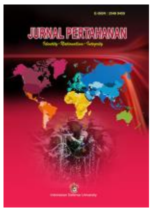
Jurnal Pertahanan

Media Informasi tentang Kajian dan Strategi Pertahanan
yang Mengedepankan *Identity*, *Nationalism* dan *Integrity*
e-ISSN: 2549-9459
http://jurnal.idu.ac.id/index.php/DefenseJournal



THE DECISION MATRIX OF THE MOST EFFICIENT ENERGY UTILIZATION FOR COLD STORAGE AT PULAU MOROTAI REGENCY

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Article Info

Article history:
Received : February 8, 2021
Revised : April 28, 2021
Accepted : April 28, 2021

Keywords:
Cold Storage,
Decision Matrix,
Fishery,
Morotai,
Photovoltaic,
PLN

Abstract

Pulau Morotai Regency is one of the areas identified by the government as a fisheries-focused Special Economic Zone. However, the reality on the ground is that the fishing industry has only one cold storage facility. One of the factors is the region's remote position, which requires a considerable amount of capital and operational expenditure. Lower energy costs are one way to reduce the operating cost. This study aims to determine the value of each energy-efficient criterion and to know the most efficient energy composition implemented for Cold Storage in Morotai. This study uses the decision matrix approach to compare the operating costs of cold storage with a capacity of 200 tons over 20 years with three possible alternatives: PLN electricity, hybrid electricity (PLN + photovoltaic), and fully photovoltaic energy. With a score of 38 in the decision matrix table, the outcome of the decision matrix calculation indicates that cold storage with a photovoltaic system is much superior.

DOI:
http://dx.doi.org/10.33172/jp.v7i1.1151

INTRODUCTION

Pulau Morotai Regency (PMR) has an area of 1,800 km² is the name of an island as well as a district located in the Halmahera archipelago, Maluku Islands, Indonesia. As part of North Maluku Province, it is one of the northernmost islands in Indonesia. PMR consists of 5 districts, namely Morotai Selatan, Morotai Timur, Morotai Selatan Barat, Morotai Utara, and Morotai Jaya. PMR was inaugurated by the Minister of Home Affairs of Indonesia, Mardiyanto, on October 29, 2008, as a result of the division of North Halmahera Regency. Most of the area is forest and produces wood and resin. This island is very strategic as a trade route in eastern Indonesia because it has natural resources such as gold, iron ore, enchanting marine tourism potential, fisheries, etc.

The largest contribution to the Gross Regional Income of Morotai Regency in 2017 at the current price was the agriculture, forestry, and agriculture sectors of Rp. 623.36 billion (47%), the trade amounting to Rp. 258.80 Billion (19%), Government Administration (9%), Construction (8%), Processing Industry (4.6%) of the total GRDP of Rp. 1,319.06 Billion. In 2018 this percentage generally did not change even though there was an increase in 2018 GDP reached Rp. 1,438,56 billion (BPS, 2019)

In the distribution of the Special Economic Zone (SEZ), the Morotai Island region as one of the SEZs in Eastern Indonesia directs the main activities of the fishery processing industry, tourism, and logistics (see Figure 1). The determination of the main activities of SEZ is in line with the geographic conditions of Morotai which are close to the Philippines, fishing routes, and its beautiful panorama.

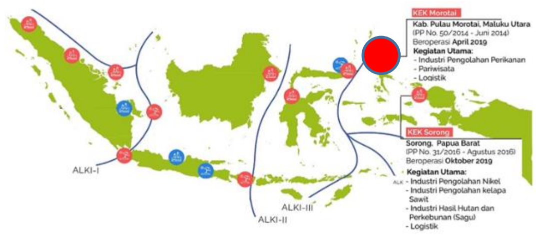

Figure 1. Morotai SEZ in red dot
Source: BPS, 2019

Even though PMR which faces the Sulawesi Sea has great fishery potential, currently there is no fish processing industry, while the availability of cold storage is only 1 at the Southern part of the Morotai Regency. The existing processing industries that play a role are the food industry with a share of 64%, the handicraft industry 19%, and building materials 17%. In the future, it can be expected that the fisheries industry will develop and give meaning to the development of PMR both in expanding employment opportunities, developing population welfare as well as increasing human resources, the economy of the community and the region, increasing the nationalism of local population, and the ultimately increasing national resilience.

To ensure the growth of the fisheries sector, a fish processing, and preservation industry is needed so that both catch and aquaculture can be absorbed, which includes the development of fishing ports, fish canning factories, as well as the provision of cold storage and an ice cube industry so that fishing times can be longer without going back and forth back to the port.

The condition of the existing area and development priorities in the Pulau Morotai Regency will require planning for the preparation of fishery facilities and infrastructure, including the provision of energy so that development targets as stated in the SEZ can be achieved optimally. The achievement of this SEZ target is expected to improve the economy of the community and the region, increase energy security and ultimately increase awareness of state defense and National Resilience.

In this regard, this study intends to research the development of the fisheries sector in PMR, in particular the development of fishing capacity, preparation of the fish processing industry, energy supply, and strategies for its preparation. Given the wide range of existing aspects, including the development of the fisheries, tourism, and logistics industries or the preparation of shipbuilding and maintenance, this research is limited to determining the most efficient energy use for the fisheries industry, especially for existing cold storage. By considering the background and problems that arise in the development of the fishery industry, research questions can be formulated:

a. What are the criteria that can be used as a basis for determining the most efficient alternative?
b. What is the most efficient alternative to be implemented for Cold Storage in Morotai?

The overall goal of this study is to provide an overview of the development of the Morotai Island Regency by using the potential of the fisheries sector, its potential for use, and the provision of energy. Seeing that there is only one cold storage fishery infrastructure in Morotai, so the focus and purpose of this study is how to maximize the existing infrastructure conditions so that it can be optimally used by the community without burdening the costs that should be suppressed. Therefore, it can be formulated that the objectives of this study are to determine the value of each energy-efficient criterion and to know the most efficient energy composition implemented for Cold Storage in Morotai

The significance or usefulness of this research can be divided into 2 (two) aspects, namely benefits in the theoretical aspect and benefits in the practical aspect, where the theoretical aspect discusses the benefits of science, while the practical aspect discusses the benefits to institutions and investors.

Theoretical Aspects

This study is expected to contribute academically and become a means and infrastructure for separate knowledge, as well as adding new experiences that will hone the abilities of academics and researchers in regional development and national development through the development of facilities and infrastructure for the development of the potential of existing natural resources, as well as in providing energy.

Practical Aspects

This study will be able to provide an overview of reference information and discoveries in contributing to defense science, especially energy security. As reference material for further research and the role of energy in supporting regional development and the environment to improve community welfare. Development of local natural resource potential through industrialization by developing local alternative energy resources to replace the use of fossil energy sources that have a time limit in their utilization. This research process can be applied to the development of other areas or other SEZs throughout Indonesia so that it can benefit the community, academics, and investors as well as decision-makers in developing their areas, increasing regional Energy Security and National Resilience.

METHODOLOGY

This study uses a decision matrix as a method of analysis for primary data. In general, the decision matrix method is a method that assesses each alternative based on predetermined criteria. The value of each alternative is then sorted so that the alternative with the highest value is obtained as the best alternative. This study uses literature data, theories, and previous research as secondary data input, while primary data comes from mathematical calculations, field data, and data derived from secondary data.

Decision Matrix Analysis is a tool that can be applied to the policy-making process in a variety of industries and government agencies. The main purpose of this method is to include the contribution of all factors and variables involved in determining the policy and then quantified and ranked then tabulated into the form of a matrix (Teriö, Sorri, Kähkönen, & Hämäläinen, 2014). The decision matrix is used to facilitate understanding and correlation of all variables and factors so that the policymaker or decision-maker can easily determine the most optimal decisions and policies.

The development of a matrix that covers a broad range of variables, factors, and problems is very important for effective and optimal implementation of the decision matrix, as well as to support the process of determining policies and decisions, it can also provide early warning to related stakeholders (Al-Tekreeti & Beheiry, 2016). One of the advantages of the decision matrix analysis method is how it can optimize limited resources such as funds, not only by helping to determine the best and optimal choice but also by managing portfolios for related projects or policies. The main objectives and competencies of the decision matrix are developed to support the main competencies of the organization, to reallocate resources for activities, and meet the goals of decision-makers (Nicholls, 1995). Other advantages of a decision matrix include 1) ease of application, 2) reliable results, 3) can provide an initial description of the flaw of each option, 4) can be applied in many forms of organizations and companies, 5) in a quantitative form so that it is easier to display in the graphic form (Domínguez, Martínez, Peña, & Ochoa, 2019).

Fish Processing Industry

In principle, the fish processing industry is divided into two parts, namely the fish preservation or freezing industry and the fish canning industry. Generally, frozen fish is fish that will be shipped to other regions in the country or exported. With a sea area reaching 70 percent of the total area, Indonesia has abundant fishery potential that is widespread from Malacca to Arafura. Through several strategic steps, fishery production is expected to support national food security. Large pelagic fish or fish that live on the sea's shore, such as mackerel, tuna, and skipjack, small pelagic fish, or small fish species that live on the sea surface, such as mackerel, *lemuru*, and kites, and demersal fish or other forms of fish that live on the seabed, such as snapper, *kurisi*, and pomfret, are among these marine resources.

Cold Storage

Cold storage is used to keep fish and fruit from spoiling when they are shipped out of the country or exported. Generally, cold storage is not equipped with a diesel generator engine as a source of electricity, although some are equipped with a diesel generator, especially for cold storage that is mobile or located in areas where there is no State Electricity Company or *Perusahaan Listrik Negara* (PLN) electricity supply. The need for cold storage in Indonesia is very high, especially in areas with large catchments. But unfortunately, until now the distribution is still not evenly distributed, because investors have to consider the availability of clean water and the availability of other challenges, such as the availability of reliable operators.

Solar Energy

As a country located on the equator, Indonesia receives an average of 4.8 kWh of solar radiation per square meter per day (Rahardjo & Fitriana, 2005). Between 2010 and 2011, the Government of Indonesia has built more than 100 integrated photovoltaic (PV) systems with a total capacity of 80 Megawatt covering more than 100 locations on various islands throughout Indonesia. Solar Power Plant (PLTS) is a device that converts radiation energy contained in sunlight into electrical energy through photovoltaic technology. Solar cells or also often called photocells are tools that can convert direct sunlight into electricity.

Photovoltaic technology is the main type of generator in utilizing the potential of sunlight energy, although in addition to radiation is used to generate electricity, energy from the sun can also maximize its heat conversion energy through the solar thermal system (Salmi, Bouzguenda, Gastli, & Masmoudi, 2012). Given that solar panel converts sunlight into electricity, this tool only works during the day. When irradiated, a typical commercial solar cell produces a DC voltage of 0.5 to 1 volt, and a short-circuit current on the scale of milliamperes per cm^2. Solar cells are a component that can convert solar energy into electrical energy using an effect principle called Photovoltaic. The photovoltaic effect is a phenomenon in which the voltage of an electric current occurs because there is a connection between two electrodes that are connected to a solid and a liquid system when receiving sunlight energy. Therefore, solar cells are often called Photovoltaic (PV) cells.

Energy Security

According to Government Regulation no. 74 of 2014 Article 1 concerning National Energy Policy, Energy Security is a condition that guarantees the availability of

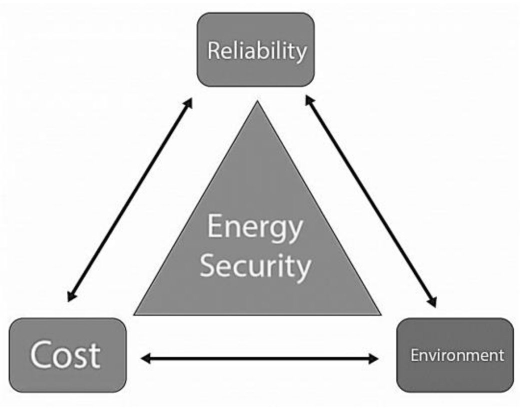

Figure 4. National energy security aspects
Source: Hikam, 2015

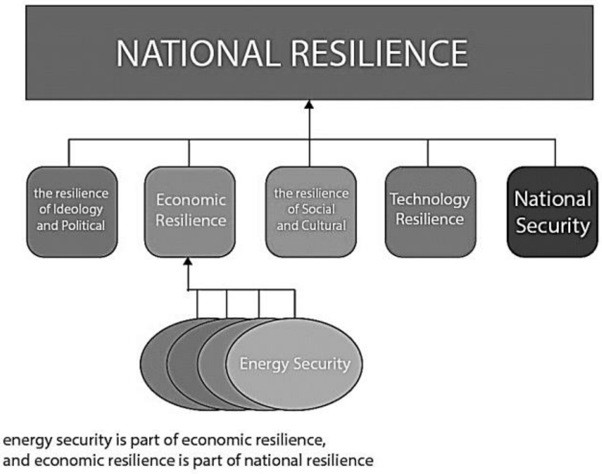

Figure 5. National Resilience Components
Source: Yusgiantoro, 2016

energy, public access to energy at affordable prices in the long term while still paying attention to the preservation of the environment. The three aspects of energy (see Figure 4) in the form of reliability of availability and infrastructure, environment, and the cost will be interrelated and synergize with each other to form a bonding ring that results in conditions of energy security (Hikam, 2014). That theory can be used to ensure good energy protection in Pulau Morotai Regency, especially in the operation of cold storage. As a result, it can be assumed that to achieve optimum performance, cold storage operations must employ a dependable energy system that is both economical and environmentally sustainable.

In the National Energy Policy as stipulated in Presidential Decree No. 79/2014, Article 5 states that the national energy policy is formulated as a guideline to provide direction for national Energy Management to realize National Energy Independence and Energy Security to support sustainable national development. National Energy Security in Indonesia is very important, to support sustainable national development. Energy Security is one part of economic resilience and is part of National resilience. Energy security is needed to strengthen economic resilience (see Figure 5), if energy security can be achieved it will create stable economic growth, because in economic growth that is needed besides capital is sufficient energy to accelerate industrial growth, without sufficient energy then production from the industrial sector will not be achieved maximally and will hinder the achievement of ideal economic resilience (Yusgiantoro, 2016).

Energy Security as stipulated in the Government Regulation of the Republic of Indonesia Number 79 of 2014 concerning National Energy Policy describes a condition of guaranteed energy availability and public access to energy at affordable prices in the long term while still paying attention to the environment. According to the National Energy Council (Dewan Energi Nasional, 2019). National Energy Security has assessment criteria that can be measured from indicators related to 4A, namely Availability, Accessibility, Affordability, and Acceptability. According to the World Energy Council (WEC) and the Asia Pacific Energy Research Center (APERC), indicators of energy security in a region or country can be seen from the perspective of Availability, Accessibility, Acceptability, Affordability. and meet the Sustainability criteria. This is in line with what was conveyed by Yusgiantoro (2016), in

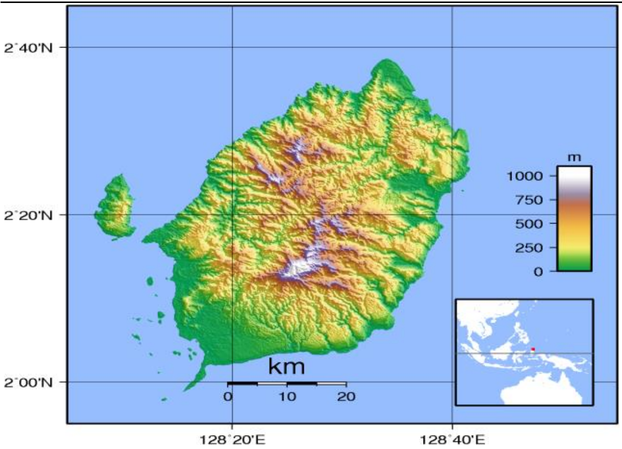

Figure 6. Pulau Morotai Regency Map
Source: BPS, 2019

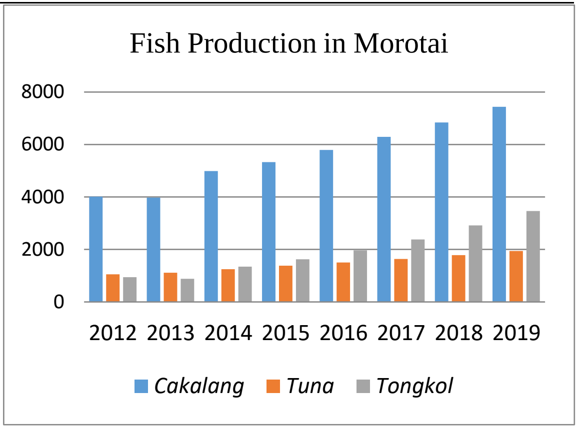

Figure 7. Capture fisheries production in Morotai
Source: KKP, 2019

determining the indicators of National Energy Security, one more parameter is needed, namely Sustainability.

Pulau Morotai Regency

Geographically, Pulau Morotai Regency is located between 2^{o}00’ North Latitude and 2^{o}40’ North Latitude and between 128^{o}15’ East Longitude and 129^{o}08’ East Longitude. Based on its geographical position, Pulau Morotai Regency has the following boundaries: North-Pacific Ocean; South-Morotai Strait; West-East Halmahera Sea-the Halmahera Sea. Pulau Morotai Regency consists of six districts (see Figure 6), namely:

a. Morotai Selatan has its capital in Daruba
b. Morotai Timur has its capital in Sangowo
c. Morotai Selatan Barat has its capital in Wayabula
d. Morotai Utara has capital in Bere-bere
e. Morotai Jaya has capital in Sopi
f. Pulau Rao has its capital in Dusun Leo-Leo

The livelihoods of the population are mostly in the fields of agriculture and fisheries. This can be seen from the Gross Regional Domestic Income (PDRB) of Morotai Island Regency between 2018 where Agriculture, Forestry, and Fisheries contributed the largest income, namely 46% with a value of Rp. 454 billion (per 2010), and increased slightly in 2019 to Rp. 458 billion, although the percentage decreased to 44% of the total GRDP (KKP, 2018). The fisheries and tourism sectors in this regency are still underdeveloped. The appointment of the status of Morotai Island Regency to the Special Economic Zone for tourism is expected to increase investment in this area and it is hoped that it can open job vacancies, increase regional income, and community welfare. To support this program, local governments must also improve the quality of human resources.

Currently, Pulau Morotai Regency only has 1 unit of Integrated Cold Storage (ICS) with a capacity of 200 tons which is operated by PT Harta Samudra. In 2018, the annual fishing capacity reached 253.78 tons (KKP, 2018), and in 2019 it reached 725.45 tons, where the highest utilization was in March 2019 which reached 189.96 tons (KKP, 2020). In general, it can be said that the capacity of the ICS in March 2019 was completely used, although in other months fishing was slightly reduced. Morotai Island, which is located in the Fishing Catching Area (WPP) 715, 716, and 717, has the potential for fishing to reach 1,714,158 tons per year.

The potential for fish in the three WPPs located on Morotai is 1,714,158 tons/year, consisting of 631,704 tons/year of WPP 715, 478,766 tons/year of WPP 716 and 603,688 tons/year of FMA 717. From the potential of the three WPP, it is estimated that around 5% of the existing potential will be landed on Morotai Island, which is as much as 85,707.9 tons/year with a Maximum Sustainable Yield (MSY) of 68,566 tons/year. Taking into account the potential for fishing that is still quite large, this is an opportunity for the development of the fisheries sector, which is of course not only from increasing fishing but also from providing supporting facilities.

With the existing fish production on Morotai of 6,272 tons/year, which only about 9.15% of its potential is utilized (see fig. 7), there is still a lot of fishery potential that can be developed. So that there is still potential for as much as 62,294 tons/year which has not been utilized. To take advantage of this potential, it is necessary to increase the fishing vessel fleet with a capacity of 30 GT as many as 252 units of ships or 60 GT vessels totaling 84 units of ships or ships 100 GT totaling 47 vessels. To process 62,294 tons of fish/year, investment is still needed in the field of fish processing units consisting of 2,656 tons of cold storage, 177 units of Air Blast Freezer (ABF) with a capacity of 5 tons, and an ice factory with a capacity of 227 tons/day.

Morotai is very strategic to be developed into one of the locations for the development of the Integrated Marine and Fisheries Center (SKPT) in Eastern Indonesia. The data for the last 3 years shows that the capture fisheries sector is more likely to be increased in the next 1 - 3 years. The government itself is targeting a significant increase in the amount of production and export value of capture fisheries nationally, including through the PSKPT program implemented in Pulau Morotai Regency. Of the five districts in Morotai, Morotai Selatan, fishery production tends to increase higher than in other districts because the only Integrated Cold Storage in Morotai is located in Morotai Selatan District.

So, it can be concluded that apart from the fact that Morotai is known as the area of the tuna migration route, Morotai Regency is also located on the border of the Indonesia-Philippine. So, considering its location, it can make it easier for this district to be developed as a hub for international trade in Eastern Indonesia and also has great potential to become the main source of raw materials for the fisheries processing industry in Eastern Indonesia.

RESULTS AND DISCUSSION

The main power source in Pulau Morotai Regency is PLTD Sopi, which operates 24 hours a day with a voltage of 1x500 Kw (Fauzi, 2018), and is supplied by PLTS Morotai, which has a capacity of 600 Kwp (Ridwan, 2020). However, due to this limited power, electricity is still primarily used to meet the electrification ratio on Morotai Island and has not been built to be optimally used by the industrial sector. Under the Regulation of the Director-General of Strengthening the Competitiveness of Marine and Fishery Products, Number 18/PER-DJPDSPKP/ 2017 concerning Technical Guidelines for Government Assistance Management for Cold Storage Development 2017, it can be calculated that 1 Cold Storage unit with a capacity of 100 tons will require 7 kVa for 24 hours. Therefore, the existing cold storage in Morotai which has a capacity of 200 tons will require 14 kVa of electricity.

In this study, there are three alternatives, first, cold storage using electricity from PLN, second, cold storage using a hybrid system (on-grid) assuming the use of electricity from solar panels for 6 hours, and third, cold storage using electricity from solar panel network (off-grid). Cold Storage can be classified into industrial types. Cold storage in Morotai with a capacity of 200 tons requires a voltage of 14 kVa, so it is included in the class of PLN customers type I-1 / TR with a tariff per 2021 of Rp. 960 per kWh. The type of solar panel used in this study is a solar panel with a usage life of 20 years with a capacity of 50 per watt peak which has a power factor of 80% has the lowest market price in Indonesia per 2021 of IDR 300,000 per panel. While the type of battery used is the valve-regulated lead-acid (VRLA) type with a capacity of 48v 100ah with a capacity factor of 80%, which per 2021 has the lowest price of IDR 8,000,000 per unit.

In this study, six criteria will determine the score for each alternative. If sorted by importance or urgency, the criteria are total costs for 20 years, electricity bill per year, Opex, and Capex. Furthermore, each of these criteria will be calculated based on their needs so that later they can be displayed in the table for further analysis using a decision matrix.

Solar Power Plant or *Pembangkit Listrik Tenaga Surya* (PLTS)

Cold Storage with a capacity of 200 tons requires electricity of 14 kVa or 336 kWh per day. With these needs, the number of solar panels needed by cold storage is:

$$number\ of\ pv = \frac{\frac{electricity}{hours}}{\frac{Pv\ Capacity}{Capacity\ factor}}$$

$$number\ of\ pv = \frac{\frac{336.000\ watts}{6\ hours}}{\frac{50\ watt\ per\ peak}{80\%}}$$

$$number\ of\ pv = 56.000\ Wp/40\ Wp$$

$$number\ of\ pv = 1400\ units$$

Meanwhile, the required number of batteries is:

$$number\ of\ batteries = \frac{electricity}{battery\ capacity * cf}$$

$$number\ of\ batteries = \frac{336.000\ watts}{48v * 100ah * 80\%}$$

$$number\ of\ batteries = \frac{336.000\ watts}{3840\ watts}$$

$$number\ of\ batteries = 87{,}5\ or\ 88\ units$$

So that the number of capex issued is equal to:

$$CapEx = cost\ of\ pv + cost\ of\ batteries$$

$$CapEx = 1400 * 300.000 + 88 * 8.000.000$$

$$CapEx = Rp\ 1.124.000.000$$

Then the Opex costs that must be spent to maintain the solar panel network and replace a damaged battery use the assumption of 0.5% per month or 3% per year of capex. Then the calculation of the opex per year is:

$$OpEx = CapEx * 3\%$$

$$OpEx = 1.124.000.000 * 3\%$$

$$OpEx = Rp\ 33.720.000$$

Meanwhile, the cost of electricity bills per year is Rp. 0 because the electricity in this alternative comes entirely from solar panels. So that the costs incurred for 20 years from this alternative are:

$$Total = CapEx + ((OpEx + Bill) * 20\ y)$$

$$Total = Rp\ 1.798.400.000$$

Hybrid Calculation

The hybrid system is a system that uses electricity from solar panels and PLN. In a hybrid system, cold storage will use electricity generated by solar panels with an assumption of 6 hours of usage. So that the required number of solar panels is:

$$a\ number\ of\ pv = \frac{\frac{electricity}{hours}}{\frac{Pv\ Capacity}{Capacity\ factor}}$$

$$number\ of\ pv = \frac{\frac{84.000\ watts}{6\ hours}}{\frac{50\ Wp}{80\%}}$$

$$number\ of\ pv = \frac{14.000\ Wp}{40Wp}$$

$$number\ of\ pv = 350\ units$$

So that the required number of batteries is equal to:

$$number\ of\ batteries = \frac{electricity}{battery\ capacity * cf}$$

$$number\ of\ batteries = \frac{84.000\ watts}{48v * 100ah * 80\%}$$

$$number\ of\ batteries = \frac{84.000\ watts}{3840\ watts}$$

$$number\ of\ batteries = 21{,}8\ or\ 22\ units$$

Then the amount of Capex needed by the hybrid network is equal to:

$$CapEx = cost\ of\ pv + cost\ of\ batteries$$

$$CapEx = 350 * 300.000 + 22 * 8.000.000$$

$$CapEx = Rp\ 281.000.000$$

Opex cost per year incurred by this alternative is:

$$OpEx = CapEx * 3\%$$

$$OpEx = 281.000.000 * 3\%$$

$$OpEx = Rp\ 8.430.000$$

Table 1. Calculation Results

Criteria	**Alternatives**		
	PLTS	Hybrid	PLN
Total costs for 20 years	1.798.400.000	2.215.616.000	2.354.688.000
Annual Electricity Bills	0	88.300.800	117.734.400
OpEx	33.720.000	8.430.000	0
CapEx	1.124.000.000	281.000.000	0

Source: Processed by Author, 2020

Table 2. Decision Matrix

Criteria	**Value**	**Alternatives**					
		PLTS		Hybrid		PLN	
		Sc	Tl	Sc	Tl	Sc	Tl
Total costs for 20 years	4	5	20	3	12	1	4
Annual Electricity Bills	3	5	15	3	9	1	3
Opex	2	1	2	3	6	5	10
Capex	1	1	1	3	3	5	5
Final Score		38		30		22	

Sc: score
Tl: total
Source: Processed by Author, 2020

The cost of annual electricity bills incurred by this cold storage with a usage period of 18 hours is:

$Bill = (Usage * 365) * tariffs$
$Bill = (252\ kWh * 365) * Rp\ 960$
$Bill = 91.980\ Kw * Rp\ 960$
$Bill = Rp\ 88.300.800$

So, the total costs incurred by the hybrid system for 20 years is:

$Total = CapEx + ((OpEx + Bill) * 20\ y)$
$Total = Rp\ 2.215.616.000$

State Electricity Company or *Perusahaan Listrik Negara* (PLN) Calculation

Cold Storage in this alternative uses a business-as-usual scenario so that the cost calculation is only on the electricity bill each month. Therefore, the electricity costs incurred by cold storage for a year are:

$Bill = (Usage * 365) * tariffs$
$Bill = (336\ kWh * 365) * Rp\ 960$
$Bill = 122.640\ kW * Rp\ 960$
$Bill = Rp\ 117.734.400$

So that the costs incurred by cold storage for 20 years with this system are:

$Total = Bill * 20years$
$Total = Rp\ 2.354.688.000$

The entire calculation results are then presented in the table to facilitate the calculation of the decision matrix at a later stage (see table 1). When the overall cost criteria for 20 years are considered, the option using photovoltaic is much superior, with the lowest cost of Rp. 1,798,400,000. In terms of annual electricity costs, photovoltaic is superior once again because the electricity is generated entirely from solar energy. In terms of OpEx and CapEx, the PLN option is much superior since it makes use of an existing network, eliminating the need for additional costs for new equipment or maintenance.

Decision Matrix Table

After the calculation of each alternative has been carried out. Then the results are distributed into a decision matrix table based on the order of the most important to the least important criteria in determining the final result. The criteria with the best value will get a value of 5, while the criteria with the worst score will get a value of 1, and those in between will get a value of 3. All of these results will be added up so that the alternative with the most optimal results is obtained.

Looking at the calculation results in the decision matrix table (see Table 2), it can be concluded that cold storage with a full network of solar panels in the long term requires the lowest cost even though the costs incurred at the beginning are much higher than the hybrid network.

CONCLUSION, RECOMMENDATION, AND LIMITATION

Conclusion

Pulau Morotai Regency as a district included in the Special Economic Zone development plan has many economic potentials, such as fisheries, tourism, and agriculture. Fishery as one of the potentials in Morotai has not been fully developed, until now there is only one cold storage as supporting infrastructure for fisheries. The high maintenance costs, especially in the utility sector, have made few investors interested in building cold storage in Morotai. This research was made to see what types of energy sources can efficiently reduce the costs of cold storage in a span of 20 years. Using the decision matrix analysis method, the researcher compared several scenarios and variables. The results of the decision matrix calculation show that the cold storage scenario that uses solar power as the main source of electricity shows the best results compared to cold storage that uses electricity from PLN, or that uses a hybrid system. This is indicated by the final result of the decision matrix of photovoltaic alternatives with a score of 38.

Recommendation

Cold storage with a grid full of solar power has proven to be the best scenario so this research can be a reference for investors to be able to build more cold storage in Morotai to support government programs in developing Special Economic Zones there. This study suggests the calculation of cost-benefit analysis in further research to see further the relationship between income from cold storage and costs incurred in 20 years.

Limitation

This research is only limited to calculating the cost of the existing cold storage in Morotai which has a capacity of 200 tons. This study does not calculate in more detail the relationship between the benefits and costs of applying solar power to cold storage. This study was carried out between August and November 2020, with direct observation of PT. Harta Samudera's cold storage in Pulau Morotai.

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