul style="list-style-type: none"> S1. Extensive Renewable Energy Infrastructure S2. Experience in Energy Management S3. Established National Grid S4. Government Support 	<ul style="list-style-type: none"> W1. Dependency on Fossil-based Infrastructure W2. Limited Green Hydrogen Production Capacity W3. Technology Gaps W4. Management of Large-Scale Green Hydrogen Projects
Opportunities (O)	S-O strategies <ul style="list-style-type: none"> SO.1. Leverage existing renewable energy infrastructure SO.2. Capitalize on PLN's extensive distribution network SO.3. Develop government and private sector partnerships 	W-O strategies <ul style="list-style-type: none"> WO.1. Invest in R&D to close the technology gaps and improve hydrogen production efficiency WO.2. Expand green hydrogen production capacity WO.3. Improve management capabilities
Threats (T)	S-T strategies <ul style="list-style-type: none"> ST.1. Enhance technological advancements ST.2. Leverage PLN's experience in energy management ST.3. Strengthen PLN's competitive advantage 	W-T strategies <ul style="list-style-type: none"> WT.1. Address infrastructure challenges by developing new storage and transportation technologies WT.2. Enhance PLN's resilience to regulatory changes WT.3. Develop strategies for cost-effective production

TOWS Matrix provides PT PLN (Persero) with clear-cut strategic directions to become a market leader in green hydrogen. With strengths like infrastructure for renewable energy and experience with energy management and weaknesses like limitations in production capacity and no technology, PLN is best positioned to capitalize on the growing global demand for green hydrogen. Success will hinge on strategic investment in R&D, international partnerships, and collaboration with the government to develop a sustainable and competitive green hydrogen industry.

CONCLUSION AND RECOMMENDATION

The accommodation of green Hydrogen in Indonesia's national energy strategy offers great opportunities and challenges for PT PLN. The analysis of external

of external influences indicates that PT PLN is set in a dynamic energy landscape where economic, political, legal, and technological forces are key drivers of transformation.

Government policies, i.e., Presidential Regulation No. 112/2022 and the National Energy Policy (KEN), focus on embracing renewable

energy, thereby providing conducive conditions for green hydrogen development [25]. PT PLN, however, has challenges including the costliness of green hydrogen production, technology constraints, as well as the need for upgrading the infrastructure, which must be met in order to achieve effective market entry.

Internally, PT PLN has significant resource and capabilities in the form of its extensive renewable energy assets and governmental backin, which can be leveraged to drive the expansion of green hydrogen production [36]. Through the efficient use of such resources and the formation of strategic partnerships, PT PLN is able to mitigate some of the prevailing entry barriers in the green hydrogen market.

In order to synchronize its strategy with national energy policy goals and attain sustainable growth, PT PLN must focus on building its technological capacity, securing long-term financing, and expanding hydrogen infrastructure. Additionally, leveraging its position in the energy sector to deploy pilot projects and enhance its competitive standing in global markets is essential.

Recommendations

- **Technological Investment:** PT PLN must increase investments in hydrogen production technologies, particularly electrolysis, to push efficiency and cost down. Cooperation with foreign technology providers could accelerate the process [41].
- **Policy Alignment and Advocacy:** PT PLN should closely collaborate with governmental bodies to formulate policies that facilitate the creation of green hydrogen, including additional tax credits and regulatory policies that stimulate investment in hydrogen [25].

- **Infrastructure Development:** With the significance of infrastructure for green hydrogen uptake, PT PLN has a need to give top priority to the establishment of hydrogen production plants and refueling stations, especially in cities where demand for clean energy options is increasing [49].
- **International Market Growth:** PT PLN should focus on venturing into international hydrogen markets, particularly in countries like Japan and South Korea, which have built a considerable demand for green hydrogen [20]. International partnerships will enhance the competitiveness of the company and raise its market share in the global hydrogen economy.
- **Customer Segmentation:** PT PLN should tailor its green hydrogen offerings to various sectors, including industry, transport, and export markets. By developing cost-effective and scalable solutions for each segment, PT PLN can effectively address unique customer requirements while ensuring long-term market growth [36]. Through these strategic fields, PT PLN can properly incorporate green hydrogen into its business model, ensure alignment with Indonesia's national energy goals, and promote sustainable development in Indonesia's renewable energy landscape.

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