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The Decision of the Most Feasible Power Plant in Underdeveloped, Remote and Outermost (3T) Region by Decision Matrix Analysis: Case Study of Pasi Island

[1]Donny Yoesgiantoro

ABSTRACT--*Underdeveloped, remote and outermost regions (3T) are regions that have a very low index of human development and infrastructure. One of the main factors in the development of the 3T regions is the fulfillment of the needs and potential demands of energy. The author determines three alternative power plants that can be built in the regions with low cost, able to be constructed in a short time, and do not require to be connected to the PLN's lines. The three alternative plants are PLTD, PLTS and also ESS batteries. The areas used as case studies are three (3) villages in Pasi Island, South Sulawesi Province. The analytical method used is a decision matrix analysis with primary data from questionnaires and mathematical calculations while secondary data from the literature review. The results indicated that battery ESS is the most optimal and cost-efficient choice as a power plant on Pasi Island.*

Keywords--*decision, matrix, renewable, battery, energy*

I. INTRODUCTION

Underdeveloped, frontier and outermost (3T) regions became the focus of development in the administration era of President Jokowi's administration, a very massive development was carried out to prosper the 3T region, especially those bordering directly with other countries. This is because the 3T region bordering other countries is the frontline of Indonesia's national defense and also has the potential to be a gateway for economic flows. In general, the 3T region can be defined as an area that has a low level of economic growth and a human development index (HDI) and is accompanied by a lack of facilities and infrastructure to support socio- economic activities, so it is directly proportional to the low socio-economic indicators compared to other regions in Indonesia (Bratakusumah, 2006).

Of course, in line with the definition above, one of the solutions in improving the welfare of the 3T region is to build its facilities so that gradually the socio-economic level can

increase, as well as its HDI. One of the facilities which is very vital to be able to support it all is the availability of reliable electric power so that socio-economic activities can run optimally, such as teaching and learning activities, business administration to local government.

[1] *Departmen of Energy Security of Indonesia Defence University, Bogor, Indonesia, energyprogram@gmail.com*.

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Fulfillment of electrification ratios in the 3T region certainly also has an impact on increasing the national electrification ratio which is being worked on to 100% by 2020, according to what is mandated by the National Energy General Plan (RUEN) (Indonesia, 2017). Every effort to fulfill the optimal and fast electrification must be done to be able to meet the electrification ratio of 100%, of course also by considering the possibility of using renewable energy (EBT) as the main choice.

The use of EBT is also expected to increase the amount of energy mix from the EBT sector which is still very low, while the RUEN mandates that the energy mix for 2025 consists of EBT by 23%, petroleum by 25%, coal by 30% and natural gas by 22%. Until now the installed capacity in 2018 is 9,471 MW (IRENA, 2019) consisting of 5,548 MW of hydropower, 76 MW of wind power, 60 MW of solar power, 1,841 bioenergy power, 1,946 geothermal power. In 2019 it is planned that an EBT plant of 560 MW (PLN) will be operational, consisting of 154 MW PLTA, 5 MW biogas power plant, 5 MW biomass power plant, PLTM 140 MW, PLTM 190 MW, PLTS 58 MW, PLTS / H 6 MW, and PLTSa 2 MW.

II. LITERATURE REVIEW

In this study, the authors use the theory of decision matrix analysis which is also supported by data on the Kepulauan Selayar district and Pasi Island itself. In general, the electrification ratio of the Kepulauan Selayar Regency is 68.46% so that there are still 31.54% of the population in the Kepulauan Selayar Regency which has not been electrified. One area in the Kepulauan Selayar Regency that has not yet been electrified optimally is three (3) villages located on Pasi Island. Geographically, Pasi Island is located in the southernmost part of South Sulawesi Province, precisely in the Java Sea. As of 2010, the population in three (3) villages on Pasi Island was 4454 inhabitants and reached 4747 inhabitants per 2019 (ESDM, 2017). Existing capacity (DM) on Pasi Island is 235 KW with peak loads and reserves of 116 KW and 119 KW, respectively. However, with the available capacity, PLN can only operate for a maximum of six (6) hours.

Decision Matrix Analysis is a medium used in the policymaking process which can be used in various types of industries and government. The main purpose of this analysis is to include the contribution of all the factors and variables involved in determining the policy and then quantified and ranked and then tabulated in the form of a matrix (Olli, Jaakko, Kalle & Jukka, 2014; Colwell, Friedmann & Carmichael, 2000). The decision matrix is used to facilitate the 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 includes a wide range of variables, factors, and problems is very important for the effective and optimal implementation of the decision matrix, in addition to supporting the process of policy and decision making, it can also provide early warning for relevant stakeholders (Al-Tekreeti & Beheiry, 2016).

One of the strengths of the decision matrix analysis is how this analysis can optimize limited resources such as funds, not only by helping to determine the best and optimal choices but also managing the portfolio for projects or related 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 objectives of decision-makers (Nicholls, 1995). Other advantages of the decision matrix such as 1) ease of application; 2) reliable results; 3) can provide an initial description of the flaw of each choice; 4) can be applied in many forms of organization and company; 5) quantitative so it is easier to display graphically (Dominguez, Martinez, Pena & Ochoa, 2019).

III. RESEARCH METHODS

Primary data is obtained using two stages, first a questionnaire and second a mathematical calculation. In the first stage, the questionnaire was spread with a population of 10 people who were experts in the energy sector. Then in the second stage, the variables are searched for by using consistent assumptions in each alternative so that a balanced calculation is obtained. While secondary data obtained from journal sources, reports, regulations, previous research and other written sources. These data are then sorted so that optimal results are obtained following the needs of this study. Secondary data is also used as a support in the search for primary data, both in terms of making questionnaires and in the analysis.

Table 1: Questionnaire form to rank variables in building power plants

Variables that are considered in the construction of power plants										
1	Capital Expenditure									
Ranking	1	2	3	4	5	6	7	8	9	10
2	Operational Expenditure									
Ranking	1	2	3	4	5	6	7	8	9	10
3	Operators									
Ranking	1	2	3	4	5	6	7	8	9	10
4	Land usage									
Ranking	1	2	3	4	5	6	7	8	9	10
5	BPP (biaya pokok penyediaan) or electricity generation costs									
Ranking	1	2	3	4	5	6	7	8	9	10
6	Loans, interests, & tranche									
Ranking	1	2	3	4	5	6	7	8	9	10
7	Externality									
Ranking	1	2	3	4	5	6	7	8	9	10
8	Lifecycle									
Ranking	1	2	3	4	5	6	7	8	9	10
9	Annual electricity production									
Ranking	1	2	3	4	5	6	7	8	9	10
10	Fuel costs									
Ranking	1	2	3	4	5	6	7	8	9	10

The questionnaire consists of ten variables in the form of tables with each question having a ranking column that can be answered by giving a cross or a checkmark (see table 1). These variables influence the consideration of power plant development, especially in the 3T region. The ranking of each variable is based on factors such as 1) objectives; 2) alternative; 3) details of each alternative; 4) results; and 5) consequences. Those variables consist of capital expenditure (CapEx); operational expenditure (OpEx); operators; land usage; electricity generating cost; loans, interests and tranche; externalities; life cycle; annual power production; and fuel costs.

In the decision matrix, variables are analyzed systematically (Rotarescu, 2010) based on 1) objectives; 2) alternatives; 3) details of each alternative; 4) results; and 5) consequences. Furthermore, the alternatives are given a ranking based on preferences (Hasan, Jain & Kumar, 2013) and interests above, then given a score by the speakers or by experts and researchers. The results are then calculated so that the best results are obtained as the first choice (Zhang & Xiu, 2018). The decision matrix quantitatively identifies the trade-offs for each alternative and then consistently compares the various objectives. The quantification of these alternatives also provides insight into the trade-off between each of these conflicting alternatives (Kailiponi, 2010).

The alternatives considered as optimal power plants for 3T areas are three (3) types, namely diesel power plants (PLTD), solar power plants (PLTS) and energy storage systems of dry battery type (battery ESS). A diesel power plant is a power plant that utilizes mechanical energy generated so that it can move a turbine rotor (Eryadi, Putra & Endayani, 2016), while a solar power plant is a power plant that utilizes solar radiation which is then converted into electricity, this phenomenon is known as photovoltaic so that PLTS in general also known as a photovoltaic power plant (Zhang et al, 2019).

The energy storage system (ESS) is a large-scale energy storage system and is usually integrated into the EBT power generation system. This is due to the intermittent nature of the EBT generator so that ESS is used to store excess energy when energy production reaches its peak but with a low load, then channeling stored energy when production is low but the load is peaking (Funabashi, 2016).

The level of reliability, the magnitude of the ESS system and the cost of procurement depends on the form of energy stored, such as electromagnetic energy, heat or thermal, kinetic, potential, chemical and so on (Nakovic & Nasiri, 2015). ESS has many types and types, such as electric double-layer capacitors (EDLC), ESS batteries, superconducting magnetic energy storage (SMES), plug-in electric vehicles (PEV), flywheels, and so on. In general, ESS batteries are dry batteries that do not produce waste or pollution and can be charged and discharged many times with different age ranges (Breeze, 2018).

IV. FINDINGS AND DISCUSSION

Pasi Island with a population of 4747 inhabitants can be assumed to consist of 1356 households with three to four members per family. If you take the standard middle-level PLN customer with a capacity of 1300 Watt with a maximum voltage load per day of 50%, it can be assumed that electricity demand per year on Pasi Island is around 7,721,064 kWh / year.

Considering the existing trade-offs, we get ten (10) variables which are assumed to have a trade-off value that influences the consideration of power plant construction. The ten (10) variables consist of

- Capital expenditure
- Operational expenditure
- Number of operators
- Land use
- BPP value used

- The amount of the loan, interest, and installments provided
- Impact on the environment and social (externality values)
- Lifecycle of a generator or generator
- Annual electricity production
- Fuel costs

The ten (10) variables above will then be ranked to facilitate the calculation of the final value. The next stage is determining the value of each variable so that it can be ranked so that it makes the calculation process easier. The data search method used is a questionnaire with a population of experts in the energy sector with a population of 10 experts.

The results of the questionnaire from ten informants were distributed into a table and then added together the results of each variable (see table 2). The summation results can then provide a direct description of the level of each variable based on input from the resource person. The variable with the highest value is a CapEx with a total score of 78, followed by an OpEx variable with a score of 73, in the third with a score of 69 is the variable BPP or electricity generation costs.

Table 2: Ranking Data for Each Variables

	Variables	**Score**	**Ranking**
1	Capital Expenditure	78	First
2	Operational Expenditure	73	Second
3	BPP (biaya pokok penyediaan) or electricity generation costs	69	Third
4	Fuel costs	64	Fourth
5	Lifecycle	55	Fifth
6	Annual electricity production	48	Sixth
7	Loans, interests, & tranche	45	Seventh
8	Operators	44	Eighth
9	Land usage	42	Ninth
10	Externality	35	Tenth

Fourth rank, fuel costs with a score of 64 while ranked fifth, the life-cycle of the generator with a score of 55. Furthermore, in the sixth rank the annual electricity production variable with a value of 48 and the seventh rank of the loan variable with a value of 45. The eighth rank, the number of daily operators with score 44. In the ninth and tenth rank, land use and externalities with a score of 42 and 35.

Mathematicl Calculation Capital Expenditure

CapEx is all expenditures incurred at the beginning both for the expense of building construction to the procurement of generators and its complement, and the calculation of CapEx using the formula (1)

CapEx = Cplant x Splant x CCplant x Skurs

Cplant = generating capacity Splant = generator quantity Ccplant = construction costs Skurs = exchange rate

The power demand of Pasi Island are 7,721,064 kWh/year, so it can be assumed that to meet this demand, a diesel generator (PLTD) with a capacity of 1200 kW is needed with a total of 1 unit, while in PLTS, 5400 kWp solar panels are needed and for ESS batteries, 10 units of battery with a capacity of 100 kW are needed.

Ascertainment of the amount of capacity and units of the three plants above is based on the amount of demand and also mitigation measures in case of a surge in needs and other possibilities. The cost of procuring PLTD generators is USD 700/kW USD 900/kWp and battery ESS per unit is USD 900. The exchange rate used is Rp 14,200/USD, so by utilizing formula (1), the CapEx of PLTD is Rp 11,928,000,000, PLTS is Rp 69,012,000,000 and ESS batteries is Rp 12,780,000,000 (see table 3).

Table 3: CapEx Calculation

CapEx				
Power Plant	Cplant	Splant	CCplant	Skurs
PLTD	1200kw	1	USD 700	
	Total	IDR 11.928.000.000		
PLTS	5400kwp	1	USD 900	IDR 14.200
	Total	IDR 69.012.000.000		
Battery ESS	100kw	10	USD 900	
	Total	IDR 12.780.000.000		

Operational Expenditure

OpEx consists of all expenses incurred in the context of operation and maintenance for a full year. Formula (2) is used to calculate OpEx

OpEx = O + T+ W + M (2)

O = overhead

T = transport

W = wages

M = maintenance

Overhead costs can be assumed at 5% of the total cost of each CapEx for each plant. Then the transportation costs are costs incurred for the refueling process both refueling trucks and the costs of crossing from the main island to the island of Pasi. Salary costs are the costs of the total number of workers times in salaries per year. Similar to overhead costs, maintenance costs are an assumption of 5% of the CapEx cost of each plant. So, if using formula (2), the OpEx in PLTD is IDR 4,675,429,738, PLTS is IDR 1,719,857,520 and ESS battery is IDR 3,654,211,680 (see table 4)

Table 4: OpEx Calculation

	OpEx			
Power Plant	**O**	**T**	**W**	**M**
PLTD	IDR 59.640.000	IDR 44.400.000	IDR 1.716.229.200	IDR 59.640.000
	Total	IDR 1.879.909.200		
PLTS	IDR 345.060.000	-	IDR 1.029.737.520	IDR 345.060.000
	Total	IDR 1.719.857.520		
Battery ESS	IDR 63.900.000	IDR 44.400.000	IDR 686.491.680	IDR 63.900.000
	Total	IDR 858.691.680		

The Operator

The operator is the number of workers needed to operate the plant for 24 hours and is divided into several work shifts. The number of operators of each power plant is influenced by several factors, such as the area of the power plant; the difficulty level of the operation; and also maintenance. For example, PLTS with large areas but requires fewer workers than PLTD which have fewer areas, this is because the operation and maintenance of PLTS are very minimum so that the number of workers needed is less (see table 5).

Table 5: the Amount of Operators

	The Operator		
Power Plant	1st Shift	2nd Shift	Administration
PLTD	22	22	8
PLTS	12	12	6
Battery ESS	6	6	4

Land Use

Land use is the area of land used as the location of a power plant (see table 6). This land use includes the generator area, operator's office, maintenance department and substation connecting to the PLN electricity grid. In PLTS, if a 350 Wp photovoltaic panel is used to make solar farm then around 15,430 panels are needed. a 350 Wp photovoltaic panel has a size of 1m x 2m, assuming the path between each panel takes up 25% of the width of the panel. So to calculate the land-use on solar power plants can use the formula (3)

$$Lregion = Lpv + Lspace \quad (3)$$

Lregion = region width Lpv = panel width Lpath = path width

Table 6: The Width of Each Power Plant

Land Use	
Power Plant	Width
PLTD	1.200 m^2
PLTS	38.571 m^2
Battery ESS	675 m^2

Power Sales Tariff

The power sales tariff used is the one by the Ministerial Decree of the Ministry of Energy and Mineral Resources in 2019 regarding the amount of the BPP tariff for the Kepulauan Selayar Regency (ESDM, 2019). Fossil power plants get the full payment or 100% of the applicable tariff BPP, whereas for Renewable Energy, the maximum payout percentage of 85% of the applicable tariff BPP. An exception is applied to solar energy, this renewable energy gets full payment or 100% of the BPP tariff just like fossil energy (see table 7).

Table 7: Power Sales Tariff

BPP Tariff		
Power Plant	Rate Percentage	Net Tariff
PLTD	100%	IDR 2.445
PLTS	100%	IDR 2.445
Battery ESS	85%	IDR 2.078,25

Loans, interests, & tranche

The loan amount, interest, and tranche follow the amount of CapEx of each power plant. So that the installment of the loan of each power plant also varies. The repayment period and loan interest in all three types of power plants have the same value. The repayment period is 20 years with a 10% interest (See table 8).

Table 8: the Amount of Loans, interests, & tranche

Loans				
Power Plant	Loan	Period	Interest	Annual Instalment
PLTD	IDR 12.000.000.000	20 years	10%	IDR 600.000.000
PLTS	IDR 69.500.000.000			IDR 3.475.000.000
Battery ESS	IDR 13.000.000.000			IDR 650.000.000

The Externality

The externality is the estimated impact caused by the operation of the power plant on the surrounding environment which is quantified in monetary form. The impact can be either negative or positive externalities, but this study only includes negative externalities. PLTD become the only power plant that generate externality (see table 9) as much IDR 21,215 per kWh (Tampubolon, Fauzi & Ekayani, 2015).

Table 9: Negative Externality

the Externality	
Power Plant	The Externality
PLTD	IDR 21,215/kWh
PLTS	-

Life Cycle

Life-cycle is the optimal period of operation of the power plant until the time of replacement with a new unit or other type of generator (see table 10). the difference between the life cycle each of the power plants is influenced by many factors, such as the level of technological progress; manufacturing company; quality and quantity of maintenance; voltage capacity and also the type of fuel. The life-cycle of each power plant starts from 25 years to

54.7 years (Incorporated, 2018).

Table 10: Power Plant Life Cycle

Life Cycle	
Power Plant	Life Cycle
PLTD	30 years
PLTS	25 years
Battery ESS	54,7 years

Annual Power Generation

Annual power generation is the total electricity production produced by the power plant during one year of operation which is sold directly to PLN. The amount of annual electricity production can be calculated using the formula (4)

Selectric = Cplant x Splant x Cfactor x 8760 hour(4) Selectric = annual power generation

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Cplant = generator capacity Splant = generator quantity Cfactor = *capacity factor*

the capacity of each power plant is adjusted to the needs on Pasi Island at 7,721,064 kWh / year. PLTD requires a diesel generator with a capacity of 1200 kW, PLTS with a photovoltaic farm with a capacity of 5400 kWp and Battery ESS with a capacity of 1000 kW consisting of 10 units of batteries with a capacity of 100 kW (see table 11). This capacity is also influenced by the capacity factor of each power plant which also varies. In PLTS, the calculation of the amount of electricity generated each year uses a modified version of formula (4). Formula (5) is influenced by the fact that the quality of the sunlight in Indonesia can generate a total of 4 hours of power equivalent kWp installed

Selectric = Cplant x Splant x 4 hours x 365 days (5)

Table 11: Electricity Generated per Annum

Annual Power Generation				
Power Plant	Cplant	Splant	Cfactor	Hours
PLTD	1200 kW	1	85%	8760
	Total		3.935.200 kWh/year	
PLTS	1 kWp	5400	**-**	1460
	Total		7.884.000 kWh/year	
Battery ESS	100 kW	10	100%	8760

Fuel Costs

Fuel is the total cost incurred each year for the procurement of fuel to support the continuous operation of the plant. The calculation of total fuel, in general, has the formula (6). PLTS does not require the cost of fuel so the cost is eliminated. In the PLTD, fuel costs are the cost of purchasing diesel fuel of Pertamina dex type at a cost of IDR 6,977 per kWh, while in battery ESS, fuel costs are the cost of charging at the charging depot at a cost of IDR 1,115 per kWh (see table 12).

Sfuel = Selectric x F (6)

Sfuel = Total expenditure on fuel costs for a year Selectric = Total annual electricity production

F = Fuel cost per kWh

Because PLTD generator engines have different fuel consumption, the formula (6) is modified by adding a variable specific fuel consumption (SFC) to the formula (7)

Sfuel = Selectric x F x SFC (7)

Table 12: The Cost Incurred per Annum for Fuel/Charging

Fuel Costs			
Power Plant	Selectric	F	SFC
PLTD	8.935.200 kW	IDR 6.977	0,275
	Total	IDR 17.143.744.860	
PLTS	-	-	-
	Total	-	
Battery ESS	8.760.000 kW	IDR 1.115	-
	Total	IDR 44.400.000	

Decision Matrix Table

The variables that have been ranked through questionnaires are then sorted into a decision matrix table (see table 13). These variables are then given a value, with the first rank getting a value of 10 and the tenth rank having a value of 1. All the variables that have been calculated above are then distributed into the decision matrix table. This table will be used as a comparison table which will further determine the level of each generator on existing variables.

Table 13: the Result of All Mathematical Calculation

				All Variables			
No	Variable	PLTD 1x1200kw		PLTS 5400kwp		*Battery ESS* 10x100kw	
1	*Capex*	11.928.000.000	Rp	69.012.000.000	Rp	12.780.000.000	Rp/yr
2	*Opex*	1.879.909.200	Rp/yr	1.719.857.520	Rp/yr	858.691.680	Rp/yr
3	Operators	50	people	30	people	20	people
4	Land Use	1.200	m^2	38.571	m^2	675	m^2
5	BPP Tariff	2445	Rp/KWh	2445	Rp/KWh	2078,25	Rp/KWh
6	Loan	12.000.000.000	Rp	69.500.000.000	Rp	13.000.000.000	Rp
7	Eksternality	21,215	Rp/KWh	0	Rp/KWh	0	Rp/KWh
8	*Life-cycle*	30	Yr	25	Yr	54,7	Yr
9	Power Generation	8.935.200	KWh/yr	7.884.000	KWh/yr	8.760.000	KWh/yr

Furthermore, the three types of plants in the decision matrix table are compared between each variable. Each generator with the best value gets a score of 5, the middle value gets a score of 3 and the lowest value with a score of 1. If there are similar values between the two types of plants in a variable, then both of them get the same value.

For example, generators A and B both have a value of 10 and the value of 10 is the best for that variable, then both generators get a value of 5 for that variable.

Table 14: Decision Matrix Table

No	**Criteria**	**Weighting**	**Power Plant Alternatives**					
			PLTD		PLTS		Battery ESS	
			Score	Total	Score	Total	Score	Total
1	CapEx	10	5	50	1	10	3	30
2	OpEx	9	1	9	3	27	5	45
3	BPP tariff	8	5	40	5	40	1	8
4	Fuel costs	7	1	7	5	35	3	21
5	Lifecycle	6	3	18	1	6	5	30
6	Power Generation	5	5	25	1	5	3	15
7	Loans	4	5	20	1	4	3	12
8	Operators	3	1	3	3	9	5	15
9	Land usage	2	3	6	1	2	5	10
10	Externality	1	1	1	5	5	5	5
			Total	179	Total	143	Total	191

Based on the results of the questionnaire and mathematical calculations for each variable, the results in the decision matrix table (see table 14) exhibit that battery ESS is far superior to PLTD or PLTS. This is indicated by variables number two, five, eight, nine and ten where ESS batteries have an absolute advantage. In variable number two, the operational costs of the battery ESS of Rp. 885,691,680 are superior to the OpEx costs of the PLTD and PLTS both of which reach figures above 1.5 billion rupiahs. In the fifth variable, the life-cycle of an ESS battery is also superior to other generators, which on average are only half the life span of an ESS battery.

In the eighth variable, with only twenty operators, the costs incurred from the personnel expenditure sector are also greatly reduced. This is because the operation of the ESS battery itself does not require workers with special expertise and can be operated with a minimum number of workers. The minimalist and modular form of ESS batteries also has itsadvantages so that large land uses are not required. This makes the best position in the ninth variable also achieved by ESS batteries. In the last variable, one of the advantages of ESS battery which is a dry battery type is very environmentally friendly and does not produce hazardous waste. So that the operation of this type of plant does not provide a negative externality value for the environment and surrounding communities

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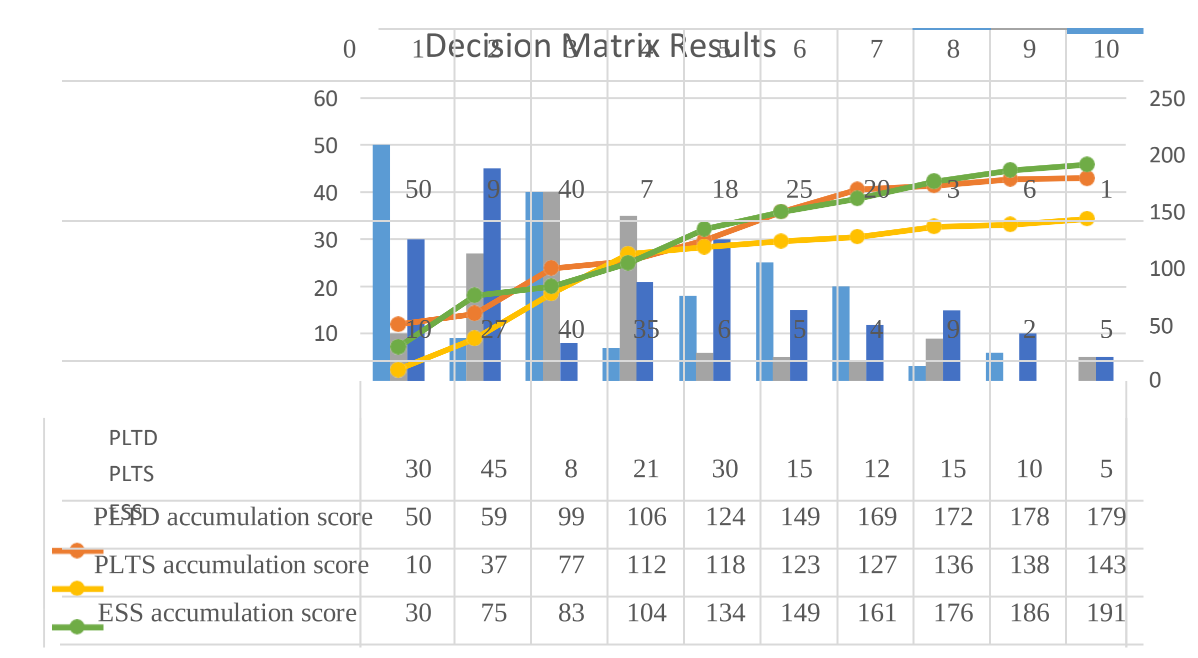

Figure 1: Graphic of Decision Matrix Results

In addition to the above advantages, there are also four variables of battery ESS that are in the middle or we can conclude as mediocre variables or variables that are not bad or not superior (see picture 1). The four variables are variables number one, four, six, and seven. In the first variable, the amount of capital cost needed to build the ESS battery system on Pasi Island requires more costs than the construction of a PLTD, but it is still superior to the cost of building a solar power plant. In the variable fuel costs or the fourth variable, the cost of fuel incurred each year is far more than PLTS which does not require fuel costs at all but is still cheaper when compared to PLTD which has a very large fuel load.

Whereas in the sixth variable, the amount of electricity distributed by ESS batteries is still superior to the power generated by PLTS because ESS batteries can operate all day, in contrast to PLTS which only has a cumulative power generation of four hours. But the amount of electricity that can be channeled by the ESS battery is still far less than the power generated by the PLTD. In the seventh variable or loan variable, the value is directly proportional to the CapEx variable so of course, the ESS battery is still less superior than PLTD but still superior when compared to PLTS.

However, ESS batteries also have one variable that is not superior compared to PLTD and PLTS, namely the amount of the BPP tariff used in buying and selling electricity. Unlike the PLTD and PLTS which have a percentage of 100% BPP value, battery ESS as one of the energy systems that can be categorized as EBT only has a BPP percentage of 85% from the local regional BPP. PLTS as EBT still gets a percentage of 100% because there are revised regulations that are used to encourage the use of PLTS as a power plant.

V. CONCLUSION AND RECOMMENDATION

Pasi Island is located in the Selayar Islands Regency, South Sulawesi Province. There are three villages in Pasi Island, namely Kahu-kahu, Bontoborusu and Bontolebang with a total population of 4,747 people in 2019. Existing capacity (DM) on Pasi Island is 235 kW with a peak load of 116 kW and a reserve load of 119 kW with a maximum operating period of six hours each day.

Based on the results of a questionnaire of ten experts in the energy sector, ranking one to ten of the variables starts from 1) capital expenditure; 2) Operational expenditure; 3) Number of operators; 4) Land use; 5) BPP value used; 6) The amount of the loan, interest, and installments given; 7) Impact on the environment and social (externalities); 8) Lifecycle of a generator or generator; 9) Annual electricity production; 10) Fuel costs.

Analysis of the three alternatives using a decision matrix shows that the ESS battery is the most optimal choice as a power plant in the Pasi Island region. This is indicated by the superiority of battery ESS on variables number two, five, eight, nine, and ten. However, there is one variable that has the lowest value compared to two other alternatives, namely the BPP tariff variable. This variable has the lowest value because the BPP rate used for ESS batteries is only 85% of the applicable BPP rate, where PLTD and PLTS get full payment (100%) for the applicable BPP rate.

Considering the small gap between the values of the Battery ESS and also diesel in the decision matrix table, so that the battery ESS can look superior two things can be done in terms of the policy. First, the government reduces the subsidies that have been given to fossil (diesel) plants and second, the government provides incentives both in terms of import taxes and in the BPP tariff (the percentage of electricity purchases or BPP is synchronized like fossils and solar energy to 100%).

Besides, given that Battery ESS is a new technology that is generally more used as a complement to renewable energy, the government must be able to see the potential of ESS batteries as a source of new electricity supply by utilizing existing large plants. On the bureaucratic side, ESS batteries are much easier than building diesel and solar power plants. Permit is also not needed as much as the other two generators because the ESS battery is only a battery but immense.

On the efficiency side, ESS batteries have much higher efficiency, this can be seen from the life cycle they have and also the efficiency as a baseload of electricity (input = output). In terms of fairness, the application of ESS batteries can provide justice for people in remote areas to enjoy electricity like other Indonesians. Meanwhile, the application of Battery ESS also does not burden the government in terms of cost because it does not need to build a new power plant and is fast in its implementation (the time from procurement to COD is less than or only one year).

However, behind the convenience and advantages offered by Battery ESS, politically will experience many challenges. There will be a lot of opposition from parties who might lose the potential benefits of switching from fossil energy to new renewable energy such asbattery ESS. So, this technology can be applied optimally if the government has a solid political will to meet the electricity needs of all Indonesian people and also fight climate change which is increasingly showing its negative impacts.

The author recommends another three public policies, namely the energy market authority; non departmental government agencies in terms of renewable energy (RE Agency); and carbon market management institutions. First, the energy market authority has the authority to regulate the interests of producers and consumers outside the "public service obligation" (PSO) market which is held by PLN. Because by developing a reliable electricity supply capacity, it can increase innovation that also encourages the adoption of new technologies (transfer of technology) such as Battery ESS while maintaining competitive market prices.

Second, the RE agency has the main task in the micro sector, namely overseeing and ensuring the implementation of micro regulations on IPP in the field of renewable energy. Inaddition, this institution is also obliged to coordinate with various relevant sectors and stakeholders such as the ministry of finance, the ministry of environment and other related institutions. Finally, the carbon market management agency has the duty to supervise and ensure the implementation of regulations on carbon trade. This agency is only tasked with BPH Migas in the oil and gas sector. All financial affairs are left to the ministry of finance.

The author also has two recommendations for the next research, namely regarding the application of ESS batteries and also about the submarine cable development plan. First, further research on the application of ESS batteries in Pasi Island, both the multiplier effect and the application system, such as the method of charging power, the location of the charging depot or even the optimal number of ESS battery units. secondly, looking at the trend of distributing power to remote islands via submarine cables by PLN, it is necessary to further study the comparison of benefits and costs between electricity distribution with submarine cables compared to ESS batteries.

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