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ANALYSIS OF DECISION MAKING STRATEGIES IN RESOLVING ENERGY DEFICIT IN PARANG ISLAND, GENTING ISLAND AND NYAMUK ISLAND Case Study on PT PLN (Persero) Central Java and DI Yogyakarta Distribution Unit

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Abstract

Energy deficit is one of the problems that often occurs in remote areas, such as in Parang Island, Genting and Nyamuk. This requires the best solution to overcome the existing problems. Decision making is a process in which choosing various options to get maximum results. This process includes identifying needs or problems, collecting relevant data, assessing existing alternatives and selecting the most appropriate and suitable solution. Effective decision making will have a good influence on the company in increasing efficiency, solving problems and achieving targets. Qualitative research with case study as the research design was used to develop the case. Semi-structured interviews with 4 informants who had been selected through purposive sampling were conducted to collect research data. The interview results were analyzed and processed using triangulation techniques, and member checking was conducted to ensure credibility and trustworthiness in the research. This study aims to determine the best decision-making in overcoming the problem of electricity deficit. The results of the study indicate that the criteria considered are energy independence, cost efficiency, and an effective management system, adjusted to geographical conditions to create a stable and reliable electricity supply for the community. Solar Power Plants (PLTS) are the most appropriate choice as a utilization of new renewable energy sources through efficient and environmentally friendly management. Optimizing decision-making requires effective collaboration between stakeholders from the regions and centers, to involving the community and experts to ensure success in overcoming the problem of electricity deficit on Parang Island, Genting Island and Nyamuk Island.

Keywords: ***Energy Deficit, Electricity, Decision Making, Solar Power Plant (PLTS)***

INTRODUCTION

Among the many challenges that governments and societies in developing countries must manage is access to, and the cost burden of, energy. Most developing countries rely heavily on imported fossil fuels, especially oil, for electricity generation and primary energy supply, as well as for transportation, a situation that creates direct financial burdens, supply risks, and indirect costs associated with climate change.(Atteridge & Savvidou, 2019; Purwanto et al., 2015). The electrical system in Indonesia is increasingly becoming a vital need, where the need for electricity has now become a primary need in meeting the needs of daily activities for both a business company, government and the public itself. Electricity is one aspect of the driving force of economic growth and an indicator of welfare for a country including the people of Indonesia.

Electricity users are not only for people in developed areas but also for remote areas and people in 3T areas which we often refer to as Disadvantaged, Frontier and Outermost areas. The availability of electricity on islands and provinces in Indonesia is quite diverse according to the availability of supply from power plants such as PLTU, PLTA, PLTB, PLTS, PLTM and so on. In practice, the government as a policy maker in the energy sector is to utilize natural resources with the principle of benefit for all Indonesian people. Based on the Regulation of the Minister of Energy and Mineral Resources of the Republic of Indonesia Number 11 of 2021 concerning the Implementation of Electricity Business.

PT PLN (Persero) is a State-Owned Enterprise (BUMN) engaged in the electricity sector in Indonesia, PT PLN (Persero) itself has the purpose and objectives of the organization is to complete the matter of granting power to the public interest in a satisfactory quantity and quality and to encourage benefits and carry out government duties

in the electricity sector to support development by applying the principles of limited liability companies (source: pln.co.id).

Karimunjawa Islands has a land area of + 1,500 hectares and waters of + 110,000 hectares. The Marine Park tourist destination which is currently being developed on a number of islands in Karimunjawa is starting to get a lot of attention and popularity from both domestic and international visitors. This area consists of many islands and the main islands are Karimunjawa, Kemojang, Parang, Genting and Nyamuk presented as follows.

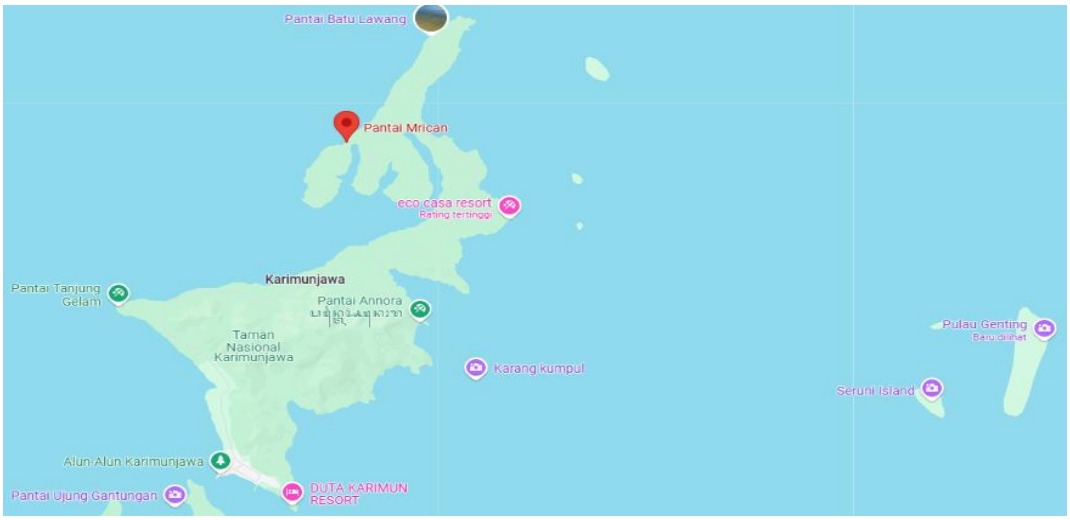


Figure 1. Karimunjawa Maps
Source: in-indonesia.com

The electricity condition in the islands is currently electrified, the management of which was previously carried out by the Jepara district government. In order to provide a stable and efficient electricity supply and in line with the dedieselization program, the Jepara regional government is working with PLN regarding the management of operations and maintenance. The Jepara Regency Government has given authority regarding the Handover of Operations and Maintenance (STOP) of the Parang, Genting and Nyamuk Islands PLTD and PLTS to PT PLN Persero and was then initiated with a memorandum of understanding between the two parties betweenJepara Regency Governmentand PT PLN Persero on July 21, 2022 and the Minutes of Operation and Maintenance Handover (BASTOP) number 2295.BA/HKM.02.01/E03000000/2022 dated September 27, 2022 regarding the transfer of electricity management on Parang, Genting and Nyamuk islands.

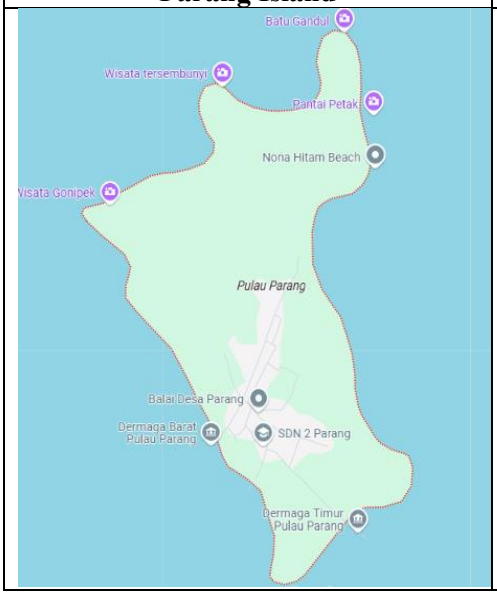
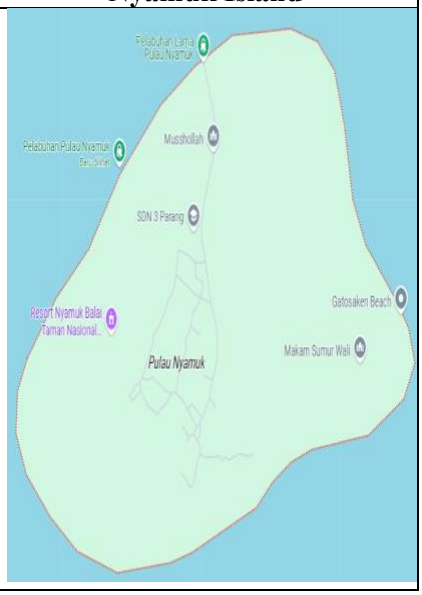
Parang Island	Genting Island	Nyamuk Island
		

Figure 2.Maps of Parang, Genting and Nyamuk Islands
Source: in-indonesia.com

PLN UID Central Java & DIY has created a program to replace PLTD with PLTS and Batteries, it is hoped that with the presence of PLTS and Batteries, the electricity supply will be more reliable, efficient, clean and able to increase the electrification ratio of Central Java. In 2022, PLN has carried out the construction and revitalization of the electricity network on Parang, Genting and Nyamuk Islands through the rural electricity program (Lisdes). In line with the dedieselization program, PLN will build Off-grid PLTS in 2023 on Parang, Genting and Nyamuk Islands in order to reduce the use of PLTD fuel which reaches IDR 2.35 billion per year and the achievement of the Electrification Ratio (RE) in Central Java of 99.99% (2023) and 100% (2024) and support the achievement of a new renewable energy (EBT) mix of 23% in 2025 in accordance with the PLN RUPTL 2021 - 2030.

Customer service on Parang, Genting and Nyamuk islands related to electricity consumption is currently implemented by implementing a Load limiter on the customer's kWh meter of 1.5 kWh/day/customer with an average operating time on the three islands of 100 Hours of Operation (JN) (source: official portal of Central Java province, accessed December 20, 2023). The implementation of this load limiter is due to several things, namely; the electricity supply system for Parang Island is currently supplied by PLTD with 2 units of machines with a capacity of 100 kW each, 1 machine is damaged. In addition to PLTD, there is also a PLTS with a capacity of 75 kWp (in damaged condition) and 60 kWp. The total installed power is 335 kW and the capable power is 160 kW, presented in the table below.

Table 1. Condition of Power Plant on Parang Island

Generator Type	Diesel Power Plant (kW)		Solar Power Plant (kWp)	
Capacity	100	100	75	60
Condition	Normal	Damaged	Damaged	Normal

Source:(PT PLN RUPTL, 2021)

The current Parang Island distribution network is JTR (Low Voltage Network) using 2 types of conductors, namely NFA2X-T 3x35+1x35 mm2 and NFA2X-T 3x95+1x95 mm2 with a total JTR length of 7.4 kms as seen in Figure 3.

Figure 3. Parang Island Generation and Distribution Network (existing)
Source: Researcher Documentation

Then, the electricity supply of Genting Island is currently supplied by PLTD with 2 units of engines with a capacity of 30 kW each, 1 engine is damaged, in addition to PLTD there is also a PLTS with a capacity of 36 kWp. The total installed power is 96 kW and the capable power is 66 kW which is seen as follows.

Table 2 Condition of Power Plants in Genting Island

Generator Type	Solar Power Plant (kWp)	Diesel Power Plant (kW)	
Capacity	36	30	30
Condition	Normal	Normal	Damaged

Source :(PT PLN RUPTL, 2021)

The distribution network on Genting Island currently uses JTR (Low Voltage Network) with NFA2X – T 3x35+1x35mm2 conductors with a length of 1.45 kms as shown below.

Source: Researcher Photo

Figure 4. Genting Island Generation and Distribution Network (existing)

Furthermore, the electricity supply system for Nyamuk Island is currently supplied by PLTD with a 1 unit engine with a capacity of 100kW, besides PLTD there is a PLTS with a capacity of 25kWp (damaged) and 86 kWp with a total installed power of 211 kW and a capable power of 186 kW as follows.

Table 3. Condition of Generators on Nyamuk Island

Generator Type	Solar Power Plant (kWp)		Diesel Power Plant (kW)
Capacity	25	86	100
Condition	Damaged	Normal	Normal

Source:(PT PLN RUPTL, 2021)

The current distribution electricity network on Nyamuk Island is JTR (Low Voltage Network) with NFA2x – T3x95+1x95 mm2 conductors along 2.16 kms. In the growth of electricity needs, PT PLN UID Central Java and DIY will calculate the demand forecast according to the growth of electricity needs. Demand forecast is an estimate of future electricity usage. Demand forecast is analyzed using the regression method – econometrics using the Simple – E application based on statistics. In determining the correlation between variables, this approach has advantages because it produces more specific and precise estimates. This is in accordance with the projection of population growth, economy, electricity tax, electrification ratio target, very large consumer potential, real energy supply information, number of customers and related energy. (PT PLN's RUPTL, 2021).

On the background explainedshows that there is a gap phenomenon that emerged in this study is the availability of reliable and affordable electrical energy is a crucial basic need for the survival of the community, especially in island areas such as Parang Island, Genting Island, and Nyamuk Island in the Karimunjawa area. However, until now the three islands are still facing a significant energy deficit. The high cost of providing diesel-based electricity, dependence on unstable fuel supplies, and limited infrastructure are the main causes of the low electrification ratio and poor continuity of electricity supply. The above phenomena indicate a gap between the potential of available alternative energy and effective, efficient, and sustainable energy implementation strategies in island areas. In other words, although various new energy alternatives have been identified and some have been tested, strategic decisions in their utilization still face technical, economic, social, and institutional obstacles.

This research is also to fill **research gap** In several previous studies, there has been a lot of discussion about the potential and challenges of utilizing renewable energy in island areas such as Karimunjawa. Permana et al. (2022) showed that the use of a hybrid system between diesel and wind power can increase the use of renewable energy, but requires quite large investment costs. Meanwhile, Novitasari et al. (2020) emphasized the importance of multi-party collaboration and community involvement in the development of renewable energy so that the project can run

sustainably. Atteridge & Savvidou (2019) highlighted that although global funding for renewable energy in the Small Island Developing States (SIDS) region has increased, dependence on fossil fuels is still high, requiring a more systematic energy transition strategy. Research by Ismanto et al. (2019) identified the potential of ocean currents as an alternative energy source in Karimunjawa, but has not yet studied in depth the aspects of technological application as well as policy and institutional support.

On the other hand, Simatupang & Faskayana (2019) showed that a hybrid solar and diesel power system can reduce fuel consumption and produce an attractive rate of return on investment (IRR), although it has not touched on institutional and social aspects. Naimah et al. (2020) proved that the installation of PLTS can increase electricity access and reduce carbon emissions, but it is still not economically feasible without policy support such as subsidies or incentives.

Based on the description, it can be concluded that most research still focuses on the technical and economic aspects of renewable energy development.However***Novelty***in this study lies in the absence of a study that specifically analyzes the institutional decision-making strategy, especially by PT PLN (Persero) in resolving the energy deficit on small islands such as Parang Island, Genting Island, and Nyamuk Island. This is the research gap that needs to be filled through this study.

FORMULATION OF THE PROBLEM

In this problem formulation, the research questions are as follows:

a. There is an energy deficit in the Parang, Genting and Nyamuk Islands
b. The limited available power generation sources and the condition of the power plants in the Parang, Genting and Nyamuk Islands.
c. The unpreparedness of PT PLN (Persero) UID Central Java & DIY in facing the growth in electricity needs in the Parang, Genting and Nyamuk Islands
d.

LITERATURE REVIEW AND MODEL DEVELOPMENT

Energy Management

Due to population growth, industrialization, and urbanization, global energy and electricity demand is increasing. The world faces significant difficulties in providing a safe and affordable energy supply to consumers, this is because natural energy sources are already widely used and have harmful emissions.(Khan et al., 2022). Energy consumption is increasing faster than global population growth, and is projected to increase by almost 50% by 2050.(Vaikund & Srivani, 2024). The trend of using energy from various sources and renewable is something that can have an impact on the environment for sustainable development. The problem of energy shortages and environmental pollution is getting more serious all over the world, making full use of renewable energy has become a matter of special attention.(Zhao et al., 2023). However, due to the characteristics of renewable energy such as volatility, randomness, and intermittency, the match between renewable energy and the power grid is still inadequate, Therefore, a multi-energy interconnection system can help achieve stable energy consumption.

Understanding and Problems of Energy Deficit

Demand for electricity supply in Indonesia is growing rapidly, driven by strong economic growth combined with growing urbanization and industrialization. Increasing energy efficiency can reduce the country's electricity demand, thereby providing financial savings, greenhouse gas and other pollutant reductions and increasing energy security.(McNeil et al., 2019). There also needs to be consideration in choosing electrical energy efficiency in reducing problems related to electrical power deficits.

The electricity deficit is a crucial problem currently being faced by PLN and has not been fully resolved in several areas, especially in several islands in Karimunjawa. Minimizing the use of electricity is done to provide for the needs of the people living there. The decline in power quality is another problem caused by the lack of electricity supply. The decline in quality that can occur such as poor electricity voltage, unstable voltage frequency and excessive harmonic distortion(Mwanza & Ulgen, 2020; Sunitiyoso et al., 2020).

Alternative Rolling Blackouts to Overcome Energy Deficit

In many developing countries, where power generation capacity is underfunded or infrastructure is poorly managed, rolling blackouts are common or even daily occurrences. Blackouts are planned, scheduled, and publicized in advance in well-managed systems that have the capacity to prevent rolling blackouts. In ineffective monitoring systems, they occur suddenly, usually when transmission frequencies fall below protected limits.

A rolling blackout, also referred to as rotational or rotational load shedding, rotational outage, feeder rotation, or rotational blackout, is a deliberately engineered outage of electric power in which the supply of electricity is stopped for a non-developing period of time in various parts of a distribution area.(Agarwal & Khandeparkar, 2021). Rolling blackouts are a last resort used by electric utility companies to avoid total blackouts.(Shrestha et al., 2023).

Alternative Rental Generators to Overcome Energy Deficit

Several areas that still lack power or electricity supply are the focus of attention by the relevant government. One of the attitudes taken in overcoming the energy deficit is to rent a generator. Renting a generator is a short-term solution that can be done in providing electricity availability for use(Espinosa et al., 2021).

In the 2021 RUPTL, one aspect related to security of supply is the risk of delays in completing PLN and IPP projects. Obstacles in the early stages (pre-construction) such as funding, licensing, land funding, customer processes, inappropriate design, as well as social, environmental, and other problems are potential sources of this risk.(PT PLN RUPTL, 2021). Another thing that can happen is due to the technical ability or financial ability of the contractor being problematic.

In accordance with the very large increase in additional limits every year, the potential impacts that will arise from this opportunity include the failure to achieve the focus of the fuel mix due to the expansion of the BPP, so that one of the temporary arrangements offered is generator rental and can also be in the form of rolling blackouts.(Mehedi, 2022).

Alternative Development of New Power Plants to Overcome Energy Deficit

Usable electricity is not freely available in nature, so it must be produced by converting other forms of energy into electricity. Production is done in also called power plants. Power plants are industrial facilities that produce electricity from primary energy.(Kaplan, 2008). Electromechanical generators, primarily driven by heat engines and combustion or nuclear fission, produce most of the power in power plants. Other energy sources include wind, the kinetic energy of moving air, solar photovoltaics, and geothermal energy.

To meet the electricity needs of the community, most power plants use one or more generators that convert mechanical energy into electrical energy. Power lines are used for the transmission of electricity. The electricity coming out of the power plant passes through a transmission station where it is increased (step-up). This means that the voltage is increased, with a proportional decrease inelectric current(amountelectronflowing per second). This voltage increase is done by a transformer. This electricity can flow long distances with a typical maximum distance of about 500 kilometers.

Optimizing Decision Making in Handling Energy Deficit Problems

Decision making is a critical skill in the complex and dynamic business world. Every organization, regardless of its size, grapples with the challenge of making well-informed choices to optimize efficiency, profitability, and sustainable growth. Business economics, often called Managerial economics, is an important bridge connecting economic theory with practical business practice.

To make wise decisions, we need to use a structured method. This method helps us to objectively assess various options and choose the best one according to the goals and criteria we have set.(Kepner & Tregoe, 1981). The human capacity to make more intelligent decisions, coupled with the ability to plan goals and consider the impact of their actions, allows them to sometimes wait for the right time to act, rather than rushing into it.

Theoretical Framework

Energy is an important asset in supporting economic activities and must be managed optimally for the benefit of the community. Decision making is key in determining the best steps to overcome the energy deficit, especially in Parang, Genting, and Nyamuk Islands in the Karimunjawa Islands. This problem requires management to choose one of three best alternatives: rolling blackouts, renting power plants, or building new power plants, to ensure sustainable energy availability in the region.

The problems described in the theoretical framework are shown in the figure below:

Figure 1. Theoretical Framework of Thought

RESEARCH METHODOLOGY

Stages of Research Methods

The stages of the method in this study are intended so that the research to be conducted can understand each step and method in tracing various aspects of the energy deficit, identifying and understanding alternative solutions with the aim of optimizing decision making for existing problems. This research was conducted with various systematic work steps so as to obtain optimal results.

Types and Sources of Research Data

This research is a qualitative study with an exploratory case study approach that aims to deeply understand the energy deficit phenomenon on Parang, Genting, and Nyamuk Islands, Karimunjawa Islands. The case study approach is used because the context of the problem and the boundaries of the phenomenon being studied cannot be separated from the environment or managerial dynamics in the field (Yin, 2018). This method allows researchers to focus attention on key issues that are relevant and important in order to understand the system being studied.

The research data were obtained from two main sources: primary data and secondary data. Primary data were collected through in-depth interviews with key informants who directly understand the case and are involved in the decision-making process related to the energy deficit in the region. Meanwhile, secondary data in the form of internal company documents and archives that support the analysis, and are used for triangulation to create a more comprehensive and valid perspective on the phenomenon being studied (Creswell, 2009; Yin, 2018).

Participants in this study were selected using purposive sampling technique, namely the selection of subjects who are considered to have high relevance and knowledge of the research issue. Participants consisted of four officials in strategic positions at PT PLN UID Jateng & DIY, namely 1 General Manager, 1 Senior Manager, 1 UP3 Manager, and 1 MULP Manager. These participants were selected because they have a direct role in strategic decision making, as well as experience and in-depth understanding of energy problems in the Karimunjawa Islands.

Data collection technique

This study combines multiple data sources to increase the credibility of the findings, using three main techniques: interviews, direct observation, and archival documents. The interviews were conducted using a semi-structured approach, allowing the researcher to dig deeper into information by adjusting questions as the conversation progressed. The purpose of the interviews was to determine the best actions for managers to take regarding the energy deficit problem in Parang, Genting, and Nyamuk Islands. In addition, archival documents such as official company reports, photographs, and interview recordings were used to verify and strengthen the data obtained through the interviews.

Data Processing Techniques

Data processing in qualitative research is carried out continuously during data collection and is followed by systematic steps. Data reduction is carried out to filter and classify relevant data, and eliminate unimportant information. This process makes it easier for researchers to focus on core problems and avoid data accumulation.

After the data is reduced, the next stage is data presentation, which presents information in narrative, graphic, or diagram form to help understand the relationships between data. Drawing conclusions is the final stage, where researchers draw meaning from the data that has been presented, considering causal relationships or emerging patterns. Conclusions in qualitative research are temporary and can change according to new evidence found throughout the research process.

Data Analysis Techniques

Data analysis techniques in qualitative research according to Yin (2011) consist of five stages: Compiling, where researchers collect and sort all the data obtained; Disassembling, which is coding data by marking interview transcripts and documents; Reassembling, which groups data into relevant categories; Interpreting, where researchers analyze and present the results in narratives, graphs, or tables; and Concluding, which is drawing conclusions based on the interpretation of the data that has been analyzed.

RESULTS OF ANALYSIS AND DISCUSSION

Understanding and Problems of Energy Deficit

Energy plays a crucial role in human and economic development, but in developing countries like Indonesia, stable and sustainable energy provision still faces many challenges. Energy infrastructure is burdened by industrialization, population growth, and surging energy demand, leading to inefficiency, high costs, and environmental degradation. Geographical limitations, lack of funding, and poor grid connectivity are obstacles to implementing large-scale energy projects, especially in remote areas. Communities' dependence on expensive alternative energy sources such as fossil fuels and diesel generators also exacerbates socio-economic disparities and slows down improvements in welfare.

Indonesia as an archipelagic country faces unique challenges in ensuring equitable distribution of electricity. Although large cities are relatively more stable in energy supply, remote areas such as the outer islands still experience energy deficits and blackouts. The electrification ratio is not evenly distributed, while the national energy mix is still heavily dependent on coal. Efforts to transition to renewable energy such as solar, wind, and hydropower face major obstacles, including regulation, high initial costs, location access, and limited infrastructure. One example is the Karimunjawa region which still relies on diesel generators and experiences blackouts, which have an impact on economic growth and quality of life.

Unfortunately, despite the vital role of electricity in economic growth and public welfare, many regions still experience energy deficits that hamper development. In some areas in Indonesia, especially remote and underdeveloped rural areas, inadequate infrastructure and limited investment can result in unreliable electricity distribution, leaving people without a stable electricity supply. The following is an understanding from informants regarding energy deficits:

"The energy deficit is where the energy needs of a region or a place exceed the production capacity or available energy supply. This can be caused by a higher level of demand because PGN has started to make many resorts or tourist attractions, and there are also many places for managing marine products. In addition, it can be caused by limited energy resources, because indeed many of our power plants there have been damaged." ~ Informant 1 ~.

"Because the generators are limited while energy consumption continues to rise with the development of tourism which also continues to rise." ~ Informant 2~.

"Energy deficit is the energy prepared by the system does not match the needs. So it is less than what is needed so that the community does not use electrical energy as they need." ~ Informant 3~.

"So if the energy deficit is first in terms of supply, it is indeed less than demand, from the needs of the community and also what may be related to the time, from the supply is sufficient but in terms of time it cannot meet the needs of the community." ~ Informant 4 ~

Informants stated that an energy deficit occurs when the electricity demand in a region exceeds the available supply capacity, creating an imbalance between energy demand and availability. One of the main causes of this deficit is the rapid growth of the economy and tourism sector, such as the increase in the number of resorts, tourist attractions, and marine product management businesses that drive a surge in electricity consumption. However, the damaged generating infrastructure is unable to keep up with the increasing demand.

The limited number of power plants is a fundamental problem, because the energy supply does not grow in line with the increase in consumption. In addition, the existing electricity system has not been able to distribute energy optimally, so that people cannot use electricity according to their needs. Not only the amount of supply, but

also the effectiveness of distribution and time management are significant challenges. Even when supply is available, delays or inaccuracies in distribution time hinder the fulfillment of people's energy needs.

This condition causes pressure on the electricity system which leads to blackouts, price increases, and limited access to electricity for some people. Therefore, to overcome the energy deficit, a comprehensive strategy is needed that includes improving the power plant infrastructure, diversifying energy sources, and optimizing the distribution system so that energy services become more efficient and sustainable.

Electricity supply and crisis management are particularly complex in developing countries, where a large proportion of the population does not have access to electricity.(Hunt. et al., 2018). In terms of supply, energy deficit directly reduces electricity production capacity. Existing power plants cannot operate optimally due to fuel shortages or other technical problems. This causes a decrease in the amount of electricity generated. As expressed by several informants, as follows:

"The energy deficit is very influential because we all know that it can cause an imbalance between supply and demand, both from PLN and the demand of the surrounding community. So an insufficient energy supply will definitely increase energy prices, because people will try to meet their shortcomings. An energy deficit can also reduce the availability (supply) of energy needed to meet future energy needs." ~ Informant 1
"...while the needs of the community are increasing, because PGN has become a tourist area, so it has an impact on supply and demand." ~informant 2
".....limiting the use of electricity in the village community, so that they use limited electricity so that the energy remains available, even though it may not be according to what they want but according to the readiness of the provision of electricity by PLN there." ~ Informant 3

Energy deficit has a major impact on the balance between electricity supply and demand, especially in areas with limited resources. This imbalance not only disrupts electricity distribution, but also causes energy prices to rise as people have to look for alternatives that tend to be more expensive and inefficient. This condition can also hinder economic growth and the development of sustainable energy infrastructure. In addition, energy deficit directly affects the lives of rural communities, where they have to adjust their electricity usage to the limited capacity of PLN, which although intended to maintain electricity availability, still reduces the quality of life and limits daily activities. The impact of energy deficit includes economic and social aspects, by limiting people's access to the energy they need.

"From the supply side, yes we need it, in other words we have to add from the power plant side or we reduce from the usage or demand side." ~ informant 4.

To overcome the energy deficit, a dual approach is needed, namely increasing the capacity of power plants and managing public consumption. One temporary solution that has been implemented is quota restrictions through the use of limiters, but this step does not solve the root of the problem. A more effective long-term approach includes building new power plants, developing renewable energy, and optimizing the distribution system to be more efficient. The imbalance between electricity supply and demand causes pressure on the electricity system, resulting in blackouts, price fluctuations, and limited public access to electricity. Therefore, handling the energy deficit requires a comprehensive strategy, including reducing dependence on fossil fuels, increasing distribution efficiency, and encouraging investment and use of new renewable energy by top management.

“.....what we need to do to overcome the energy deficit is first we have to increase investment from PLN and external sources.” ~ Informant 1.

Increased investment is directed towards encouraging the development of new technologies that support the efficient use of renewable energy to address the energy deficit, in line with informants' expectations for sustainable solutions.

"..... the next one is to look for new or renewable energy alternatives so that the provision of electrical energy will be wider and in accordance with the conditions there." ~ Informant 3

In addition, several informants stated that one of the steps that can be taken is to increase energy efficiency by using energy-saving technology. Moreover, in an effort to avoid energy deficits in the research object area, there needs to be development and maintenance of existing infrastructure.

"Then the fourth one is that we have to strengthen the energy infrastructure, such as the electricity network and energy storage facilities where this infrastructure helps us when we have a surplus." ~Informant 1
"To overcome the first energy deficit, the assessment of the current machine is possible in terms of capacity that needs to be added, maybe that's the cheapest. Or in terms of spare parts, because the machine is old there, so maybe no one is producing it anymore and maybe compensation from the community so that capacity can be added." ~ Informant 4

Energy deficit occurs when supply is insufficient to meet demand, such as in the PGN region triggered by increased tourism and industrial activities and limited capacity of damaged power plants. The impacts include consumption restrictions, blackouts, and rising energy prices due to the search for expensive alternatives. To overcome this, short-term strategies are needed, such as limiting the use and rental of power plants, as well as long-term strategies that include increasing investment, strengthening energy infrastructure (grid and storage), diversifying renewable energy sources (solar, wind, waves), energy efficiency, and maintenance of power plants. This approach must involve technical collaboration and community participation to create a reliable, efficient, and sustainable electricity system.

Alternative Rolling Blackouts to Overcome Energy Deficit.

The increase in global electricity consumption has caused an imbalance between production and demand, including in Indonesia, which has resulted in an energy deficit and rolling blackouts. An example is the Karimunjawa Islands, where the generating capacity is insufficient to meet the peak load. Ironically, this occurs even though Indonesia is rich in energy resources, including renewable energy. Rolling blackouts are an alternative for PLN to maintain the balance between electricity supply and demand, so that energy distribution remains even and avoids total blackouts. Although only a short-term solution, this strategy is important to maintain the stability of the electricity system while waiting for generator repairs or the development of new energy.

"In an area that has a reliable system, for example, the islands of Java and Bali, PLN used to do rolling blackouts with a shortage of energy supply, let alone the condition of a small island and remote area like PGN. Like it or not, rolling blackouts are an alternative that has a very big impact and maybe even an absolute necessity." ~ Informant 1

".....rolling blackouts or quota restrictions are the last option, they are the last option if we have not added power plants in terms of capital and in practice, we have no choice but to limit their use so that they can still be met even though they are not optimal." ~ Informant 4

Informants agreed that rolling blackouts are an emergency strategy that can be implemented to overcome energy deficits, especially in remote areas or small islands with limited supply. This policy has also been implemented in areas such as Java and Bali when supply is insufficient. In conditions of limited power plant construction due to technical and capital constraints, rolling blackouts or quota restrictions are the last alternative to keep electricity distribution running. Although it has a significant impact, this step is considered necessary to maintain the balance of electricity supply and demand.

The implementation of electricity quota restrictions is also carried out in the alternative of rolling blackouts. If PLN cannot meet the needs of the community, then what is done is electricity restrictions in the hope of getting rights even though it is not as expected.

"If there are rolling blackouts, the impact will be less negative, if the restrictions seem to only limit them so that they only use lights for basic needs. I think with energy restrictions it is enough for basic needs such as lights and simple electronics." ~ Informant 3

Rolling blackouts are the last resort to maintain the balance of electricity supply and demand in the face of an energy deficit. Although it can prevent total blackouts, its implementation requires careful consideration. Several factors must be considered by management so that this policy is effective and the negative impact on society and industry can be minimized.

"...the first is certainty, namely we must determine a clear and fair schedule so that the community and sectors there, both the business sector and the tourism sector. The second is we ensure this is the most important thing is effective communication to the community regarding the time and duration of the blackout, especially to the Village Head there so that there is no more unrest in the community." ~ Informant 1

The first informant emphasized the importance of optimal, clear, and fair blackout scheduling to minimize negative impacts. This scheduling must be conveyed transparently to the public through various communication channels, such as mass media and digital platforms. Effective communication and active community participation are essential to reduce dissatisfaction. In addition, the rolling blackout strategy must consider its impact on vital sectors that can affect people's livelihoods and industry.

"We have to minimize the impact on vital sectors, if there are hospitals, or important security and industrial facilities, those are the last priorities for extinguishing." ~ Informant 1

"The consideration is a priority, so the priority is related to the livelihood of many people, the last priority to be turned off will be communicated about the condition between PLN and stakeholders." ~ Informant 2

"What is certain is that we see the priority of the load needs there. For example, if it is for the night, it can be focused on customer homes or residents' homes that need lighting. But during the day, maybe there are small industries there that are directed there for electricity so that maybe at home it cannot be supplied but its productivity is to earn a living" ~ Information 4.

The implementation of rolling blackouts must prioritize vital sectors such as hospitals, security services, and essential industries to minimize negative impacts. Scheduling must consider electricity consumption patterns in various sectors, for example focusing on household lighting at night and small industries during the day. Clear and transparent communication with the community is essential for the policy to be well received. Effective blackout management must include certainty of schedule, priority of vital sectors, as well as development of renewable energy and consumption restrictions. Rolling blackouts have two sides, namely negative impacts on people's lives and the economy, but can also have positive impacts if managed properly.

"The first and most obvious positive impact is that we prevent damage to the electrical system due to the current overload so that our equipment is safer and even its service life is longer. The second positive impact is that we also help maintain electrical stability because even though the load is small there and with a simple electrical system, when a blackout occurs, it will take longer for us to recover, so this impact is one of them to maintain the stability of the electrical network." ~ Informant 1

"The positive impact is that from the internal side of PLN we can maintain the lifetime of the generator, because it is maintained as optimally as possible and is not forced to exceed its capacity." ~ Informant 4

Rolling blackouts have a positive impact on protecting electrical systems and equipment. These blackouts prevent damage due to overload, extend the life of equipment, and maintain the stability of the electrical system. In addition, rolling blackouts also help maintain the reliability of electricity supply, avoid total blackouts, and ensure grid stability. Although it seems like an emergency solution, rolling blackouts provide an opportunity for PLN to evaluate and improve energy structures, such as generating capacity, grid efficiency, and energy consumption, in order to improve a more reliable and sustainable electricity supply.

"Then the third is to give us as PLN employees the opportunity to identify and improve less than optimal energy structures." ~ Informant 1

Unlike informant one and informant four, informant two and informant three did not provide an explanation of the positive impact of rolling blackouts. The view related to the negative impact is more pronounced according to their explanation as follows:

"From the external side, it is socio-economic, because if there is no electricity, everything from the social side is also hampered by the influence, yes, our potential to sell." ~ Informant 2.

"Then in terms of the quality of life of the community, daily activities such as studying, working and household needs will be hampered." ~ Informant 3

Rolling blackouts have a dual impact, both positive and negative. Positively, these blackouts prevent damage to the electrical system due to overload, maintain the stability of the electricity supply, and provide an opportunity for PLN to improve the less than optimal energy structure. However, the negative impacts are significant, including disrupting economic activities and the quality of life of the community, such as hampering business, the tourism sector, and daily activities. Blackouts also cause inconvenience, damage to electronic equipment, and increase the potential for criminal acts. Overall, although rolling blackouts help maintain the stability of the electricity system, their impact on society and the economy requires a better and more sustainable solution.

Alternative Rental Generators in Overcoming Energy Deficit

The energy crisis, characterized by energy deficits and rolling blackouts, requires a comprehensive solution. One of the alternatives being considered is renting a power plant. To determine whether renting a power plant is the right solution, an in-depth analysis of the advantages, disadvantages, and comparisons with other alternative solutions in dealing with the energy deficit in Parang Island, Genting Island, and Nyamuk Island is needed.

"I think renting a power plant is an alternative to deal with the energy deficit, because by renting a power plant in a region or area, it can quickly increase electricity production so that it can easily meet the reduced energy needs." ~ Informant 1

"It can. So when demand increases and supply decreases, then renting a generator can be an alternative." ~ Informant 2

"Yes, so renting a generator is also an alternative for PLN to overcome the short-term electricity deficit." ~ Informant 3

Yes, renting a generator is one of the alternatives that can be done in the short term, in the near future and is not too burdensome from the company's financial side, because the rental system means that the asset is not ours and we do not need to maintain it.

Power generation rental can be a short-term solution to overcome energy deficits, especially in areas with urgent energy needs. The advantages include rapid increase in electricity supply without the need for new infrastructure development, as well as flexibility in procurement, operation, and maintenance. However, power generation rental relies on fossil fuels which can increase operational costs and environmental impacts. Therefore, power generation rental should be considered as a temporary solution, with long-term efforts to develop renewable energy and increase existing power generation capacity.

Selecting the right vendor is also key to success, considering generating capacity, technology, vendor reputation, and cost. This solution requires a comprehensive approach that involves cooperation with third parties and investment in sustainable energy infrastructure to maintain national energy security.

"First in the selection we have to look at the experience, so we can choose a vendor that has a good reputation and experience, which is sufficient in providing energy generation solutions as proven by clear evidence and a history of existing contracts." ~ Informant 1

"What is clear is the vendor's competence."~ Informant 2

"The first is related to the capacity of the quality of the generator, then the reputation of the credibility of the vendor that has experience and a good track record in providing similar services, for example in other places besides PGN." ~ Informant 3

"What could be a consideration is the track record itself, whether they have worked with PLN before and whether they do not have any negative records that can be assessed from the procurement side later" ~ Informant 4.

All four informants agreed that in selecting an energy generation vendor, the four main criteria to consider are experience, competence, reputation, and track record. Vendor experience, especially proven by a good contract history, is the main basis for ensuring the quality and success of the project. Vendor competence in understanding customer needs and providing appropriate technical solutions is also very important. In addition, a good reputation and track record of the vendor, including whether they have a positive record in working with PLN, also need to be considered to minimize risk.

Informants also emphasized that vendors should pay attention to environmental impacts, ensuring that the rented power plants do not damage the ecosystem or the community. Selecting vendors that meet these criteria will help companies ensure project success and reduce risks, as well as improve the quality of decisions and overall project outcomes.

*"Then the second one is related to environmental issues.....*Did the generator rental pass through that coral reef route without a previous survey, so when he wanted to go in there there was an obstacle." ~ Informant 2

"Next, for environmental safety, the vendors provided are environmentally friendly or generators with low emission values." ~ Informant 3

Both informants emphasized the importance of environmental factors in selecting a power plant vendor. Informant two reminded that the lack of adequate environmental surveys could lead to serious problems, such as undetected coral reefs, which could damage the environment and worsen the project. Therefore, a comprehensive environmental survey and risk analysis are essential.

Informant three emphasized the importance of choosing an environmentally friendly vendor with low emission values, to reduce carbon footprint and negative impacts on the environment. This shows that awareness of environmental sustainability is increasingly important in choosing a vendor, especially in dealing with the impact of conventional energy generation on climate change.

In addition, operational cost factors are also an important consideration in vendor selection, to ensure that the costs incurred do not burden the company. By considering environmental factors and operational costs, companies can ensure energy generation projects that are economically profitable and environmentally sustainable.

"Emphasizing the importance of paying attention to rental costs, contract duration, and providing time extension options in the generator rental contract. (Informant 1).

"Highlighting the need for transparency of costs and clear payment schemes, as well as avoiding unexpected additional costs. (Informant 3).

"Remind that operational and maintenance aspects are carefully considered, so that there are no other costs outside of the rental fee that must be incurred. (Informant 4).

Renting a power plant is an attractive option to meet the increasing energy needs, because it offers flexibility and speed in energy provision. However, like any other option, renting a power plant has positive and negative impacts that need to be carefully considered before a decision is made. Here are some opinions regarding the positive impacts from informants.

"The first is a rapid increase in energy. Because we at PGN can immediately press the capacity to meet the demand and needs of customers around PGN, so we can reduce the energy deficit quickly." ~ Informant 1

"The positive side is that there is no deficit, the electricity can be turned on." ~ Informant 2

"The first is that the energy crisis can be overcome." ~ Informant 3

".....a very fast short-term solution because it lasts for a short time, here the needs of the community and the productivity of the community are also immediately met." ~ Informant 4

Several informants mentioned that power plant rental not only functions as a short-term energy supply strategy, but also provides other positive impacts, such as management flexibility that can reduce economic and social impacts, especially in maintaining the stability of the electricity system. According to Khani et al. (2012), economic, technical, and environmental reasons encourage the use of distributed generation units as a complement to traditional large generators connected to the transmission system. Access to the latest technology in power plant rental also allows efficiency and adjustment to the company's capacity and needs.

"Then we also have to have flexibility in energy management. We can also get access to renewable technology, because if we rent a more efficient generation technology we don't need to invest anymore." ~ Informant 1

".....the next is that the disruption of economic and social activities can be minimized. The stability of the electricity system and the existence of generator rentals can help balance demand and supply for the system." Informant 3

Alternative Development of New Power Plants to Overcome Energy Deficit.

The energy sector currently faces major challenges related to the construction of new power plants, with decision-making having to address energy efficiency, energy security, and environmental issues simultaneously (Rudenko & Tanasov, 2022). The construction of new power plants is an important alternative to increase electricity supply that supports economic growth and public welfare. However, this decision is not simple because various aspects must be considered in depth, both internally and externally, so that development can be effective and sustainable.

According to informants, aspects that need to be considered in the construction of new power plants, especially from an internal perspective, are feasibility studies. Informants one and two highlighted the importance of project feasibility testing as a crucial stage in planning the construction of new power plants (Ahsan, 2021). This feasibility test aims to evaluate the financial and technical feasibility of the project and identify potential risks and benefits. The main focus of the feasibility test is the analysis of investment costs, operating costs, and potential income to be generated by the power plant (Muljiyanto et al., 2024).

"*First we have to conduct a feasibility study to assess the investment costs, operations and revenues from the power plant." ~Informant 1*

"It's called a project feasibility test. So what needs to be debated is a feasibility study of the operation first. So whether it is technically possible or not. Then there is a financial feasibility study so whether it is financially feasible or not, and the third is risk feasibility, so those risks can be feasible or not in terms of risk." ~ Informant 2

".....its sustainability ensures that this power plant can operate efficiently in the long term." ~ Informant 3

Furthermore, informants also consider the use of new renewable energy associated with sustainable energy. Such as solar, wind, water and other power plants.

"We also have to choose the energy source that will be used, for example whether we want to use fossil fuels, nuclear or renewable energy and of course we have to consider the sustainability impact." ~ Informant 1

"So whether we like it or not, we have to use generators with new renewable energy. One that can be implemented is maybe PLTS, solar power, and we can also use solar as support" ~ Informant 4

By considering sustainability factors and ecosystem impacts comprehensively, PLN can make wise decisions in choosing energy sources for power plants. The goal is to provide enough electrical energy to meet the needs of the community, while maintaining environmental sustainability and ecosystem balance. This also supports the zero emission program.

"We include primary energy options, whether they are in accordance with our country's planning towards zero emissions by 2060." ~ Informant 1

"The government itself also supports the zero carbon emission program." Informant 4.

The selection of the type of power plant based on New and Renewable Energy (EBT) must be carried out strategically by considering various factors to ensure the sustainability of energy supply. The best solution is a combination of various renewable energy sources that are adjusted to the potential of each region. This approach not only increases national energy efficiency and resilience, but also encourages economic growth and community welfare. In building new power plants that support EBT, an in-depth study of the existing challenges and opportunities is needed so that the energy transition can run optimally and sustainably. Several informant views regarding conditions on Parang Island, Genting, and Nyamuk also illustrate this.

"I think the renewable energy that suits the location is solar power and wind power, so what we need to build is solar power plants and wind power plants." ~ Informant 1

"So there are two potentials. PLTS and PLTA. If PLTS is prioritized there, first it supports EBT 2060. The second is about what technology to use." ~ Informant 2

"The supporting factors for selecting this generator are available, such as PLTS, and Indonesia's geographical conditions on the equator support PLTS, it is suitable for that." ~ Informant 3

Optimizing Decision Making in Overcoming Energy Deficit Problems

Optimizing decision-making in addressing energy deficit issues is a collaborative process involving various parties with their respective roles and responsibilities. Leaders or managers have a key role in determining strategic direction and final decisions, as well as allocating the necessary resources. Teams of experts provide analysis and recommendations based on their expertise, while employees provide insights from direct experience and are involved in implementing solutions. External stakeholders, such as customers, partners, and the general public, provide perspectives on relevant needs. External consultants or advisors can also be involved to provide objective perspectives. By involving various parties, it is hoped that the decisions taken can be comprehensive, effective, and sustainable.

Decision-making related to energy deficit issues involves various parties. The parties involved include the Central or District Government, energy companies, communities, NGOs, local communities, energy experts and researchers, investors, and regulators who oversee decisions in accordance with laws and regulations ~Informant 1.

Adding that the parties involved internally include the Kudus UP3 Manager and the Jepara ULP Manager, while externally involving the local government, as well as cooperation with expert teams and universities to provide input related to technology that is appropriate to conditions at the location.~ Informant 2.

There are several parties involved, namely the central government, then the regional government, then there are private parties or partners, then the community or academics. For the center, there is the Ministry of Energy and Mineral Resources, then the Ministry of Finance, then Bappenas, then the regional government. Then the private sector or vendors also play a role in the scheme for the construction of the power plant. Then there are the community and stakeholders and academics." ~ Informant 3

Decision-making related to handling the energy deficit involves various parties with different roles. The government, both central and regional, plays a strategic role in formulating policies, licensing, and supervision of the energy sector. The Ministry of Energy and Mineral Resources, the Ministry of Finance, and Bappenas have important roles in regulation, budget allocation, and strategic planning, while regional governments are responsible for local policies and the development of energy infrastructure. PLN also has a crucial operational role in the operation of electricity generation, transmission, and distribution, and collaborates with the private sector to accelerate the development of power plants.

External stakeholders, such as civil society, NGOs, and local communities, play a role in providing input on social and environmental impacts, increasing accountability and transparency in decision-making. Academics and researchers contribute to environmental impact analysis, feasibility studies, and renewable energy technology development. Investors also have a key role in providing funding by considering financial viability and risk.

Overall, decision-making in addressing the energy deficit requires collaboration between the government, PLN, the private sector, external stakeholders, and experts, to achieve optimal and sustainable solutions. A flexible and adaptive approach, which takes into account various factors, is essential to ensure the sustainability of energy supply and stable economic growth.

"The development of power plants with new renewable energy such as solar power plants. Because we have to consider the sustainability of this renewable energy is sustainable and can reduce dependence on fossil fuels which are increasingly limited. Then the second is the minimal environmental impact because the development of this renewable energy has a lower impact compared to energy plants." ~ Informant 1

"So the most suitable is a new power plant with renewable energy, especially solar power." ~ Informant 2

"If we look at the electricity conditions on PGN Island and the alternatives that were conveyed earlier, yes, we convey that PLN will choose the best, of course, choosing our place which has EBT, yes, has new renewable energy." ~ Informant 3

"In my opinion, if it is indeed from the perspective of society that is very urgent, it can be seen from the perspective of economic growth, it can be between renting or building a new power plant. If from the perspective of demand that is more advanced and can be more sustainable, then it is possible to build a new power plant." ~ Informant 4

The decision to prioritize the development of New and Renewable Energy (EBT) as the main solution to overcome the energy deficit must be based on in-depth analysis and careful consideration. Integration of EBT into the electricity system is expected to reduce dependence on limited fossil energy and minimize negative impacts on the environment. In addition, this decision can encourage technological innovation and create new jobs in the renewable energy sector. The informants provided views on how this alternative can help address the existing energy deficit problem.

First is increasing energy production capacity because by adding many renewable energy generators, the total energy production capacity in the PGN region will definitely increase, which will help meet energy demand to date. Then the second is diversifying energy sources, namely reducing dependence on one type of energy source related to the resilience of the energy system and reducing the risk related to fluctuations in global energy prices, especially fossil energy which is always unstable. Then the third is the emission component, then long-term investment. "~Informant 1

"So, we just need to increase the supply to handle the existing problems, the existing energy deficit." ~ Informant 2

"So when we choose renewable energy development as a long-term solution, it will be able to overcome the deficit permanently, while also supporting the sustainability of energy supply and attracting investors to invest, yes, and boosting the economy there, on Parang Island, Genting and Nyamuk. And this is supported by the optimization of network infrastructure that can be built." ~ Informant 3

"In my opinion, the decision taken can be fast, both in terms of renting the power plant and construction, of course, in the short term it will be fulfilled, and in terms of the long term it can be permanent, so in terms of community productivity it will be better and develop in terms of the long term, later the power plant will be ready for more capacity." ~ Informant 4.

CONCLUSION

This study aims to understand how managerial decisions determine the best alternatives to overcome the energy deficit on Parang Island, Genting Island, and Nyamuk Island.

1. The results of the study show that handling the problem of electricity deficit considers several criteria, including the use of environmentally friendly and sustainable renewable energy sources. Energy independence by utilizing local resources is also important to improve the reliability of electricity supply. Cost efficiency, including investment, operations, and maintenance, is a major consideration in providing electricity access to the community. An effective management system and good service to the community are also crucial in increasing trust in energy providers.
2. To overcome energy problems, informants agreed that the use of renewable energy, especially through Solar Power Plants (PLTS), is the right choice. PLTS is suitable for application in island areas with high sunlight

intensity. Diversification of energy sources, development of electricity networks with appropriate technology such as Battery Energy Storage System (BESS), and adaptation of technology to local resources are also considered important steps to create an efficient and sustainable energy system.

3. The decision-making strategy in addressing the energy deficit involves collaboration between various stakeholders, namely the Central Government (Ministry of Energy and Mineral Resources), Regional Government, Experts or Academics, Community, NGOs, Vendors, and internal PT Perusahaan Listrik Negara (PLN). Before decision-making, comprehensive data analysis, mature planning, technology implementation, and efficient and responsive management to change are required. Collaboration between stakeholders and a mature data-based approach are key to ensuring that the energy system can adapt to evolving needs. With this approach, it is hoped that the electricity deficit can be addressed effectively, improving the quality of life of the community, and encouraging economic development on Parang Island, Genting Island, and Nyamuk Island.

Future Research Agenda

It is necessary to add informants and diversify informants. This aims to expand the scope of the data so that the information or data collected will be more diverse which will later affect the research results process.

This research was only conducted on the top management of PLN UID Central Java & DIY, considering that many stakeholders must be involved so it would be better if future research was conducted comprehensively starting from the community, related NGOs, academics and vendors who are able to provide information related to optimizing decision making.

This study uses a qualitative method, so for future research the author suggests conducting research using a quantitative method with measurement value testing so that the research results can be generalized to other sectors. This can later be an indicator of the company's successor according to the company's needs and desires.

REFERENCES

Abdel-Baset, M., Chang, V., Gamal, A., & Smarandache, F. (2019). An integrated neutrosophic ANP and VIKOR method for achieving sustainable supplier selection: A case study in importing field. In Computers in Industry (Vol. 106, pp. 94–110). Elsevier BV https://doi.org/10.1016/j.compind.2018.12.017

Afif and, F., & Martin, A. (2022). Review of Solar Energy Potential and Policy in Indonesia. Journal of Engine: Energy, Manufacturing and Materials, 6(1), 43–52.

Agarwal, A. (2024). FAlloc: A Fair Power Limit Allocation-Based Approach to Implement Brownout. Journal of Control, Automation and Electrical Systems, 35(2), 361–375. https://doi.org/10.1007/s40313-024-01077-x

Ahmad, A., Jrad, F., & Makia, S. (2023). A Data-Driven Approach to Supplier Selection in Industrial Construction Projects. The Journal of Duhok University, 26(2), 201–215. https://doi.org/10.26682/csjuod.2023.26.2.20

Akrami, A., Doostizadeh, M., & Aminifar, F. (2019). Power system flexibility: an overview of emergence to evolution. In Journal of Modern Power Systems and Clean Energy (Vol. 7, Issue 5, pp. 987–1007). Springer Heidelberg. https://doi.org/10.1007/s40565-019-0527-4

Arinaitwe, A., Bagire, V., Tukamuhabwa, B., & Sulait, T. (2023). Energy management in small and medium manufacturing firms: examining the enhancing role of top management commitment in a developing country context. International Journal of Energy Sector Management. https://doi.org/10.1108/IJESM-05-2023-0017

Atteridge, A., & Savvidou, G. (2019). Development aid for energy in Small Island Developing States. Energy, Sustainability and Society, 9(1). https://doi.org/10.1186/s13705-019-0194-3

Awad, ASA, El-Fouly, THM, & Salama, MMA (2014). Optimal distributed generation allocation and load shedding for improving distribution system reliability. Electric Power Components and Systems, 42(6), 576–584. https://doi.org/10.1080/15325008.2014.880962

Bahari, MIAT, Supriyadi, S., Pryambodo, DG, & Prihantono, J. (2022). Identification of Groundwater Using Geoelectrical Method VES (Vertical Electrical Sounding) in Karimunjawa City, Central Java. Journal of Physics: Conference Series, 2392(1). https://doi.org/10.1088/1742-6596/2392/1/012003

Borodinecs, A., Zajecs, D., Lebedeva, K., & Bogdanovics, R. (2022). Mobile Off-Grid Energy Generation Unit for Temporary Energy Supply. Applied Sciences (Switzerland), 12(2). https://doi.org/10.3390/app12020673

Busby, J.W., Baker, K., Bazilian, M.D., Gilbert, A.Q., Grubert, E., Rai, V., Rhodes, J.D., Shidore, S., Smith, C.A., & Webber, M.E. (2021). Cascading risks: Understanding the 2021 winter blackout in Texas. In Energy Research and Social Science (Vol. 77). Elsevier Ltd. https://doi.org/10.1016/j.erss.2021.102106

Cinantya, P., Widiastuti, H., & Lumombo, L. (2024). Feasibility Study of Floating Solar Power Plant Development on Drinking Water Source Reservoir in Batam. JPII, 2(2), 65–70. https://doi.org/10.14710/jpii.2024.21723

Creswell, J. W. (2009). Research Design Qualitative, Quantitative, and Mixed Methods Approaches (3rd ed.). SAGE Publications, Inc.

Creswell, W. J., & Creswell, J. D. (2018). Research Design: Qualitative, Quantitative and Mixed Methods Approaches. In Journal of Chemical Information and Modeling (Vol. 53, Issue 9).

Espinosa, VI, Peña-Ramos, J.A., & Recuero-López, F. (2021). The political economy of rent-seeking: Evidence from Spain's support policies for renewable energy. Energies, 14(14). https://doi.org/10.3390/en14144197

Falentina, AT, & Resosudarmo, BP (2019). The impact of blackouts on the performance of micro and small enterprises: Evidence from Indonesia. World Development, 124. https://doi.org/10.1016/j.worlddev.2019.104635

Filippov, S.P., Malakhov, V.A., & Veselov, F.V. (2021). Long-Term Energy Demand Forecasting Based on a Systems Analysis. Thermal Engineering, 68(12), 881–894. https://doi.org/10.1134/S0040601521120041

Ghodoosi, F., Abu-Samra, S., Zeynalian, M., & Zayed, T. (2018). Maintenance Cost Optimization for Bridge Structures Using System Reliability Analysis and Genetic Algorithms. Journal of Construction Engineering and Management, 144(2). https://doi.org/10.1061/(asce)co.1943-7862.0001435

Gürtürk, M. (2019). Economic feasibility of solar power plants based on PV modules with levelized cost analysis. Energy, 171, 866–878. https://doi.org/10.1016/j.energy.2019.01.090

Hunt., JD, Stilpen, D., & de Freitas, MAV (2018). A review of the causes, impacts and solutions for electricity supply crises in Brazil. In Renewable and Sustainable Energy Reviews (Vol. 88, pp. 208–222). Elsevier Ltd. https://doi.org/10.1016/j.rser.2018.02.030

Islam, M.M., Yu, T., Giannoccaro, G., Mi, Y., Scala, M. La, Rajabi, M.N., & Wang, J. (2024). Improving Reliability and Stability of the Power Systems: A Comprehensive Review on the Role of Energy Storage Systems to Enhance Flexibility. In IEEE Access. Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/ACCESS.2024.3476959

Ismanto, A., Ismunarti, DH, Sugianto, DN, Maisyarah, S., Subardjo, P., Dwi Suryoputro, AA, & Siagian, H. (2019b). The potential of ocean current as electrical power sources alternatives in Karimunjawa Islands Indonesia. Advances in Science, Technology and Engineering Systems, 4(6), 126–133.

Jalo, N., Johansson, I., Andrei, M., Nehler, T., & Thollander, P. (2021). Barriers to and drivers of energy management in Swedish SMS. Energies, 14(21). https://doi.org/10.3390/en14216925

Kaiser, N., & Barstow, C. K. (2022). Rural Transportation Infrastructure in Low- and Middle-Income Countries: A Review of Impacts, Implications, and Interventions. In Sustainability (Switzerland) (Vol. 14, Issue 4). MDPI.

Kautsary, J. (nd). The 3rd International Conference on Coastal and Delta Areas-PROCEEDINGS 625 ICCDA#3 Problem, Solution and Development of Coastal and Delta Areas Public Infrastructure Problem For Developing Tourism Destinations In Coastal And Small Islands Areas Case Study In Karimunjawa Archipelago.

Khan, T., Yu, M., & Waseem, M. (2022). Review on recent optimization strategies for hybrid renewable energy systems with hydrogen technologies: State of the art, trends and future directions. In International Journal of Hydrogen Energy (Vol. 47, Issue 60, pp. 25155–25201). Elsevier Ltd. https://doi.org/10.1016/j.ijhydene.2022.05.263

Komal. (2019). Fuzzy reliability analysis of the compressor house unit (CHU) system in a coal fired thermal power plant using TBGFLT technique. International Journal of Quality and Reliability Management, 36(5), 686–707. https://doi.org/10.1108/IJQRM-07-2017-0123

Li, C., Kang, Z., Yu, H., Wang, H., & Li, K. (2024). Research on Energy Optimization Method of Multi-microgrid System Based on the Cooperative Game Theory. Journal of Electrical Engineering and Technology. https://doi.org/10.1007/s42835-024-01806-x

Luburić, Z., Pandžić, H., Plavšić, T., Teklić, L., & Valentić, V. (2018). Role of energy storage in ensuring transmission system adequacy and security. Energy, 156, 229–239. https://doi.org/10.1016/j.energy.2018.05.098

Marzban, E., Firoozpour, A., & Marzban, M. (2023). Electricity as a common good/resource: a scenario based approach. International Journal of Energy Sector Management, 17(3), 510–530. https://doi.org/10.1108/IJESM-08-2021-0020

Maulidia, M., Dargusch, P., Ashworth, P., & Ardiansyah, F. (2019). Rethinking renewable energy targets and electricity sector reform in Indonesia: A private sector perspective. In Renewable and Sustainable Energy Reviews (Vol. 101, pp. 231–247). Elsevier Ltd. https://doi.org/10.1016/j.rser.2018.11.005

Miles, M. B., Huberman, A. M., & Saldana, J. (2014). Qualitative Data Analysis A Methods Sourcebooks (3rd ed.). SAGE Publications, Inc.

Mirjat, N.H., Uqaili, M.A., Harijan, K., Valasai, G. Das, Shaikh, F., & Waris, M. (2017). A review of energy and power planning and policies of Pakistan. In Renewable and Sustainable Energy Reviews (Vol. 79, pp. 110–127). Elsevier Ltd. https://doi.org/10.1016/j.rser.2017.05.040

Mori, A. (2020). Foreign actors, faster transitions? Co-evolution of complementarities, perspectives and sociotechnical systems in the case of Indonesia's electricity supply system. Energy Research and Social Science, 69. https://doi.org/10.1016/j.erss.2020.101594

Mou, Y., Wang, B., & Shen, Z. (2023). An optimization scheme for designing power rationing schedules in a long-term power shortage. Electric Power Systems Research, 225. https://doi.org/10.1016/j.epsr.2023.109816

Muljiyanto, WP, Wiyoga, BR putri, Wartana, IM, & Sulistiawati, IB (2024). Financial Feasibility of Hybrid Power Plant Development in Sanggar, Batu City, East Java. Journal of Electrical Energy Engineering, Telecommunication Engineering & Electronic Engineering, 12, 1063–1073.

Mwanza, M., & Ulgen, K. (2020). Sustainable electricity generation fuel mix analysis using an integration of multicriteria decision-making and system dynamic approach. International Journal of Energy Research, 44(12), 9560–9585. https://doi.org/10.1002/er.5216

Nasrullah, M., Arnold, Y., & Soetrisnanto. (1999). Application of Lease-Purchase Financing Model for Power Plant Development in Indonesia. Journal of Nuclear Energy Development, 1, 131–141.

Novitasari, D., Salis, FR, Budiarto, R., & Sarjiya. (2020, October 20). Challenges in Using Renewable Energy for Islands in Indonesia: A Case Study of Karimunjawa. Proceedings of the 2020 International Conference and Utility Exhibition on Energy, Environment and Climate Change, ICUE 2020. https://doi.org/10.1109/ICUE49301.2020.9307078

Nurjanah, N., & Fatmawati, I. (2020). ANALYSIS OF VENDOR SELECTION USING ANALYTICAL HIERARCHY PROCESS (AHP) METHOD (Case Study at PT BUKIT ASAM UNIT TARAHAN). Journal of Business Logistics, 10(2). https://ejurnal.poltekpos.ac.id/index.php/logistik/index

Nuwa, AM, Ballo, FW, & Tiwu, MIH (2024). The Impact of the Development of the Ropa PLTU on Sustainable Development in Keliwumbu Village, Maurole District, Ende Regency. Journal of Development Economics, 6, 37.

Okwanya, I., Alhassan, A., Migap, J.P., & Adeka Sunday, S. (2021). Evaluating renewable energy choices among rural communities in Nigeria. An insight for energy policy. International Journal of Energy Sector Management, 15(1), 157–172. https://doi.org/10.1108/IJESM-12-2019-0001

Paryono, P., Absori, A., Dimyati, K., Basri, M., & Rismawati, SD (2020). Liberalization and electricity policy changes: Problems and challenges in the electricity sector in Indonesia. International Journal of Energy Economics and Policy, 10(1), 170–177. https://doi.org/10.32479/ijeep.8636

Pasimeni, M.R., Petrosillo, I., Aretano, R., Semeraro, T., De Marco, A., Zaccarelli, N., & Zurlini, G. (2014). Scales, strategies and actions for effective energy planning: A review. Energy Policy, 65, 165–174. https://doi.org/10.1016/j.enpol.2013.10.027

Permana, DA, Wibawa, U., & Utomo, T. (2022). Analysis Study of Hybrid Power Plant (Diesel - Wind) in Karimun Jawa Island. 1–7.

Prus, P., & Sikora, M. (2021). The impact of transport infrastructure on the sustainable development of the region—case study. Agriculture (Switzerland), 11(4). https://doi.org/10.3390/agriculture11040279

Rafinia, A., Moshtagh, J., & Rezaei, N. (2020). Stochastic optimal robust design of a new multi-stage under-frequency load shedding system considering renewable energy sources. International Journal of Electrical Power and Energy Systems, 118. https://doi.org/10.1016/j.ijepes.2019.105735

Raghu, C. N., & Manjunatha, A. (2017). Assessing effectiveness of research for load shedding in power systems. International Journal of Electrical and Computer Engineering, 7(6), 3235–3245. https://doi.org/10.11591/ijece.v7i6.pp3235-3245

Rahmanta, MA, Adhi, AC, Tambunan, HB, Digwijaya, W., Damanik, N., & Al Hasibi, RA (2023). An Analysis of National Position, Opportunity, and Challenge of Indonesia's Nuclear Program to Support Net-Zero Emissions by 2060. Energies, 16(24). https://doi.org/10.3390/en16248089

Rudenko, D., & Tanasov, G. (2022). The determinants of energy intensity in Indonesia. International Journal of Emerging Markets, 17(3), 832–857. https://doi.org/10.1108/IJOEM-01-2020-0048

Ryan, B., Johnston, K.A., Taylor, M., & McAndrew, R. (2020). Community engagement for disaster preparedness: A systematic literature review. International Journal of Disaster Risk Reduction, 49. https://doi.org/10.1016/j.ijdrr.2020.101655

Saleem, F., Zhang-Zhang, Y., Gopinath, C., & Malik, M.I. (2023). Antecedents of environmental strategies: a study of the manufacturing industry in Pakistan. International Journal of Emerging Markets, 18(10), 3616–3639. https://doi.org/10.1108/IJOEM-09-2020-1153

Santoso, AD, & Muhammad Agus Salim. (2019). Household Electricity Savings in Supporting National Energy Stability and Environmental Sustainability. In Journal of Environmental Technology (Vol. 20, Issue 2).

Sarmiento-Vintimilla, J. C., Marene Larruskain, D., Torres, E., & Abarrategi, O. (2024). Assessment of the operational flexibility of virtual power plants to facilitate the integration of distributed energy resources and decision-making under uncertainty. International Journal of Electrical Power and Energy Systems, 155. https://doi.org/10.1016/j.ijepes.2023.109611

Shrestha, S., Panchalogaranjan, V., & Moses, P. (2023). The February 2021 US Southwest power crisis. Electric Power Systems Research, 217. https://doi.org/10.1016/j.epsr.2023.109124

Soltani, A., Sadiq, R., & Hewage, K. (2016). Selecting sustainable waste-to-energy technologies for municipal solid waste treatment: A game theory approach for group decision-making. Journal of Cleaner Production, 113, 388–399. https://doi.org/10.1016/j.jclepro.2015.12.041

Stern, D. I., Burke, P. J., & Bruns, S. B. (2019). Energy and Economic Growth Title The Impact of Electricity on Economic Development: A Macroeconomic Perspective Permalink https://escholarship.org/uc/item/7jb0015q Publication Date. https://escholarship.org/uc/item/7jb0015q

Suhono, & Sarjiya. (2015). Long-term electricity demand forecasting of Sumatra system based on electricity consumption intensity and Indonesia population projection 2010-2035. Energy Procedia, 68, 455–462.

Sunitiyoso, Y., Mahardi, JP, Anggoro, Y., & Wicaksono, A. (2020). New and renewable energy resources in the Indonesian electricity sector: a systems thinking approach. International Journal of Energy Sector Management, 14(6), 1381–1403. https://doi.org/10.1108/IJESM-11-2019-0019

Susanty, A., Puspitasari, NB, Saptadi, S., & Siregar, SD (2020). Using system dynamics approach to build policy scenario for reducing CO2 emissions resulting from tourism travel to Karimunjawa. Kybernetes.

Syadli, H., Abdullah, P., Hassan, MY, & Hussin, F. (2020). Demand Side Management for Reducing Rolling Blackouts Due to Power Supply Deficit in Sumatra (Vol. 69, Issue 5). www.jurnal Teknologi.utm.my

Tu, CS, Tsai, WC, Hong, CM, & Lin, WM (2022). Short-Term Solar Power Forecasting via General Regression Neural Network with Gray Wolf Optimization. Energies, 15(18).

Xiang, L. (2017). Energy network dispatch optimization under emergency of local energy shortage with web tool for automatic large group decision-making. Energy, 120, 740–750. https://doi.org/10.1016/j.energy.2016.11.125

Xu, Q., Yu, C., Yuan, X., Fu, Z., & Liu, H. (2022). A distributed electricity energy trading strategy under energy shortage environment. Complex Engineering Systems, 2(3). https://doi.org/10.20517/ces.2022.20

Yang, M., & Chou, S.Y. (2018). The impact of environmental regulation on fetal health: Evidence from the shutdown of a coal-fired power plant located upwind of New Jersey. Journal of Environmental Economics and Management, 89, 94–115. https://doi.org/10.1016/j.jeem.2017.11.005

Zaripova, R., Nikitin, A., Hadiullina, Y., Pokaninova, E., & Kuznetsov, M. (2021). Vendor selection information system on the electronic trading platform for energy supply companies. E3S Web of Conferences, 288. https://doi.org/10.1051/e3sconf/202128801072

Zhao, J., Liu, Y., & Tu, Z. (2023). Optimal energy management strategy for distributed renewable energy power generation system based on "three-flow" theory. International Journal of Hydrogen Energy, 48(87), 34045–34054. https://doi.org/10.1016/j.ijhydene.2023.05.183

Zio, E. (2009). Reliability engineering: Old problems and new challenges. In Reliability Engineering and System Safety (Vol. 94, Issue 2, pp. 125–141). https://doi.org/10.1016/j.ress.2008.06.002