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Development of Alternative Energy Transition Scenarios for Electricity Utility Companies in 2045 Using the Scenario Planning Method

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ABSTRACT

In implementing the energy transition, electricity utility companies must be able to carry out future planning to replace electricity infrastructure from a fossil energy-based generation system to clean energy generation and new renewable energy (NRE) to achieve Net Zero Emission (NZE) conditions by 2060. Term planning. What has often been done so far is to use forecasting methods, which are made by utilizing historical databases and using many assumptions about economic, social, and environmental conditions, as well as other factors that are easily changed and close to uncertainty. Therefore, planning methods must consider possible changes and uncertainties with several possible scenarios. Scenario planning is planning with a strategic approach that focuses on the process, involving finding optimal strategies for several scenarios that can occur, and this method helps deal with uncertainty. This paper explores the development of alternative scenarios that may occur in 2045, using scenario planning to help electricity utility companies capture opportunities and offset threats. It focuses on formulating broad and innovative strategies for the energy transition in the electricity business.

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1. INTRODUCTION

Electricity companies aim to provide a sufficient, continuous, and reliable electricity supply for all regional or country customers. Because of these obligations, an electricity company must have a company activity plan for the short, medium, and long term, which includes operation, maintenance, and investment in new construction of electricity generation infrastructure, transmission networks, electricity distribution networks, and customers to ensure service availability of electricity supply. Especially for long-term planning, providing the company's sustainability and supplying electricity according to customer needs is necessary. Preparing a company's long-term plan is a challenging and complicated process, considering that the business is

influenced by political, social, economic, legal, environmental, and technological conditions that are often volatile and easy to change. Changes in one factor will result in other aspects and significantly shift company planning. This is becoming more challenging now because of the energy transition, where electricity utility companies are being directed to change their electricity infrastructure from using polluting fossil energy to using clean energy, namely new and renewable energy (NRE) (Kiswantono & Shoedarto, 2023). Therefore, electricity companies need to carry out long-term planning based on energy transition with new methods and mechanisms that can consider uncertain conditions that may arise. (Paiboonsin et al., 2023). This will ensure that the long-term plan has a more accurate analysis and can be used as a reference to achieve the NZE target and determine the company's position in the future.

To see several possible futures, planners in government and large organizations usually use data-driven modeling. Models with such databases are limited by their reliance on historical data to estimate future conditions, which can distort reliability in uncertain world conditions (Sihombing, 2013). For example, in an electricity utility company, power generation systems that use conventional electricity planning usually must match demand and supply due to errors in forecasting electricity demand (Soontornrangson et al., 2003). Planning conditions based on historical data cannot predict new things that may occur and future conditions. Therefore, planning for the present and future needs to be strengthened with an "alternative future" approach that includes and considers a range of techniques for various plausible scenarios that could occur. Scenario planning is a method that does not rely on future forecasting and has strong characteristics in dealing with uncertainty in strategic decision-making.

Scenario planning has been defined in several ways. Schwartz (1991) defined scenarios as "a tool for ordering one's perception about the alternative future environment in which one's decisions might be played out" (Schwartz, 1991). Scenario planning is a structured practice of describing and anticipating future events and conditions regarding what might happen that could affect the activities of an organization. This technique helps plan company and marketing strategies, especially looking at potential future needs, markets, and products (RUN iProbe, 2023; Zhao et al., 2022). This strategy approach focuses on processes, is rationalistic, and involves the search for optimal or evolutionary strategies in finding the best solutions to face conditions of uncertainty. This scenario planning method is recommended as a decision-making tool, especially when dealing with uncertain conditions (Varum & Melo, 2010). In fields related to future energy conditions, scenario planning was used for business planning in the late 1960s and has successfully overcome future uncertainty, such as the oil crisis in the 1970s (Cornelius et al., 2005). In the 1973 oil crisis, Shell changed its traditional planning to increase refinery capacity to scenario planning, which involved increasing refinery output. With this alternative policy, the company avoided excess capacity, which was detrimental to profitability (Soontornrangson et al., 2003; Wilkinson & Kupers, 2013). Many studies have been conducted to develop and implement scenario planning methods in electric utility companies. In his research, Robinson (1988) introduced "future electricity demand scenarios" using scenario planning methods as an alternative to conventional methods in electricity planning. In the Asian region, research in Thailand presented the results of research by Soontornrangson et al. (2003), which stated that scenario planning can optimize operating costs. From this study, the scenario planning method is a popular alternative for planning for electric utility companies. In another study, Rachmatullah et al. (2007) conducted scenario planning in developing power plants in Indonesia. Ahmadi et al. (2023) also researched the application of scenario planning in Electricity Generation Companies in Indonesia by considering the energy transition. The above studies have not yet discussed the electricity company comprehensively. The two studies above have addressed the implementation of scenario planning in the electricity industry, but are still limited to the power generation sector. We all know that the scope of the electricity company is broader, covering the fields of power generation, transmission, distribution, customer service, and primary energy supply. For that, this paper discusses the development of scenario planning in a more comprehensive scope of the electricity company, covering the primary energy sector, generation, transmission, distribution, and retail. This paper discusses scenario planning in the electricity industry in Indonesia more comprehensively, from upstream to downstream.

Technological transformation in the electricity industry is very important for electric utility companies, which need to prepare for a business transition from traditional business conditions, where planning is based more on historical data on load growth, to corporate planning considering several potential changes in world conditions. By using the scenario planning method, supported by PESTLE analysis to identify driving forces factors, as well as a systems thinking approach, this paper explores potential strategies for electricity companies to capture opportunities and anticipate threats by focusing on the process of formulating a broad and innovative strategy for transitions in business electricity. This paper describes that the transformation of the energy industry in Indonesia poses severe challenges for Indonesian electricity utility companies, here refer to the state-owned electricity company PLN, as policies and regulations encourage the use of non-conventional energy sources at a time when renewable energy (RE) costs continue to decline; however, with a solid adaptive strategy, companies can better face the transition from existing businesses to new alternative businesses.

This paper explains that scenario planning is helpful for strategic thinking, but it has limitations compared to methods that use numbers and adapt to change. For instance, compared to decision analysis and options analysis, which use statistical models and cost-benefit calculations to balance choices and find the best option (Clemen & Reilly, 2013), scenario planning does not provide the same level of precise analysis. Moreover, while adaptive planning updates strategies based on current data, scenario planning remains fixed, which

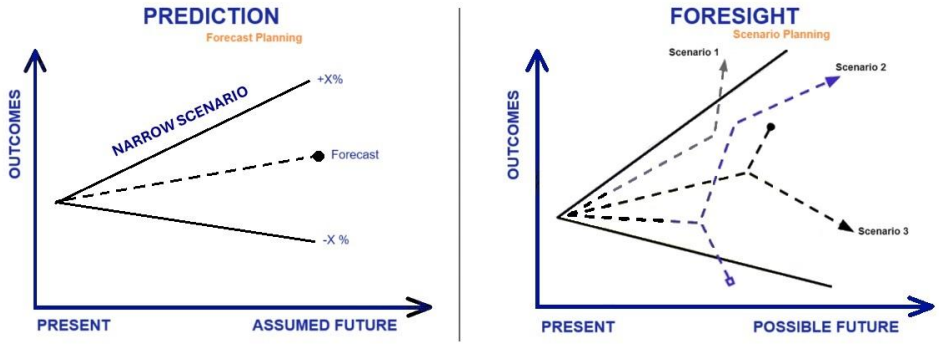

Figure 1. Forecast planning versus scenario planning (Future Station, 2024; Spitz, 2024)

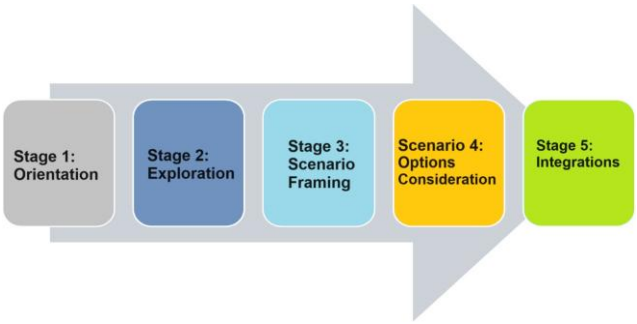

Figure 2. Scenario planning implementation stages (Resmisari & Patria, 2021)

means it may not perform well when circumstances change quickly (Walker et al., 2001). Although scenario planning portrays uncertainties through storytelling well, it might oversimplify really complex situations by not using measurable data. Therefore, combining scenario planning with adaptive or analytical methods could result in stronger and more practical strategies.

This article is presented in a structured manner with the following arrangement. The scenario planning method is explained in full, starting from the definition, literature review, and explanation in Chapter 2, including its implementation in electricity utility companies. Chapter 3 directly discusses the implementation of scenario planning, starting with an explanation of scope orientation, driving forces using PESTLE analysis, the causality of the forces, clustering of the forces, and identification of the main driving forces (Taylor, 2017). This chapter also explains the definition of cluster results and compares the impact matrix for possible uncertainties. The steps for framing the scenarios and building the narratives are discussed and explained in Chapter 4. Discussion of the results of preparing scenario planning is described in Chapter 5, with an analysis of potential possibilities. The conclusion of this discussion is presented in Chapter 6.

2. SCENARIO PLANNING METHOD

Scenario planning describes and anticipates future events and conditions that could affect an organization's activities in the next 10-20 years. This technique helps plan company and marketing strategies, especially assessing potential future needs, markets, and products. Figure 1 shows the difference between forecast planning and scenario planning. Forecast planning is planning for the future, where the characteristics of the planning are predictions or forecasts. In contrast, scenario planning is a future review that conveys several future scenarios that can be considered and set as goals for a company's future condition.

Figure 1 Compare forecast planning and scenario planning methods in a company in its long-term planning. The forecast planning method is more quantitative, analytical, and predictive, while the scenario planning method is qualitative, creative, and exploratory. In scenario planning, companies focus on the range and diversity of future possibilities. They can determine or choose which scenario best suits the conditions of the company and the environment to become the main scenario for planning a company's future. Developing scenario planning can involve participation from all company stakeholders, such as regulators, industry experts, customers, and other relevant external parties, to provide information. Implementation of scenario planning in a company is carried out in 5 stages: orientation, exploration, scenario preparation, consideration of available options, and scenario integration, as shown in

Figure 2 (Resmisari & Patria, 2021).

The orientation stage includes collecting data from books and other research literature and opinion-gathering results to determine the main focus and related challenges. The main issues in focus are uncertainty in primary energy prices, geopolitical volatility, and climate change, which may harm the company's business in the long term.

The exploration stage is carried out to obtain information from key stakeholders to identify and

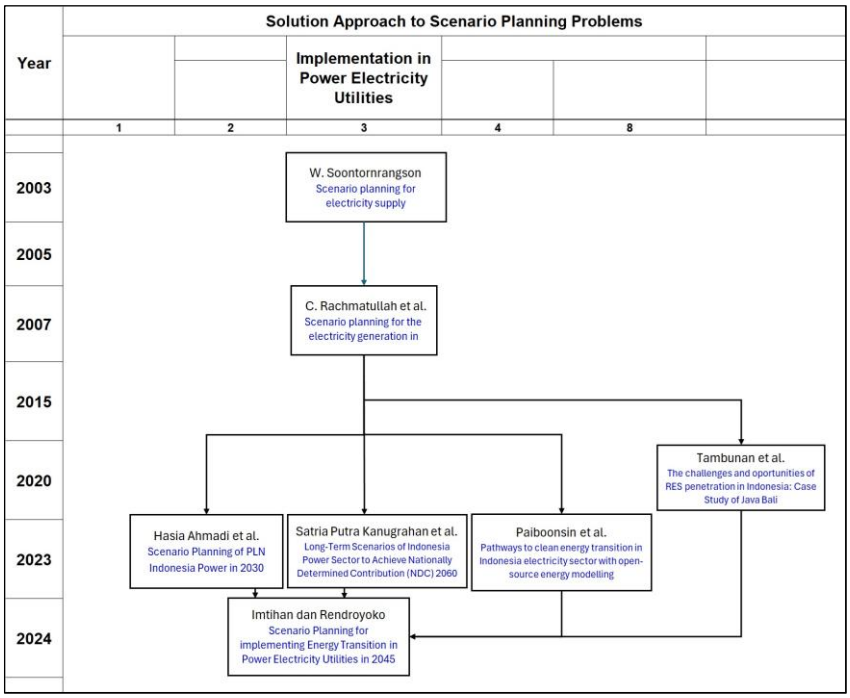

Figure 3. Literature timeline of the implementation of scenario planning in electric utilities

understand driving forces and critical uncertainties. At this stage, analysis refers to several essential factors according to PESTLE analysis, such as new trends and signals from the political, economic, legal-policy, environmental, socio-cultural, and other fields that can be identified from this activity, including related stakeholders. Aspects in the contextual and transactional environment are collectively identified as drivers of change (driving forces) (CIPD, 2024).

The exploration stage is carried out to obtain information from key stakeholders to identify and understand driving forces and critical uncertainties. At this stage, analysis refers to several essential factors according to PESTLE analysis, such as new trends and signals from the political, economic, legal-policy, environmental, socio-cultural, and other fields that can be identified from this activity, including related stakeholders. Aspects in the contextual and transactional environment are collectively identified as drivers of change (driving forces).

The fourth stage is scenario consideration or evaluation of each scenario that has been developed. This stage explains the thinking and consideration of the available scenario options. This evaluation step is carried out by following a systematic step-by-step procedure to balance creativity and free-form imagination. Here, a reasonable assessment is made based on knowledge and experience. This evaluation stage tries to think about everything that has the potential to influence the problem. (Athuraliya, 2022).

The final stage is the integration stage, where early warning signals are developed for each scenario. Early warning signals are vital indicators that determine the future direction of each possible scenario through trends and signs of change in the industry and global conditions. The result of this integration stage is that the company already knows what scenario is happening and what strategy must be implemented to achieve the company's goals, vision, and mission.

The Development process of applying the scenario planning method can be seen from the literature review of several papers, as explained below.

2.1. Literature review on scenario planning

Scenario planning is a method introduced by Herman Kahn from the RAND Institute, who developed scenario planning for military purposes, namely developing collective thought experiments to determine and develop a series of alternative futures from the current position of uncertainty (Resmisari & Patria, 2021). The military's original planning concept was imitated and further developed by a public company, Shell Oil Company, during the 1973 oil crisis (Soontornrangson et al., 2003). During this period, Shell has created several alternative business views and plausible future scenarios in the high-cost, high-risk, and long-term investment industry to help address future industry trends. In these crisis conditions, Shell shifted from expanding refinery capacity, which was experiencing enormous oversupply, to increasing refinery output. Because of these early adaptation steps, Shell could significantly reduce losses due to overcapacity and maintain company performance much better than the industry (Soontornrangson et al., 2003).

Scenario planning is also implemented to optimize the electricity industry. Several electricity experts have studied the implementation of scenario planning in electricity utility companies, as shown in Figure 3. Soontornrangson et al. (2003) said that utility companies' planning methods tend to be conventional and, therefore, often need help with a demand-supply mismatch. To deal with this problem, the scenario planning method is used, and it has been proven to improve utility companies' performance (Soontornrangson et al., 2003).

Rachmatullah et al. (2007) who implemented scenario planning in developing power plants in Indonesia in 2007, also carried out scenario planning in electricity utilities. Paiboonsin et al. (2023), in their research, present scenarios and policies of the government and utilities in Indonesia to take advantage of opportunities, overcome challenges in implementing clean energy transitions, and achieve NZE (Paiboonsin, et al., 2023), including the development of scenario planning in its renewable energy planning (Tambunan et al., 2020).

In other research, Ahmadi et al. (2023) also attempted a study on implementing scenario planning at an Indonesian Generating Company. This research reveals the application of scenario planning for power generation companies facing the challenge of changing energy use from fossil energy to clean energy and RE by considering five main driving forces: political, economic, social, technological, and environmental. In other research, Kanugrahan & Hakam (2023) presented the results of a study regarding the implementation of scenario planning also in electricity generation companies using the Low Emissions Analysis Platform method and produced five scenario choices, including the reference (REF) scenario, the conservative (CON) scenario, the moderate (MOD) scenario, the progressive (PRO) scenario, and the advanced (ADV) scenario. The studies above have discussed the application of scenario planning in the electricity industry, but are still limited to only the power generation sector. In this paper, we discuss the implementation of scenario planning more comprehensively in the electricity industry in Indonesia, from upstream to downstream, which includes electricity generation, transmission, and distribution, customer service, and primary energy supply, by referring to the energy transition program towards NZE, as well as the accompanying relationships.

2.2. Application of scenario planning of energy transition in electricity planning

Using all state institutions under it, the government, including the electricity companies, aims to provide customers with reliable, affordable, and sustainable electricity. Electricity companies develop, maintain, and operate electricity infrastructure to accomplish this mission, including power plants and electrical energy transmission and distribution networks. The development of electricity infrastructure based on energy transition is primarily needed to balance increasing demand with the ability to provide it efficiently. Building electricity facilities such as power plants and transmission requires quite a long time, usually within 2 - 10 years. These construction activities do not include planning, design, or other pre-construction activities, so a reasonably long lead time is needed to prepare electricity facilities for operation. With such a long lead time, electricity companies need adequate long-term planning to balance demand with the required supply. Specifically, at PLN, planning for electricity infrastructures is done through a 10-year General Plan for Electricity Supply (RUPTL), the latest of which is the RUPTL 2021-2030. This RUPTL is a reference for compiling the Company's Long-Term Plan (RJPP), which is five years long.

With such a long planning period, PLN needs to estimate various possibilities that may occur in the future in developing electricity infrastructure and realizing the energy transition, so that their plans can be well implemented. For this reason, the scenario planning approach is an alternative that can be used to obtain better-quality planning in electricity companies.

3. SCENARIO PLANNING FOR PLN'S ENERGY TRANSITION IN 2045

The Government of the Republic of Indonesia continues to encourage the acceleration of the energy transition in the country to achieve the Net Zero Emission (NZE) target by 2060. As a national agenda, the energy transition currently being carried out by Indonesia is an effort to maintain energy security and realize a green economy in Indonesia, according to the timeline for implementing the energy transition in the Republic of Indonesia, as seen in
Figure 4. Implementing the Energy Transition program at PLN is quite challenging, considering that 80% of the power plants operated by PLN still use fossil fuels (Kanugrahan & Hakam, 2023). In applying energy transition in scenario planning in the electricity industry, the Indonesian Government and PLN have obtained several references and examples that can be emulated from other countries. In this paper, the energy transition review is conducted from Germany, which represents a developed country in the European region, and China, which represents a country with great economic power in Asia (Kappner et al., 2023; Zhao et al., 2022).

This article discusses how PLN prepares scenario plans to understand various possible scenarios for implementing the energy transition in Indonesia in the next 15 years. After the scenarios are formed, appropriate strategies for PLN for each scenario must be developed so that PLN can anticipate the various dynamics of the energy transition and become a company that will continue to survive and be sustainable.

3.1. PESTLE analysis

PESTLE analysis is a framework used to analyze and monitor macro-environmental factors (external marketing environment) that can impact an organization, company, or industry in achieving its goals (Quiceno, et al., 2019). This analytical method examines the external environment's political, economic, social, technological, environmental, and legal factors. PESTLE analysis is used to identify threats and weaknesses in SWOT analysis. The first step in implementing scenario planning is using PESTLE analysis to obtain primary data. PESTLE analysis can create scenarios based on political, economic, social, technological, environmental, and legal changes.

For the Energy Transition program at PLN towards NZE in 2060, a PESTLE analysis was carried out on six main aspects, and the results obtained are shown in Figure 2 below.

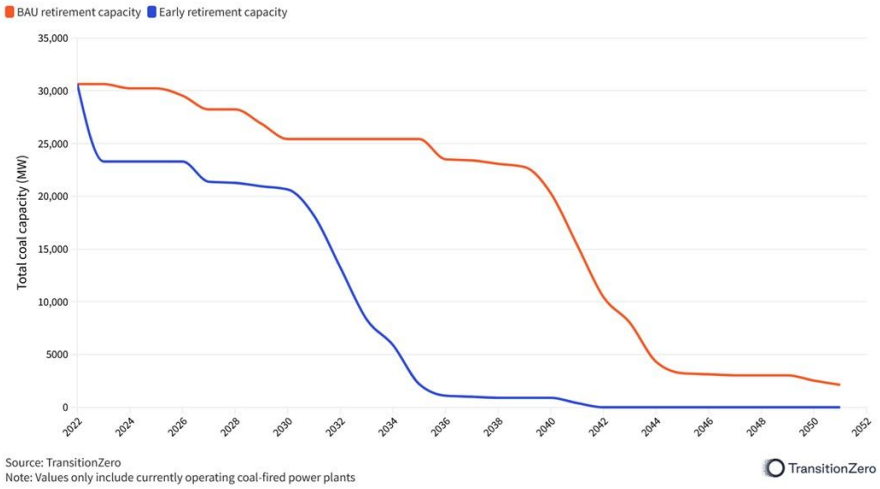

Figure 4. The energy transition timeline in the Republic of Indonesia

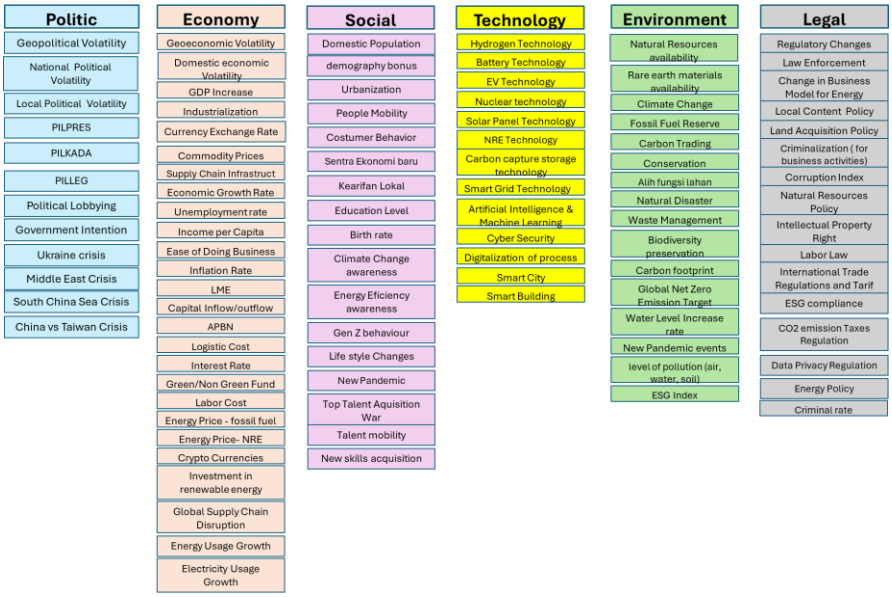

Figure 5. PESTLE analysis on the energy transition program at PLN in 2045

From the results of the PESTLE analysis, as shown in Figure 4 above, various factors that influence the energy transition from economic, social, technological, environmental, and legal aspects can be mapped.

3.2. Determination of driving forces

The next step is determining the main factors that will significantly influence preparing the company's future scenario. These factors will become the most influential key driving forces. The picture below shows the main factors for the first PESTLE aspect, namely politics.

Figure 5 shows the factors that influence the political sector. These factors are extracted and analyzed to obtain two main factors: Government Intention, which significantly influences energy management policymaking in Indonesia. Of course, geopolitical volatility also influences energy management policymaking in Indonesia, both regionally in ASEAN and Asia and internationally. The determination of the two dominant political factors in this study is similar to the results of research conducted by the UN Environment Program Finance Initiative (UNEP FI) in Switzerland and the Institute for Strategy and Foresight in Germany. (UN Environment Programme Finance Initiative (UNEP FI), 2024; Tsetsos, 2023). In the economic aspect, more factors can influence the company's future scenario, as shown in Figure 6 below.

Analysis results on economic aspects show that factors such as cryptocurrencies, commodity prices, LME, fuel prices, and disruption in the supply chain cycle will refer to geoeconomic volatility. Meanwhile, other factors consist of the exchange rate, RE investment, RE prices, inflation rate, ease of doing business, economic growth rate, increase in GDP, per capita income, unemployment rate, logistics costs, labor costs, industrialization level, Supply chain infrastructure, interest rates, and National State Budget posture together influence the main factor, namely domestic economic volatility, which is also directly influenced by the level of

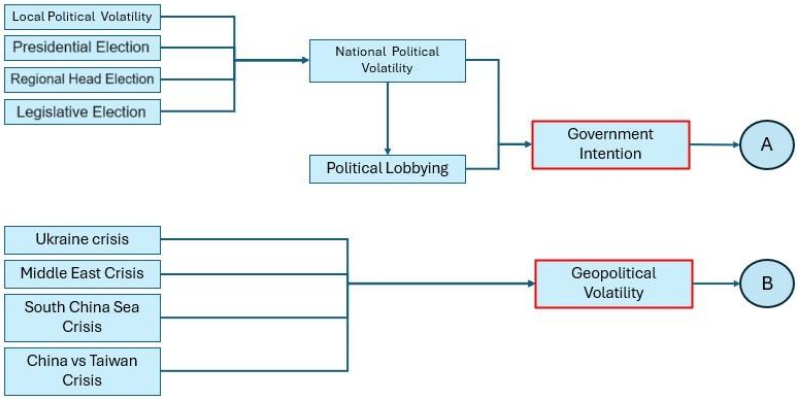

Figure 6. Political aspect of PESTLE analysis for energy transition at PLN

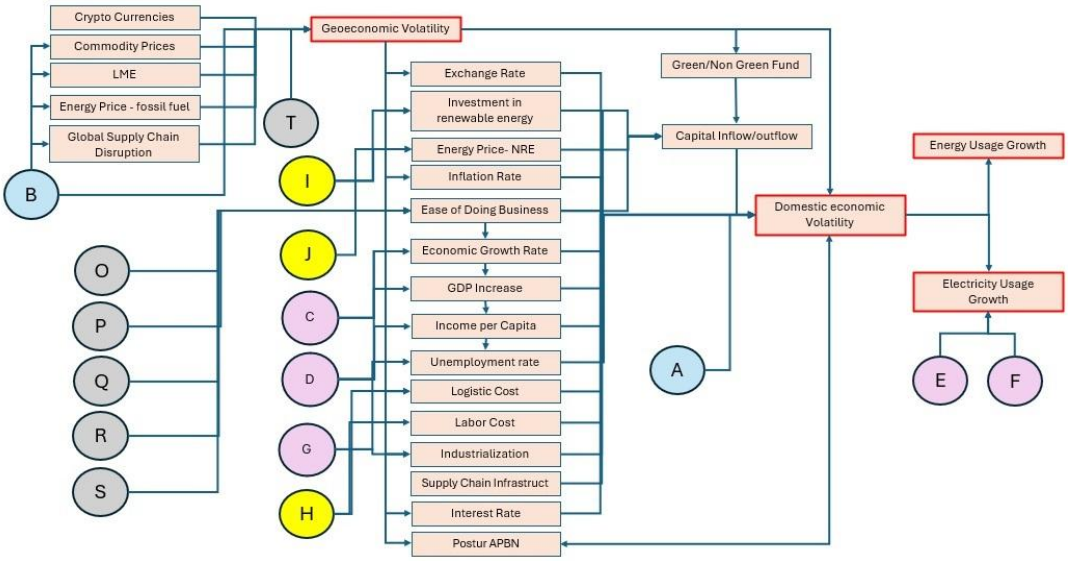

Figure 7. The Economic aspect of PESTLE analysis for energy transition at PLN

energy growth and the growth rate of electricity use. Thus, the leading financial factors are the energy growth rate, electricity usage growth rate, domestic economic volatility, and geoeconomic volatility.

Next is the PESTLE aspect, Social, depicted in Figure 7 below. In contrast to the economic aspect, here, the social aspect is more influenced by domestic factors, such as local wisdom, level of urbanization, birth growth rate, demographic bonus, influence of the new pandemic, population mobility, energy efficiency preparedness, lifestyle changes, and level of education. Generation Z behavior, talent mobility, and mastery of new skills. Three main factors are obtained from the social aspect: domestic population, customer behavior, and competition in getting top talent.

The following technological aspects play a role in the energy transition process. Figure 9 shows factors in the technological aspect that play an important role, including RE technology, electric power system regulation technology, and information technology.

In the technological aspect, technology-related factors such as artificial intelligence and machine learning, cyber security, smart cities, intelligent buildings, battery technology, EV technology, solar PV technology, hydrogen technology, nuclear, and carbon capture and storage are considered. Three main factors are obtained from these factors: digitalization, smart grid technology, and RES technology.

Next is the PESTLE aspect related to the environment, which is quite a major concern because of the world's attention on the Energy Transition. Figure 9 below provides an overview of this environmental aspect.

The environmental factors involved are water level increase rate, land conversion, Global NZE target, biodiversity preservation, carbon footprint, carbon trading, ESG index, level of pollution, fossil fuel reserve, and rare earth materials availability. Three main factors are obtained from this environmental aspect: new pandemic events, climate change, and energy usage growth. The final aspect is Legal/law, as shown in Figure 10 below.

In the legal aspect, the factors taken into consideration are data privacy regulations, intellectual property rights, local content policy, land acquisition policy, labor law, energy policy, natural resources policy, ESG compliance, CO2 emission taxes regulation, criminalization for business activities, criminal rate, and corruption index.

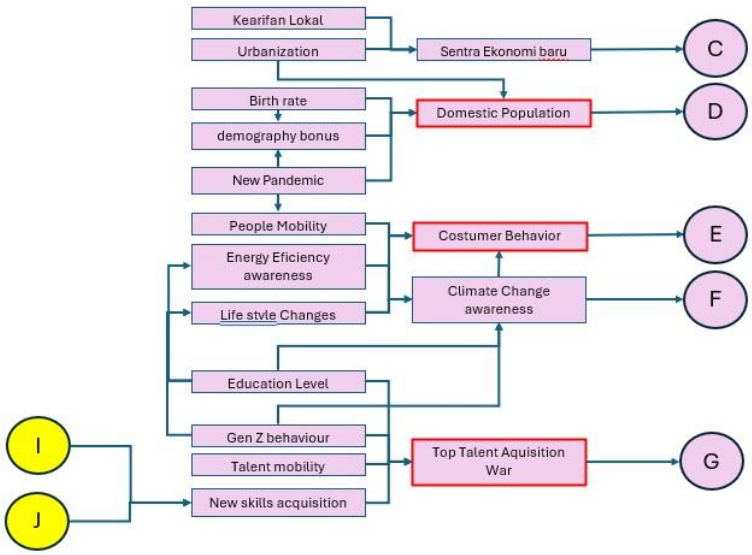

Figure 8. Social aspect of PESTLE analysis for energy transition in PLN

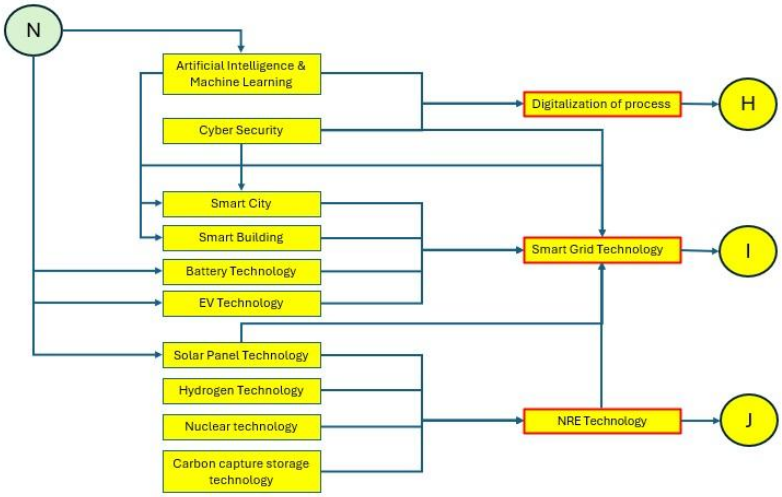

Figure 9. Technology aspect of PESTLE analysis for energy transition in PLN

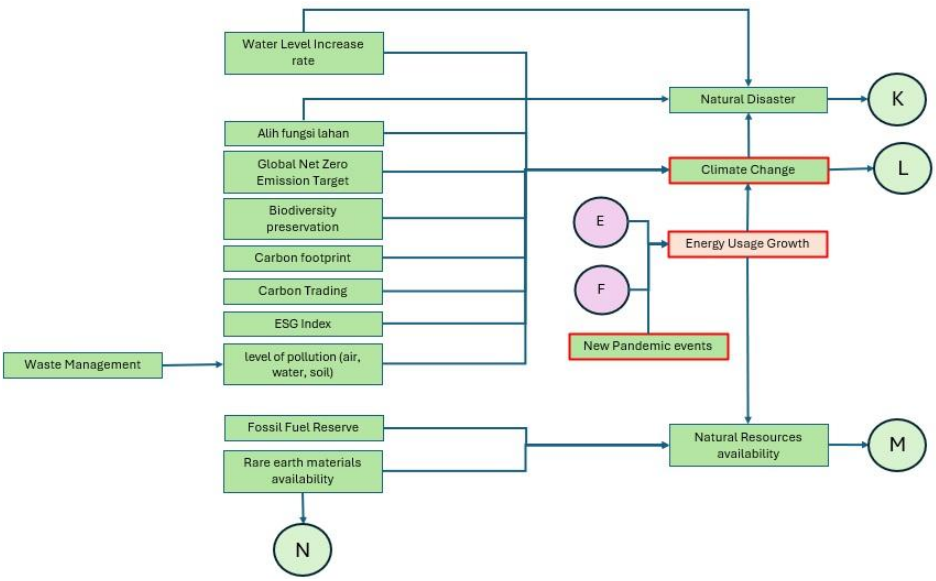

Figure 10. Environmental aspect of PESTLE analysis for energy transition in PLN

Table 1. Key driving forces outcome of scenario planning energy transition at PLN

No.	Key Driving Force	Worst	Best
1	Government Intention	Weakly support	Fully support
2	Geopolitical Volatility	Unstable	Stable
3	Geoeconomic Volatility	Unstable	Stable
4	Domestic economic volatility	Unstable	Stable
5	Energy Usage Growth	Low	High
6	Electricity Usage Growth	Low	High
7	Domestic Population	High growth	Controlled growth
8	Customer Behavior	Un-support	Support
9	Top Talent Acquisition War	Lose	Win
10	Digitalization of the process	Not optimal – not integrated	Optimal - integrated
11	NRE Technology	NRE price >> fossil price	NRE price < fossil price
12	Smart Grid Technology	High price	Reasonable price
13	Climate Change	> 4ºC	1,5ºC < T < 4ºC
14	New Pandemic events	Frequent	Very Rarely
15	Regulatory Changes	Un support	Support
16	Change in Energy Business Model	Un favorable	Favorable
17	Law Enforcement	Weak	Strong

Table 2. Key driving forces: impact–uncertainty

No.	Key Driving Force	Impact	Uncertainty
1	Government Intention	High	Low
2	Geopolitical Volatility	High	High
3	Geoeconomic Volatility	High	High
4	Domestic economic volatility	High	Medium
5	Energy Usage Growth	High	Low
6	Electricity Usage Growth	High	Low
7	Domestic Population	Medium	Medium
8	Customer Behavior	Medium	Medium
9	Top Talent Acquisition War	High	Medium
10	Digitalization of the process	High	Low
11	NRE Technology	High	Medium
12	Smart Grid Technology	High	Medium
13	Climate Change	High	High
14	New Pandemic events	Medium	Medium
15	Regulatory Changes	High	Medium
16	Change in Energy Business Model	High	Medium
17	Law Enforcement	Medium	Medium

Three main factors can be obtained from these factors: regulatory changes and changes in energy, and law enforcement business models.

3.3. Details of cluster results

The main factors from each aspect of PESTLE above are combined into a collection of crucial driving forces factors that will influence the preparation of the company's main future scenario (the next fifteen years). These key driving forces factors are shown in **Error! R eference source not found.**.

The table above maps the best and worst conditions for each key driving force to show the scope of the distribution of outcome conditions. This step obtains a picture of two polarization options for the conditions of each key driving force, which can then be mapped onto the critical driving forces quadrant matrix.

4. PREPARATION OF IMPACT/UNCERTAINTY RANKING

An essential task of scenario planning is developing actual scenarios. Here, it is necessary to build conditions based on each factor we evaluated in the previous steps and create a situation that matches the nature and trends of the market. Proper screenplay development is equivalent to writing movie scenes. Building a plot and then developing a story based on that plot is necessary. The aim of ranking the consequences and uncertainties is to obtain the fundamental driving forces that influence the achievement of goals and are the least controllable by the organization. In other words, these factors have the highest level of uncertainty. These factors will determine the formation of the scenario that will be created.

Table 2 explains the level of influence and probability of occurrence of each key driving force that will influence the scenario that will be created. The results from Table 2

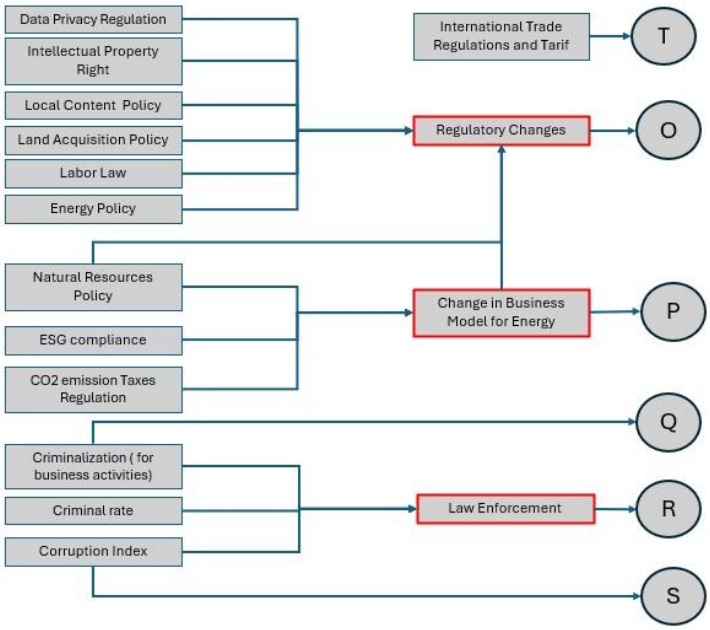

Figure 11. Legal aspects of PESTLE analysis for energy transition in PLN

Table 3. Preparation of energy transition scenarios

Key Driving Force	Scenario1	Scenario2	Scenario3	Scenario4
Government Intention	fully support	fully support	weakly support	some support
Geoeconomic Volatility	stable	stable	unstable	unstable
Domestic economic volatility	stable	some support	unstable	unstable
Energy Usage Growth	high	high	low	low
Electricity Usage Growth	high	high	low	low
Domestic Population	controlled	controlled	low growth	low growth
Customer Behavior	support	support	unsupported	some support
Top Talent Acquisition War	win	hard	loose	hard
Digitalization of the process	optimal	optimal	not optimal	suboptimal
RES Technology	RES price <fossil	competitive	RES price>fossil	RES price>fossil
Smart Grid Technology	reasonable	competitive	high price	high price
New Pandemic events	none	rarely	frequent	rarely
Regulatory Changes	support	fully support	unsupported	somewhat support
Change in Energy Business Model	favorable	favorable	unfavorable	somewhat favorable
Law Enforcement	strong	strong	weak	somewhat strong

can be depicted in a quadrant comparison graph, as shown in
Figure 12 below.

Figure 12 above shows that of the 17 fundamental driving forces, 12 factors enter quadrant 1 with high impact conditions and uncertainty. On the other hand, five factors enter quadrant 2 with high-impact conditions and low levels of uncertainty. From the quadrant graph above, three main factors have the most impact and high uncertainty: climate change, geopolitical change, and geoeconomic volatility. Next, these factors prepare scenarios to plan the company's future conditions.

5. THE SCENARIO FRAMING STAGE

Scenario planning is a strategic planning method used by organizations to create flexible long-term plans. This involves creating a series of plausible and diverse scenarios depicting different futures to help decision-makers prepare for uncertainty and risk. Scenario preparation is an integral part of this process because it determines the context and constraints in scenario development, as in **Error! Reference source not found.**.

A 4-quadrant graph, like the one shown in Figure 12 below, can depict the four-quadrant scenarios detailed in Table 3. While building a scenario, it is necessary to find the plan's strengths and weaknesses and work accordingly. It is also required to determine the touchpoints where the scenario will take place.

6. SCENARIO DESCRIPTION

Referring to Figure 13, in building scenarios, it is necessary to create a name for each scenario that attracts attention and is easy to remember. In this paper, we call scenario 1 "The Knocking on Heaven's Door," we call scenario 2 "Some Like It Hot," we will name scenario 3

"Heal the World," and we will name scenario 4 "Give Peace a Chance."

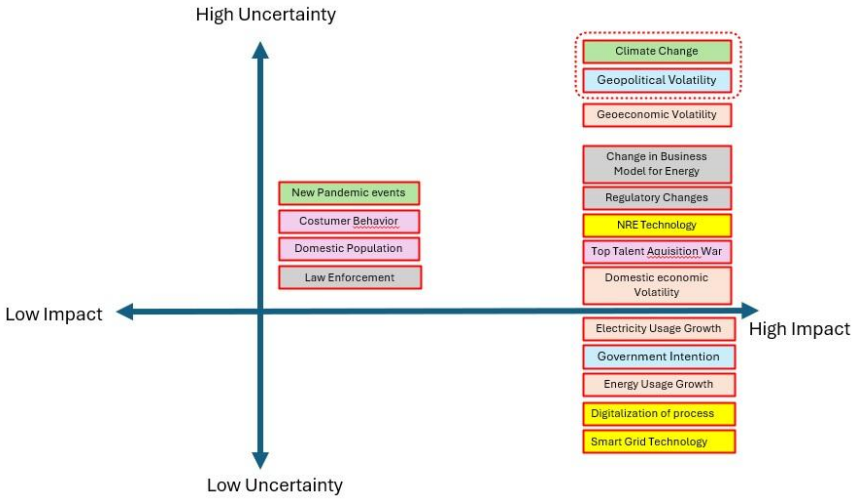

Figure 12. Quadrant graph comparison of impact and uncertainty of energy transition in PLN

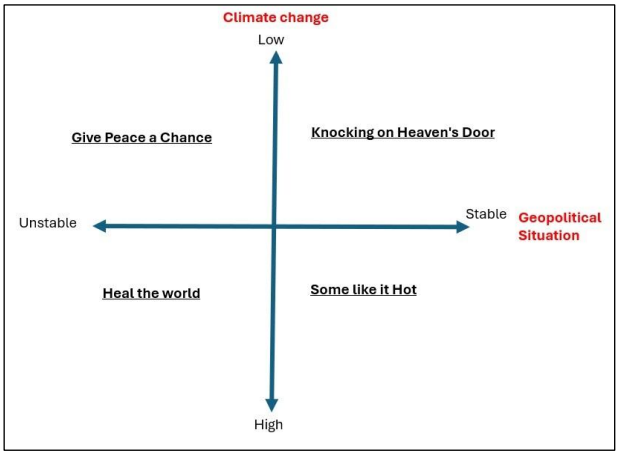

Figure 13. Four energy transition scenarios at PLN

Scenario 1: "**Knocking on Heaven's Door**" has a positive meaning. In 2045, the world transformed to become geopolitically stable and to be experiencing sustainable growth. Indonesia is emerging as a global leader in innovation and environmental management. The Indonesian government is committed to sustainable development and has utilized climate advantages and geopolitical stability to achieve prosperity.

With strategic, solid policies and institutions, Indonesia has stably faced economic volatility. Advanced RE technologies support rising energy use, while comprehensive digitalization has strengthened public services and shifted consumer behavior toward sustainability. Indonesian cities are becoming models of urban planning and environmental resilience, with green technology and infrastructure that emphasizes ecological friendliness. Through innovation and commitment, Indonesia has survived global challenges and become stronger and more united, making the vision of a sustainable future increasingly a reality.

Scenario 2: The "**Some like it hot**" scenario describes the conditions in 2045; the world is crushed by the harsh reality of urgent climate change amid this challenge, and Indonesia has emerged as a symbol of stability and brilliant innovation. Despite significant climate change impacts, Indonesia has leveraged its stable geopolitical situation and government commitment to environmental challenges. Its skylines are adorned with wind turbines and solar panels, reflecting their dedication to RE and carbon reduction.

With minimal geoeconomic volatility, Indonesia provides a stable environment for emerging industries. Strategic investments in green technologies and sustainable practices have bolstered economic resilience, even amid domestic challenges. Record-high energy use, driven by population growth and industrial development, supports adopting competitive renewable technologies like solar, wind, and ocean current power. Although smart grid technology is still evolving, it enhances energy distribution and efficiency.

Digitalization has revolutionized operations, from automated waste management to AI-driven energy algorithms. Public support for sustainability is strong, bolstered by government incentives and awareness campaigns.

Despite strict immigration policies, Indonesia attracts talent with a supportive ecosystem for research and innovation, particularly in clean energy and climate

adaptation. Thanks to strong law enforcement and health infrastructure, the country has effectively managed rare new pandemics. Its regulatory framework supports progressive environmental policies and rapid adaptation to green economy opportunities.

The energy sector's business models are evolving through public-private collaborations on renewable projects and carbon capture, enhancing energy security and positioning Indonesia as a global leader in climate resilience and sustainable development. Amid climate challenges, Indonesia exemplifies human ingenuity and offers hope and opportunity for cities worldwide seeking sustainable solutions.

Scenario 3: "**Heal the world**" means that in 2045, the world faces a double crisis: the worsening impacts of climate change and an unstable geopolitical landscape. Amid uncertainty and instability, Indonesia reflects global challenges as it struggles to find a path forward. Weak government support for environmental initiatives hampers efforts to tackle climate change, exacerbated by geopolitical instability. Economic volatility and domestic instability strain industries, livelihoods, and infrastructure.

Low energy use and cautious consumption respond to economic uncertainty and rising costs, while socio-economic factors and climate-driven migration influence stagnant population growth. Consumer preferences for convenience over sustainability impede environmental progress, and inadequate digitalization limits energy management and public service efficiency.

High fossil fuel dependence and costly RE technologies restrict energy innovation. Frequent pandemics strain an already weak healthcare system, and inconsistent regulatory changes fail to support environmental protection, worsening climate impacts. The energy sector remains dominated by fossil fuels, with weak law enforcement undermining environmental regulations.

Despite these challenges, local communities drive small-scale sustainability projects like community gardens and RE cooperatives. As global climate crises and geopolitical tensions rise, Indonesia's future hinges on collective action and international cooperation to navigate these turbulent times.

Scenario 4: "**Give peace a chance**" means that in 2045, the world is in a fragile balance between environmental stability and geopolitical uncertainty. Amidst a challenging landscape, Indonesia is emerging as a resilient nation where innovation and community strength thrive. Although the government’s support for environmental initiatives is limited, there is recognition of the need to address climate change impacts. Public support for sustainability varies, and economic instability and high energy costs complicate growth and resource management. The country’s low energy use and slow digitalization hinder efficiency, while the high costs of advanced grid technology restrict optimal energy distribution. Despite these obstacles, Indonesia maintains stable population growth and trends toward sustainable consumer choices. Cities face new pandemic challenges, but have robust healthcare systems. Though financial and regulatory hurdles persist, the energy sector shows potential for renewables. Community-led sustainability projects highlight Indonesia's adaptability and commitment to a resilient future despite external pressures.

7. CONCLUSIONS

In this paper, qualitative research focuses on primary data obtained from a detailed discussion of the step-by-step preparation of scenario planning. This study integrates internal and external analysis as well as strategic analysis. Combined with a literature review, the analysis's results become input for developing scenario planning for the Energy Transition in PLN towards 2045.

Therefore, the volatility of geopolitical conditions and the level of climate change are two crucial uncertainty factors for companies to consider in the long term. From these two critical uncertainties, a scenario matrix is formed which consists of four plausible scenarios: 1) the "Knocking on Heaven's Door" scenario, 2) the "Some Like it Hot" scenario, 3) the "Heal the World" scenario and 4) the "Give Peace a Chance" scenario. These four scenarios can then be used to develop alternative strategies for companies to implement the energy transition.

This article discusses the implementation of scenario planning to describe various alternative scenarios that might occur in implementing the energy transition at PLN in 2045. According to Figure 2 above, the following stages, stage 4, options consideration, and stage 5, integration **Error! Reference source not found.**will be e xplained explicitly in another article in future studies.

8. FUTURE STUDIES

Several further studies can be conducted as a continuation of this paper, including those related to building a strategy based on the 4 scenarios built in this study. Other studies that can be conducted are those related to risk identification and mitigation for each strategy, which are compiled based on each scenario built.

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