

Scenario Planning of PLN Indonesia Power in 2030: To Be a Leading Green and Sustainable Power Generation Company

Hasia Ahmadi, Yos Sunitiyoso, and Agung Wicaksono

ABSTRACT

Following the company's transformation in 2023, PLN IP's generating capacity now reached 21 GW, establishing it as the largest power generation company in Southeast Asia. However, most of PLN IP's power plants rely on fossil fuels. Therefore, the purpose of this study is to formulate a strategy that enables PLN IP to become a leading sustainable company and support Indonesia's target of achieving a renewable energy mix of 24.8% by 2030. The scenario planning method is used in this study to anticipate and prepare for future critical uncertainties that may impact the business of PLN IP. Critical uncertainties are obtained from analyzing the company's business, which is then elaborated with the results of semi-structured interviews from internal and external stakeholders. Five scenarios have been identified, namely: Parking the Bus, Kick & Rush, Tiki Taka, Gegenpressing, and Catenaccio. Each scenario is driven by a different critical uncertainty, consisting of electricity supply and demand, fuel prices, regulations, technological advancements, and investments. Key leading indicators of driving factors have been determined to detect potential scenario trends as early warning signals. This study is expected to serve as a reference for policymakers and stakeholders in the electricity sector to apply a balanced strategy for providing clean, reliable, and affordable electricity in Indonesia.

Keywords: Electricity; PLN IP; Renewable Energy; Scenario Planning.

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I. INTRODUCTION

In 2023, the Indonesia state-owned electricity company PT PLN (Persero) underwent a transformation into a Holding Sub Holding company. As part of this, PT Indonesia Power became a sub holding company called PT PLN Indonesia Power (PLN IP), focused on electric power generation. In the Java Madura Bali (JAMALI) grid, PT Indonesia Power has a market share in 2022 of 17.11% for existing power plants and 14.53% for O&M power plants (PT Indonesia Power, 2022). Once the power plant assets transfer from PLN to PLN IP is completed, the total power generation capacity of PLN IP will reach 21 GW (PT Indonesia Power, 2023), establishing it as the largest power generation company in Southeast Asia.

PLN IP's business is influenced by a range of stakeholders as illustrated in Fig. 1, including PLN, Independent Power Producer (IPP), green and renewable financing, technology industries, society/community, Government, and competitors. Additionally, global economic conditions, electricity demand, primary energy supply and price, and global commitments to achieve net-zero emissions affect the company's operations. To achieve the target of the Paris Agreement, each country must contribute to reducing Greenhouse Gas (GHG) emissions as outlined in the National Determined Contribution (NDC) document. In addition, Indonesia has ratified the Paris Agreement through Law no. 16 of 2016 concerning Ratification of the Paris Agreement to

The United Nations Framework Convention on Climate Change (ditjenppi-menlhk, 2016).

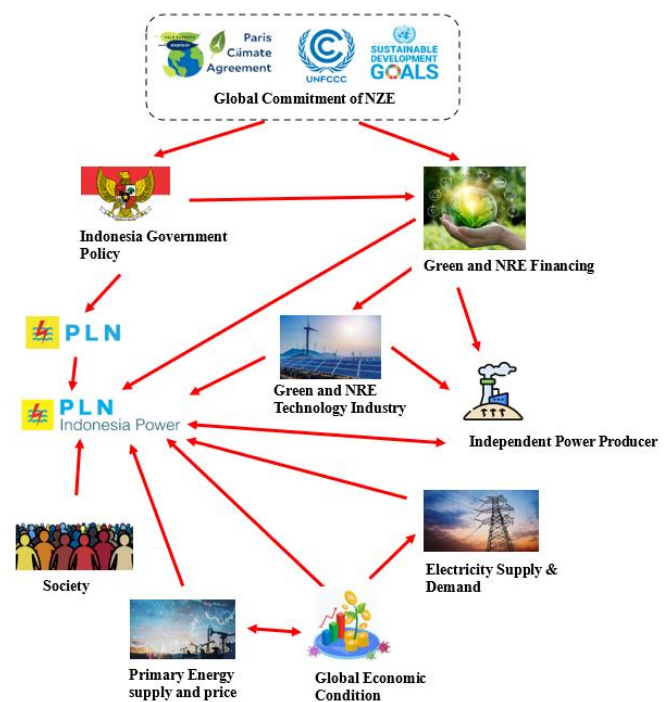


Fig. 1. Rich Picture of PLN IP business.

The target of the Indonesian Government's renewable energy mix in 2025 is 23% and in 2030 is 24.8% based on the RUPTL 2021–2030 (MEMR, 2021). Meanwhile, the new renewable energy mix only reaches 14.11% in 2022 even though it has increased compared to 2021 which amounted to 13.65% (Rizaty, 2023). The Indonesian Government has promulgated Presidential Regulation Number 112 of 2022 concerning the Acceleration of Development of Renewable Energy for the Provision of Electricity on September 13, 2022. This regulation is one of the manifestations of the Government's commitment in efforts to accelerate the development of new and renewable energy nationally (EBTKE, 2022). As a state-owned company in electricity, PLN has prepared a comprehensive roadmap for achieving Indonesia's National Determined Contribution (NDC) commitment and action in 2030 and in pursuing the Carbon Neutral 2060 target while maintaining business growth (PLN, 2021).

According to the MEMR's press release (EBTKE, 2023), the successful implementation of the energy transition by the Government relies on the collective support of diverse stakeholders, such as Government agencies, State-Owned Enterprises (BUMN), the private sector, academic institutions, associations, and the wider community. The role of Independent Power Producer (IPP) is important in developing electricity infrastructure and selling the product to PLN (Sunitiyoso, Mahardi, Anggoro, & Wicaksono, 2020). So that it has the potential to become a competitor as well as a business partner for PLN IP.

Green and Renewable Energy Financing also have an important objective to encourage the growth and expansion of renewable energy sources while decreasing reliance on non-renewable sources like coal, oil, and gas. According to Gyamfi *et al.* (2022) research, the decline of emission is influenced by increased foreign direct investment (FDI). The continued progress of renewable energy technologies holds great promise for enhancing access to affordable and reliable sources of clean energy. The availability of affordable, green, and reliable energy aligns with RE's mission of achieving more sustainable development goals (Ali *et al.*, 2023).

Supply and demand of electrical energy will affect the production and sale of electricity from PLN IP. However, Indonesia's economic growth will trigger an increase in national electricity consumption. Electricity consumption is positively and significantly associated with economic growth in all the study countries in the long run (Chirwa & Odhiambo, 2020). According to IEA (2022), geopolitics in 2022 caused a quick economic recovery from the pandemic to turn into widespread energy turmoil. All fuels were affected, with high gas and coal prices accounting for 90% of the pressure on electricity costs worldwide. The operations of PLN IP are highly dependent on the availability and cost of primary energy. The fuel price of generation has a positive significant effect on the average electricity price (Adi, 2023). The community is also an essential element in the PLN IP business since the purpose of the business is to provide benefits to the community, especially through the provision of electrical energy.

PLN IP aims to be a leading sustainable energy company, following the Sustainable Development Goals (SDGs) and global efforts to create a better world. However, most PLN

IP's power plants are coal-based, which supports the electrical system as a baseload. This puts PLN IP at a crucial juncture where it must decide between renewable and fossil energy sources. Fossil energy power plants contribute 77% of PLN IP's revenue in 2022 (PT Indonesia Power, 2022). Therefore, PLN IP should adopt a balanced strategy that considers the company's internal and external conditions to ensure sustainable business while providing reliable, clean, and affordable electricity. To formulate effective strategies and roadmaps for PLN IP, it is essential to undertake scenario planning. This approach will help organizations identify warnings that can trigger strategic pivots or risk mitigation strategies, meaning both opportunities and risks are taken into consideration in planning and decision-making (Deloitte, 2022).

II. LITERATURE REVIEW

Scenario planning is a strategic planning technique used to help an organization explore and prepare for various possible futures (Causal, 2023). For businesses, scenario planning enables decision-makers to identify ranges of potential outcomes and estimated impacts, evaluate responses and manage for both positive and negative possibilities (Luther & Ali, 2022). Systems thinking is critical in scenario planning because it views complex systems as many interconnected parts that interact unpredictably. Systems thinking is an approach that considers various factors and interactions that may affect a potential outcome (Morganelli, 2020). This approach helps decision-makers take a more comprehensive view of their organization and environment, enabling them to identify key change drivers and predict the effects of different scenarios. (Indeed Editorial Team, 2021). Creating a rich picture is an effective way to more convincing and enjoyable than just reading about systems thinking ideas, as is often the case (Armson, 2011).

According to Veldsman (2022), scenario planning is essentially about understanding the external dynamics that could influence the operating environment of business. Like in strategic planning, scenario planning starts from strategic analysis of macro-environment and micro-environment (Cherepovitsyn & Ilinova, 2018). Strategic management process includes evaluating strategies, analyzing the internal organization and competitive environment, and ensuring strategy execution throughout the company. Strategic management sets objectives, analyzes the environment and organization, evaluates strategies, and ensures their implementation across the organization (Kenton, 2022).

A PESTLE analysis studies the key external factors (Political, Economic, Sociological, Technological, Legal and Environmental) that influence an organisation (CIPD, 2021). While the Five Forces model is widely used to analyze the industry structure of a company as well as its corporate strategy (The Investopedia Team, 2023). The Boston Consulting Group (BCG) growth-share matrix is a planning tool that uses graphical representations of a company's products and services to help the company decide what it should keep, sell, or invest more in (Hayes, 2022).

Despite the limited research and theses available on scenario planning in power generation companies, some

relevant works that touch on scenario planning, energy, and electricity are worth noting. For instance, the Bandung Scenario (2014) offers stakeholders in the Indonesia energy sector a comprehensive plan by anticipating potential scenarios. This study consists of four planning scenarios, each arising from a different critical uncertainty such as reform, geopolitics, climate change, and decentralization/local autonomy. On the other hand, the Mont Fleur Scenario created by Roux *et al.* (1992) aims to stimulate debate on how to shape the next 10 years rather than presenting definitive truths. The project involved 22 prominent South Africans from various backgrounds to develop and disseminate a set of stories about what might happen in their country over 1992–2002.

Meanwhile, Shell has been developing possible visions of the future since the early 1970s, helping generations of Shell leaders, academics, governments, and businesses to explore ways forward and make better decisions. Shell Scenarios ask, “what if?” questions, encouraging leaders to consider events that may only be remote possibilities and stretch their thinking (Shell, 2023).

Drawing on insights gleaned from the literature review, this study aims to develop plausible scenarios that could unfold in the Indonesian electricity sector by 2030. This study involves constructing a scenario planning framework that considers each critical uncertainty identified through the analysis of the company's business data and stakeholder interviews. This approach enables a holistic view of the potential trajectories of the Indonesian electricity sector.

III. RESEARCH METHODOLOGY

The research methodology for PLN IP scenario planning involves several steps, starting with the identification of issues in the PLN IP business using analytical tools such as PESTLE, Porter's Five Forces, and Growth Share Matrix. The research process then moves to external and internal analysis, scenario planning data collection, and qualitative analysis to identify key focal issues. This study examines driving forces from politics, economics, social, technology, environment, and legal to understand their impact on the organization's goals.

Various sources are used for data collection, such as PLN IP corporate data, interviews, reports, literature reviews, and online sources. Stakeholder interviews are conducted to identify critical uncertainties related to these factors, which are used to create multiple scenarios. To get different perspectives and produce comprehensive data, semi-structured interviews were conducted with several stakeholders, both internal and external to the company. Each

TABLE I: LIST OF EXTERNAL RESPONDENTS

Initial	Company	Position	Experiences
HNR	PT. PLN – Head Office	Expert of Power Plant Management (Former Operation Director of PLN IP)	30 years
FHM	PT. PLN – Distribution	Manager	15 years
EFF	PT. Adaro	Commissioner (Former President Director of Adaro Power)	45 years

TABLE II: LIST OF INTERNAL RESPONDENTS

Initial	Division	Position	Experiences
BEN	Business Development	Director	30 years
SLH	Technology Development	Vice President	22 years
HRI	Corporate Strategic Growth	Manager	15 years
ADH	Business Development	Manager	19 years
GNR	Engineering of PLTGU	Manager	18 years
YNR	Engineering of PLTU	Manager	15 years
ARS	Project Procurement	Manager	15 years

respondent has a different background and position so that the interview results are expected to minimize personal bias. The list of respondents from external companies in this semi structured interview is shown in Table I. While the list of respondents from internal companies in this semi structured interview is shown in Table II.

During the interviews, participants were queried regarding PLN IP's business and the advancement of renewable energy in Indonesia. The aim was to gain insights into the country's energy transition, encompassing the hurdles and difficulties encountered. Furthermore, the primary objective of these inquiries was to identify pivotal uncertainties that could impact PLN IP's operations in the upcoming 5–10 years.

IV. RESULTS AND DISCUSSION

A. Business Environment Analysis

To analyze the external macro-environmental that affects PLN IP's business related to the development of renewable energy, the PESTLE analysis tool is used. PT PLN IP business is heavily influenced by political factors in Indonesia, including national political stability and global geopolitics which may affect world trade and fuel price.

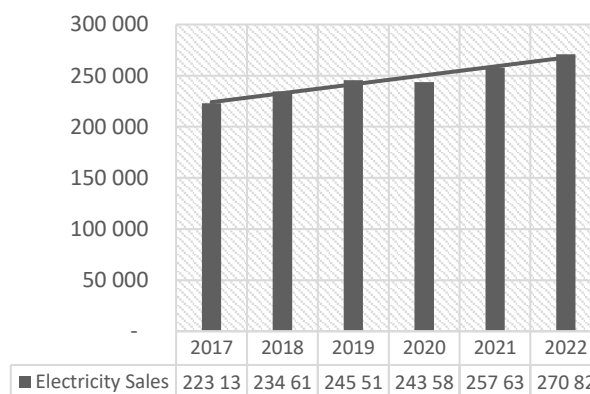


Fig. 2. PLN Electricity Sales 2017–2022. Source: (PLN, 2022).

In the economic sector, there are several factors that can influence its business operations and performance, including demand and supply of electricity, fuel prices, exchange rates, energy transition financing, and limitation of PLN investment funds. Even though Indonesia was hit by the Covid 19 pandemic in 2020–2022, PLN's electricity sales only experienced a slight decline in 2020 while in 2021 and 2022 PLN's electricity sales experienced an increase as shown in Fig. 2. Based on information from the official PLN Press Release (PLN, 2023), PT PLN (Persero) managed to record the best sales in 2022 of 270.82 treated hours (TWh) with a total of 85.28 million customers. This acquisition increased by 15.75 TWh or 6.17 percent compared to the previous year

which was only 255.07 TWh.

On the other hand, the change in primary energy prices has a significant impact on production costs, as it accounts for 60-70% of the production cost (Indonesia Power, 2022). Meanwhile, changes in exchange rates can affect the company's revenue, expenses, and profitability. Based on PLN's financial reports for 2021, PLN's portion (loss)/gain on foreign exchange is quite large from year to year as shown in Fig. 3.

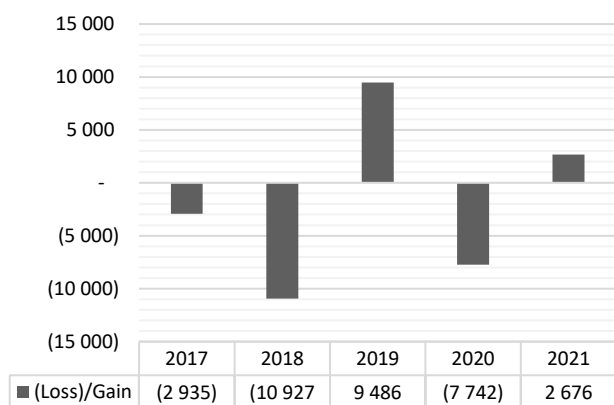


Fig. 3. PLN (Loss)/Gain on foreign exchange – net. Source: (PLN, 2022).

In the sector of energy transition financing, several global financial institutions in the banking and insurance sector have agreed to no longer fund projects that contribute to environmental damage and are only committed to funding green energy-based projects (Buckley, 2019). According to ADB (2019), the Government of Indonesia is looking at new financing and incentive models to increase the deployment of clean and efficient technologies. The Government intends to provide financial incentives for renewable energy developers via an Energy Resilience Fund (ERF).

However, PLN must remain careful in managing its finances, this causes PLN to limit investment. Based on PLN's 2021 annual reports (PLN, 2022), PLN's total long-term liabilities reach IDR 485 trillion. Even though PLN's debt to equity ratio (DER) in the last 5 years is still reasonable as seen in Fig. 4. with DER in 2021 at 42.71%.

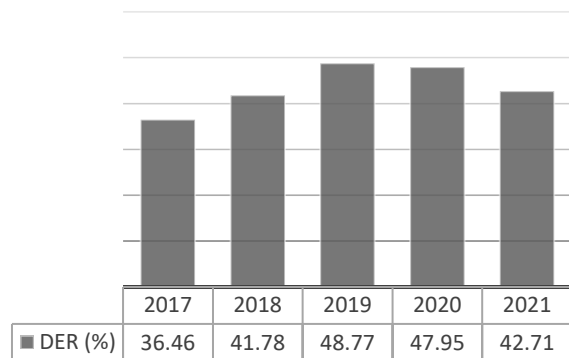


Fig. 4. PLN Debt to Equity Ratio 2017–2021. Source: (PLN, 2022).

PLN's IP is also influenced by environmental issues and social trends that can affect its business, especially related to climate change and environmental awareness trends. While in the technological sector, PLN IP's business is heavily

influenced by technological development, such as clean and renewable energy technologies, smart grid technologies, and energy storage technologies. Technological developments cause renewable energy to become cheaper currently. The global weighted average levelized cost of electricity (LCOE) of renewable energy such as solar and wind has decreased significantly since 2010. Based on IRENA (2022), the LCOE of newly commissioned utility-scale solar PV projects fell by 85% between 2010 and 2020, that of CSP by 68%, onshore winds by 56% and offshore winds by 48%. Technological developments in Power Plant will affect the company's business decisions whether to fully switch to renewable energy or continue to maintain fossil energy power plants.

PLN IP business is also significantly impacted by various legal factors. Among the Government regulations that affect the PLN IP business are energy transition laws, electricity laws, carbon emission laws, and labor law.

As stated by Porter (1980), forces outside the industry are significant primarily in a relative sense; since outside forces usually affect all firms in the industry, the key is found in the differing abilities of firms to deal with them. The industrial environmental business analysis of PLN IP, using Porter's Five Forces framework, needs to be combined with PESTLE analysis to provide insights into the competitive landscape of the industry, potential threats and opportunities, and overall industry attractiveness. Porter's framework considers five forces, including the threat of new entrants, bargaining power of suppliers, bargaining power of buyers, threat of substitutes, and competitive rivalry.

The new electricity law (Law Number 30 of 2009) encourages the private sector to enter the electricity industry. Based on PLN 2021 statistical data (PLN, 2022), the number of Independent Power Producer (IPP) power plants in Indonesia is 372 units with an installed capacity of 18,722.32 MW. Meanwhile, PLN's electricity purchase data from IPP power plants in 2021 is 106,496.69 GWh (37%) as shown in Fig. 5. The purchase of electricity increased by 9,337.95 GWh or 9.61% compared to the previous year. This shows that the threat of new entrants in the electricity generation industry is high.

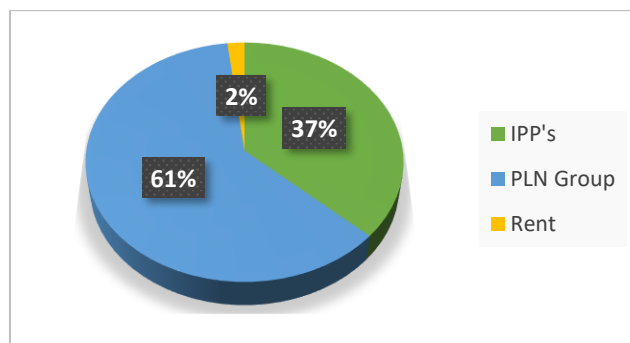


Fig. 5. Indonesia Electricity Production in 2021 Source: (PLN, 2022)

The bargaining power of suppliers for PLN IP is moderate. The company sources fuel and equipment from various suppliers, but the availability and pricing of these resources are subject to market fluctuations. PLN IP's biggest expenditure is to purchase fuel with a percentage of 60–70% (Indonesia Power, 2022). Based on DMO (Domestic Market

Obligation) regulations from the Government, domestic coal prices are pegged at \$70/ton so that with the increase in world coal prices due to geopolitics in Eastern Europe, coal suppliers are more interested in exporting coal. Meanwhile, PLN IP has more supplier options for the purchase of equipment, spare parts, and consumables.

The bargaining power of buyers is high for PLN IP. The majority of PLN IP's revenue comes from the electricity sales business. PLN IP sells electricity to its own holding company through PLN P2B with a single buyer scheme. So that PLN IP does not have bargaining power over its electricity buyers (PLN P2B). Meanwhile the threat of substitutes for PLN IP is moderate. PLN IP is one of several suppliers of electricity to PLN P2B, alongside other power plants within the PLN groups and independent power producers (IPPs). In the JAMALI grid, PLN IP has a market share of 31.64% while IPP's has a market share of 38.66% (PT Indonesia Power, 2022). According to Muliawati (2023) report, the oversupply of electricity in Indonesia averages above 40%. So that PLN P2B as a PLN transmission unit that buys electricity from power plants has many choices of electricity suppliers. Finally, the competitive rivalry in the energy industry in Indonesia is intense. There are several players in the market, and the industry is highly regulated. PLN IP faces competition from other state-owned companies and private players (IPP's).

The result of industrial environmental business analysis of PLN IP using Porter's Five Forces framework indicates that the company operates in a moderately attractive industry with high competition, high bargaining power of buyers, and moderate bargaining power of suppliers. The condition of oversupply of electricity in Indonesia has caused an increase in the threat of substitutes, but PLN IP still could increase the efficiency and reliability of Power Plants to compete for merit orders priority from dispatcher.

In order to comprehensively analyze PLN IP's business, it is essential to conduct an internal factor analysis to identify and evaluate the company's available resources. This analysis will help to determine the factors that contribute to the company's competitive advantage, growth, and profitability (Paryo, 2017). The useful tool for conducting internal analysis of PLN IP business is the Growth Share Matrix. In general, the PLN IP business consists of an electricity sales business, a power plant operation & maintenance (O&M) service business, and a derivatives business. Electricity Sales Business is the business of selling electricity (PJBTL/Perjanjian Jual Beli Tenaga Listrik) generated by PLN IP's power plants. The total capacity of PLN IP's power plants in 2022 is 9 GW. The total production of renewable energy power plants in 2022 is 7,300 GWh. While the total production of fossil energy power plants in 2022 is 30,506 GWh.

Meanwhile, the percentage of PLN IP electricity production in 2022 consists of 19% NRE power plants and 81% fossil power plants (PLN IP, 2023). Based on Presidential Regulation Number 112 of 2022, Indonesia will not add more coal-fired power plants except for projects that are already develop. So that PJBTL's additional business in fossil power plants for PLN IP is only from ongoing development projects.

For PJBTL's business development in renewable energy power plants, most PLN IP power plant development plans are hydropower and solar power. In addition, the transfer of power plant assets from PLN in waves 2 and 3 is planned for 148.1 MW for hydropower, 12.5 MW for geothermal, and 22 MW for solar/hybrid (PT Indonesia Power, 2023).

O&M Service Business is a PLN IP business that manages PLN's power plants including operation, maintenance, and management of power plants assets. By 2022, PLN IP's O&M business will cover the management of 27 power plants belonging to PLN (PT Indonesia Power, 2023). PLN IP only gets revenue from O&M services and does not sell electricity. This business will not continue in 2023 because all of PLN's power plants managed by PLN IP will be handed over to PLN IP. So that in 2023 sales of PLN IP electricity will increase dramatically.

Derivatives Business is a derivative business from the main business of PLN IP covering the O&M business in private companies, MRO (Maintenance, Repair, Outage), EPC (Engineering, Procurement, Construction) including Power Plant Relocation, Power Generation Digitization, Consulting, and other businesses related with power plant. This business continues to grow, including the business in renewable energy technology where PLN IP is planning to develop a solar PV manufacturing business, battery manufacturing, smart grid development, nuclear power plant development with SMR (Small Modular Reactor) technology, and other technology developments related to power generation.

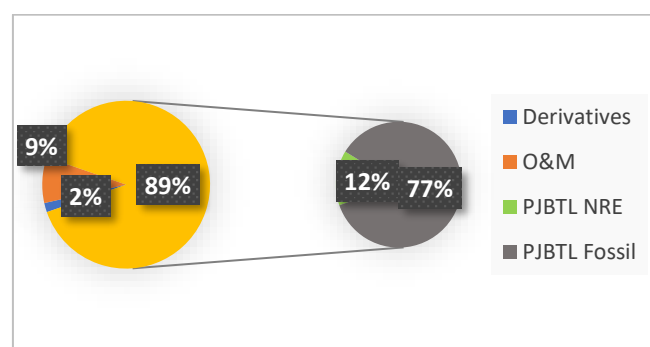


Fig. 6. Revenue Percentage of PLN IP business in 2022.
Source: (PLN IP, 2023).

Based on revenue from each business in 2022, PLN IP's business that generates the most revenue is the business of selling electricity from PLN IP's own power plants. Fig. 6. shows the percentage of revenue for each PLN IP business line in 2022. The total revenue of PLN IP in 2022 is IDR 42,794 billion, while with the addition of power plant assets, the projected revenue for PLN IP in 2023 is IDR 99,000 (PLN IP, 2023).

From the revenue projection in 2023, the percentage of revenue based on business classification can be seen in Fig. 7. While the projection of the total production of PLN IP in 2023 is 78,000 GWh with a percentage of production from NRE power plants of 15% and fossil power plants of 85%.

Based on the above data, the Growth Share Matrix analysis of PLN IP business in 2023–2026 can be determined as shown in Fig. 8.

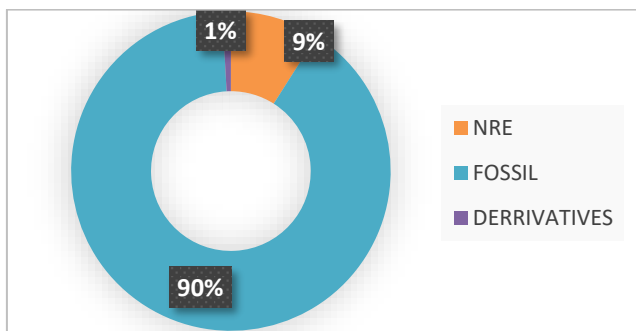


Fig. 7. Revenue Percentage Projection in 2023. Source: (PLN IP, 2023).

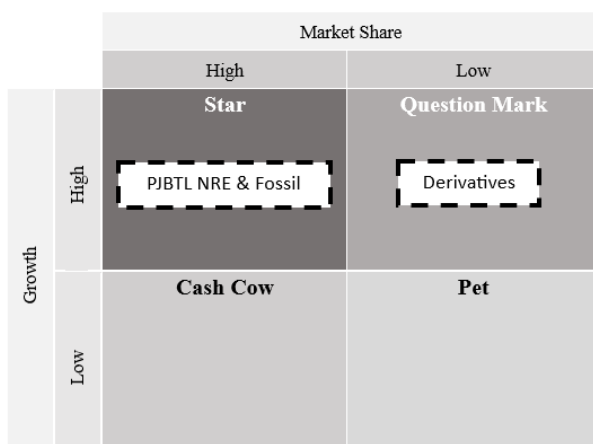


Fig. 8. The Growth Share Matrix analysis of PLN IP business in 2023–2026.

A "star" business or product is one that has a high market share in a growing market and generates significant revenue with potential for further growth. PJBTL's business in renewable and fossil energy power plants falls under this category. The derivatives business, on the other hand, is a "question mark" because it has a low market share but great growth potential. It is predicted to contribute between 2–5% of PLN IP's revenue in 2023–2026 and has the potential to become a "star" business with a market share above 5% by 2027–2030. Finally, a "cash cow" business is one that has a high market share in a low-growth market. PJBTL's fossil energy generation business is predicted to become a cash cow after 2027 because there will be no additional production from fossil energy power plants, meaning revenue cannot increase and the business will not grow.

B. Driving Forces and Critical Uncertainties

After conducting a literature review and analyzing the company's business environment, the driving factors that affect the company's operations were identified. These driving factors were further elaborated through semi-structured interviews, and the results are presented in Table III.

To identify the driving forces with the highest level of uncertainty, in the semi-structured interview questions were asked about which driving forces have the possibility of uncertainty in the next 5–10 years. The results of the semi-structured interview show that the choice of driving forces that have uncertainty level in the next 5–10 years is as shown in Table VI.

TABLE III: DRIVING FORCES

Factors	Driving Forces
Political/Legal	- Global Geopolitics
	- Government Policies and Law related to electricity and energy transition
	- National Political stability
Economical	- Demand and supply of electricity
	- Fuel Prices
	- Exchange rates
Social	- World Energy Transition Financing
	- PLN investment funds
	- Social Trends
Technological	- Clean and Renewable Energy Technologies Development
	- Smart Grid Technology
	- Energy Storage Technologies
Environmental	- Climate Change

The semi structured interview results are also used to identify the level of impact of the driving forces on the PLN IP business. The results of the analysis of the impact level of the driving forces based on the results of semi-structured interviews are shown in Table VII.

The results of this semi-structured interview were obtained from internal and external stakeholders of the company. With different positions and experiences, it will produce different points of view on each of the interviewed stakeholders. Key stakeholders explored their experience to gain perspectives on PLN IP business and energy transition trends during interviews. To obtain accurate data, the main stakeholders are given an introduction regarding data related to the PLN IP business and the energy transition. Critical uncertainty is obtained by collaborating the level of uncertainty and the level of impact of the driving forces.

Based on the results of semi-structured interviews with stakeholders, the critical uncertainty matrix can be seen in Table VIII. The driving forces that are critical uncertainties can be categorized into three variables: **Government Regulation, Technology Development, and Economic Condition**. Technology development variable is a combination of technologies related to renewable energy, energy storage technology, and smart grid technology. While the economic condition variables consist of issues: **electricity supply & demand, fuel prices, and investment** where each of the three issues of economic conditions will become critical uncertainty.

C. Scenario Creation

After analyzing the results of the semi-structured interviews, five critical uncertainties emerged: **Government Regulation, Technology Development, electricity supply & demand, fuel prices, and investment**. Scenario planning framework was devised based on these five critical uncertainties, as illustrated in Table IV. Each scenario is made based on a critical uncertainty that creates a certain situation related to electricity conditions in Indonesia.

Parking the Bus Scenario is driven by the critical uncertainty 'Electricity Supply & Demand (Economy),' with the oversupply of electricity being a keyword. The oversupply of electricity in Indonesia is a result of the slower growth in electricity demand compared to the growth in

TABLE VI: DRIVING FORCES WITH LEVEL OF UNCERTAINTIES

Driving Forces	ADH	ARS	GNR	HRI	SLH	YNR	BEN	FHM	HNR	EFF	Total
Political/Legal											
Global Geopolitics				1	1						2
Government Policies and Law	1	1	1	1	1	1	1	1	1	1	10
National Political stability					1						1
Economic											
Demand and supply of electricity			1		1		1				3
Fuel Prices				1	1	1	1				4
Exchange rates					1						1
Energy Transition Financing			1		1	1			1	1	5
PLN investment funds	1					1			1	1	4
Social											
Social Trends			1								1
Technological											
Clean and Renewable Energy Technologies Development		1	1	1	1	1	1	1	1	1	9
Smart Grid Technology						1		1	1		3
Energy Storage Technologies		1	1					1	1		4
Environmental											
Climate Change				1				1			2

TABLE VII: DRIVING FORCES WITH LEVEL OF IMPACT

Driving Forces	ADH	ARS	GNR	HRI	SLH	YNR	BEN	FHM	HNR	EFF	Total
Political/Legal											
Global Geopolitics				1	2						3
Government Policies and Law	3	3	3	3	3	3	2	3	3	2	28
National Political stability					1						1
Economic											
Demand and supply of electricity			2		2		2				6
Fuel Prices				1	1	1	1				4
Exchange rates					1						1
Energy Transition Financing			2		2	1			2	3	10
PLN investment funds	2					1			2	3	8
Social											
Social Trends			1								1
Technological											
Clean and Renewable Energy Technologies Development		2	1	2	1	2	3	2	1	1	15
Smart Grid Technology						2		1	1		4
Energy Storage Technologies		1	1					1	1		4
Environmental											
Climate Change				1				1			2

TABLE VIII: CRITICAL UNCERTAINTIES MATRIX

		Degree of uncertainty		
		Low (1-2)	Medium (3-8)	High (>9)
Degree of impact	High (>7)	-	<ul style="list-style-type: none"> ▪ Energy Transition Financing ▪ PLN investment funds 	<ul style="list-style-type: none"> ▪ Government Policies and Law ▪ Clean and Renewable Energy Technologies Development
	Medium (3-7)	Global Geopolitics	<ul style="list-style-type: none"> ▪ Demand and supply of electricity ▪ Fuel Prices ▪ Smart Grid technology ▪ Energy Storage Technologies 	
	Low (1-2)	<ul style="list-style-type: none"> ▪ Exchange rates ▪ Climate Change ▪ National Political stability ▪ Social Trends 	-	-

TABLE IV: SCENARIO PLANNING FRAMEWORK

Critical Uncertainty	Conditions	Scenario
Demand and supply of electricity	The growth in power generation capacity has outpaced the growth in electricity demand	Parking the Bus
Fuel Prices	The energy crisis prompts each country to compete for energy supply, resulting in a surge of energy prices	Kick & Rush
Government Regulation	The tug of war between supporting renewable energy and maintaining fossil energy	Tiki Taka
Technology Development	The development of renewable energy technology has led to a reduction in the levelized cost of energy (LCOE) and provided affordable solutions to address intermittency	Gegenpressing
Investment Financing	Investors are interested in developing renewable energy in Indonesia due to its rich natural resources and increasing awareness of the benefits for the environment and society	Catenaccio

generation capacity. Due to the slow national economic growth, Government policies have focused on increasing electricity demand, which has limited the development of renewable energy technology. This, coupled with technical challenges and a lack of government support, has made it difficult to replace fossil fuels as the primary energy source. To address this issue, PLN IP needs to improve operational efficiency and reduce emissions in fossil fuel power plants while optimizing biomass cofiring and securing supply. Developing CCS/CCUS technology and uprating existing renewable energy power plants are also effective strategies. Collaborating with partners to find funding options and developing renewable energy power plants are essential steps towards increasing renewable energy's share in Indonesia's electricity mix and reducing carbon emissions.

Kick & Rush Scenario is driven by the critical uncertainty 'a Surge in Fuel Prices (Economy),' with the scarcity of energy being a keyword. The rise in global fuel prices has resulted in an energy scarcity problem in the country, leading the Government to prioritize securing the domestic electricity supply to maintain its reliability and affordability. The Government has been enforcing Coal DMO regulations and promoting renewable energy development to substitute fossil fuels due to the increasing global energy prices and scarcity. In an effort to meet domestic needs, coal exports are limited, and cofiring programs are being implemented across all coal-fired power plants. As Indonesia faces an electricity crisis, primarily due to its dependence on coal-fired power plants, PLN IP shall focus on securing coal supplies and maintaining operational excellence in fossil energy power plants while developing renewable energy power plants, expanding cofiring programs, exploring CCS/CCUS technology, and investing in solar PV and battery manufacturing to ensure a sustainable and reliable energy supply. This will help Indonesia address its dependence on coal-fired power plants and mitigate the ongoing electricity crisis.

Tiki Taka Scenario is driven by the critical uncertainty 'The regulatory tug of war (Regulation),' with the stagnation of renewable energy being a keyword. Inconsistencies in regulations, caused by conflicting interests, have hindered the development of renewable energy in Indonesia, leading to a lack of investor interest in the sector. The Indonesian Government is attempting to accelerate the implementation of renewable energy by providing new stimulus regulations, while also maintaining Coal DMO regulations due to the country's dependence on coal-fired power plants. However, the inconsistent development of renewable energy in Indonesia is causing investors to reconsider their investment decisions in the sector. To address this challenge, PLN IP shall prioritize optimizing the efficiency of its coal and gas power plants while also considering emission reduction programs such as cofiring and CCS/CCUS. Additionally, the company must focus on developing renewable energy, particularly solar power plants, and seek strategic partnerships for collaboration to ensure successful project financing and implementation.

Gegenpressing Scenario is driven by the critical uncertainty 'The exponential advancement of renewable technology (Technology),' with the balance of energy trilemma being a keyword. Renewable energy technology has improved significantly, leading to reduced costs and solutions for intermittent problems, attracting investor interest and prompting the Government to balance the energy trilemma. With exponential development and Government support, renewable energy technologies are becoming increasingly feasible, resulting in a growing demand for renewable energy and electric vehicles. Indonesia's renewable energy mix reached 24.8% in 2030, reducing carbon emissions. To maintain this progress, PLN IP shall prioritize the development of renewable energy power plants, while ensuring operational excellence in existing coal and gas power plants. They shall also plan for the early retirement of coal and gas power plants, implement cofiring and CCS/CCUS programs, accelerate the development of solar PV panel and battery factories, and direct their derivatives business towards renewable energy. Investment budgets shall prioritize renewable energy, and coal power plants shall be transformed into flexible power plants to support the intermittent problem of renewable energy.

Catenaccio Scenario is driven by the critical uncertainty 'A surge in investment funding (Economy),' with the competitiveness of domestic industry being a keyword. Increased investor interest in renewable energy development in Indonesia has led to more funding and tighter local content requirements by the government, resulting in greater domestic competitiveness. This shift towards renewable energy has not only changed the electricity industry but has also stimulated growth in electric vehicles, solar panels, and batteries in the country. As a result, Indonesia has become more self-sufficient in meeting its energy needs. To maintain this momentum, PLN IP shall focus on developing renewable energy power plants and accelerating the development of solar PV panels and battery factories to meet the TKDN requirements by 2026. PLN IP shall also collaborate with research institutions and the renewable energy industry to explore other energy alternatives and develop renewable energy technologies. Additionally, PLN IP shall prepare a

TABLE V: EARLY WARNING SIGNALS OF EACH SCENARIO

Driving Factors	Indicators	Parking The Bus “The Oversupply”	Kick & Rush “The Scarcity”	Tiki Taka “The Stagnation”	Gegenpressing “The Balance”	Catenaccio “The Competitiveness”
Regulations	Solar PV	- No flexibility of TKDN - Obstacles for on-grid solar PV	- Flexibility of TKDN - Support for on-grid solar PV	- Flexibility of TKDN - Support for on-grid solar PV	- Flexibility of TKDN - Support for on-grid solar PV	- Higher of TKDN - Support for on-grid solar PV
	NRE mix target	Remain 24.8% or lower in 2030	Remain 24.8% in 2030	Remain 24.8% in 2030	Remain 24.8% or higher	Remain 24.8% or higher
	Electricity dispatch	Prioritizing affordability (economic dispatch) Valid in 2023 and continues thereafter	Prioritizing energy security and reliability Valid only in 2023	Focus on affordability	Considering the trilemma energy balance Valid in 2023 and continues thereafter	Focus on Sustainability
	Electric vehicles subsidy	Coal DMO	Remain coal DMO policy	Remain coal DMO policy	Remain DMO policy	Coal DMO policy changes
Politic	Global/National issues	Oversupply and Power Wheeling polemic	Geopolitical issue	National interest tug of war	Coal DMO issue	TKDN polemic
Technology	NRE technology	No significant breakthroughs	No significant breakthroughs	No significant breakthroughs	Technological breakthroughs make affordable costs	Technological breakthroughs make affordable costs
	CCS/CCUS technology	No significant breakthroughs	Technological breakthroughs make affordable costs	No significant breakthroughs	Technological breakthroughs make affordable costs	Technological breakthroughs make affordable costs
Economy	NRE financing	Investment limitations for NRE	Low investor interest in NRE development in Indonesia	Low investor interest in NRE development	High Investor interest in Indonesia	Very High Investor interest in Indonesia
	Electricity demand growth	Below 6% per year	Around 6% per year	Around 6% per year	Above 6% per year	Above 6% per year
Social	Electricity trend	Affordability is a major consideration	Energy security is a major consideration	Energy security is a major consideration	Major consumer considerations are affordability, security, and environmental issues	Major consumer considerations are sustainability and environmental issues

map of Indonesia's renewable energy potential development for presentation to investors and seek funding from investors to rehabilitate and retrofit existing renewable energy power plants.

Early warning signals have been identified as leading indicators that help policymakers and stakeholders anticipate potential scenario trends. Detecting these signals accurately enables proactive responses to potential scenarios, leading to evidence-based decision-making. The analysis of early warning signals for each scenario is based on four primary driving factors: Government regulations, politics, technology, economy, and society, as presented in Table V.

V. CONCLUSION

The analysis in this research yields five critical uncertainties that have the potential to affect PLN IP's business in 2030. From each critical uncertainty the following five scenarios are created as shown in Table VI.

Early warning signals have been prepared based on the main driving factors including regulation, politics, technology, economy, and social. These signals act as leading indicators that help policymakers and stakeholders anticipate the emergence of a potential scenario before it becomes a reality. By accurately identifying these signals, policymakers can proactively respond to potential scenarios, rather than simply reacting when they have already become a reality. The ability to detect scenario trends swiftly is essential, as it provides policymakers with an opportunity to implement

strategies earlier than the competitors. PLN IP shall adopt a balanced strategy that considers the company's internal and external conditions in each scenario to ensure sustainable operations while providing clean and affordable electricity to the community. The strategic imperatives to ensure sustainable operations are focuses on maintaining the operational excellence of existing power plants while also completing ongoing power plant project, developing renewable energy power plants, and exploring beyond kwh business opportunities.

TABLE VI: CRITICAL UNCERTAINTIES AND SCENARIOS

No	Critical Uncertainty	Scenario	Keywords
1	Demand and supply of electricity	Parking The Bus	The Oversupply of Electricity
2	Fuel Prices	Kick & Rush	The Scarcity of Energy
3	Government Regulation	Tiki Taka	The Stagnation of Renewable energy
4	Technology Development	Gegenpressing	The balance of energy trilemma
5	Investment Financing	Catenaccio	The Competitiveness of Domestic Industry

CONFLICT OF INTEREST

Authors declare that they do not have any conflict of interest.

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