Battery energy storage system as the optimal solution for underdeveloped, remote, outermost region: Pasi island study case

Donny Yoesgiantoro1,2*
1 Defence Management Faculty, Indonesia Defence University, Bogor 16810, Indonesia
2 Energy Security Center for Excellence, Menara Sentraya A3, Jakarta 12160, Indonesia
*Email: energyprogram@gmail.com

Abstract. Underdeveloped, remote and outermost (3T) regions are areas that are becoming the priority of development by the Government of the Indonesian Republic in strengthening national security. However, the constraints to development in the 3T region are immense, ranging from great distances, isolated areas to its geographical location in the mountainous area of even in small islands. Pasi Island is home to three villages that fall into the 3T area category. Battery ESS is an energy storage system in the form of giant batteries with many advantages, such as inexpensive, mobile, has a large capacity, long life cycle, easy to operate and zero waste. Seeing the advantages offered by the battery ESS so that it has the potential to be an optimal solution to meet the electrification ratio in the 3T region. Cost-benefit analysis is chosen because the results can provide a clearer picture of the costs and benefits going forward. So that the calculation of the resulting cost-benefit is more optimal then two calculation scenarios are used using the basic difference in electricity sales rates. In the first scenario, it uses BPP tariff for the Selayar Regency area of Rp 2,445, and in the second scenario, it uses the BPP tariff of Rp 3,041 for small subsystem areas. The calculation results indicated that the second scenario provided immense benefits with a short payback time. The NPV value generated by scenario II is 116.5 billion rupiah with an IRR percentage of 100.33% and a cost-benefit ratio of 9.332.

1. Introduction
Underdeveloped, Remote and Outermost Regions (3T) are regions that have a low level in the human development index (HDI); availability of facilities and infrastructure; economic growth rate; and other socio-economic indicators [1] compared to other regional averages on a national basis. From a macroeconomic perspective, to be able to develop 3T regions so that they can be equal to other regions in Indonesia, it needs to be strengthened from the level of the local economy, HDI development, and improvement of adequate facilities and infrastructure. But to be able to do it all, it must be supported by an adequate supply of energy, funds and Human Resources (HR) support from the central government.

According to the National Energy General Plan [2] (RUEN), in 2025 it is mandated that Indonesia's energy mix consists of 23% renewable energy (EBT), 25% petroleum, 30% coal and 22% natural gas.
Also, the RUEN mandates that by 2020 Indonesia's electrification ratio must reach 100% with the installed plant capacity in 2025 reaching 115 GW. But until mid-2019, the energy mix ratio from the EBT sector is still very low, far from the target mandated by the RUEN itself so this can result in an electrification ratio target of 100% by 2020 will be difficult to fulfill if it does not reach 3T areas that are geographically far from an existing utility network. Therefore, an optimal solution is needed, to be able to quickly electrify the 3T region to achieve the target of 100% electrification ratio by 2020. 

Energy Storage System (ESS) is an important part of the new renewable energy generation system due to the nature of the EBT itself which is still largely intermittent so that for reliable electricity supply, reliable ESS is needed [3]. The size, cost, and reliability of ESS depend on the form of energy stored in it, be it potential energy, kinetic, chemical, electromagnetic, thermal, and so on [4]. There are many types of ESS itself, such as Electric Double Layer Capacitor (EDLC); Battery ESS; Superconducting Magnetic Energy Storage (SMES); Flywheel; Plug-in Electric Vehicle (PEV); etc. Battery ESS is one type of ESS that is widely used in EBT generation. This type of ESS is based on a secondary battery that can be charged and discharged repeatedly with a certain life span [5].

Pasi Island is an island located in Selayar Regency, South Sulawesi Province. There are three (3) villages on the island located in the Java Sea region, which had a total population of 4454 people in 2010 and reached 4747 inhabitants per 2019 [6]. Selayar Islands Regency, in general, has an electrification ratio of 68.46% which means 31.36% of the population has not enjoyed electricity, especially in villages located outside the main island (Selayar). The existing electricity grid on Pasi Island only has a capable power capacity of 235 KW with a peak load of 116 KW and a reserve load of 119 KW. But unfortunately, with the existing network, PLN is only able to illuminate the island for only six (6) hours per day, this has reduced the interest of the public to subscribe to PLN electricity.

Therefore, we need an optimal solution so that it can quickly, cheaply and efficiently meet the national electrification target of 100% as announced by President Jokowi and also PT. PLN (Persero). Battery ESS is the optimal solution in responding to the needs of electrification in the 3T region, because of low procurement costs, fast and efficient commercial operation date-time both in terms of charging, operating and also without waste.

2. Cost-Benefit Analysis Variables
To simplify the calculation, a basic parameter must be set to get reliable and accountable results according to scientific rules. The calculation compares between the two (2) scenarios using Battery ESS as a baseload with a project period of thirty years (30) according to the Build, Own, Operate and Transfer (BOOT) scheme in the Power Purchase Agreement (PPA) [7]. In first the scenario, the selling price of electricity used is the BPP tariff in the Selayar Islands Regency and the second scenario, the BPP tariff used is a small subsystem BPP tariff.

The 3T areas used as the basis for the calculation are three (3) villages in Pasi Island in the Regency of Selayar Islands with a total of 1356 heads of households (HH) with the assumption that the installed capacity in each HH is 1,300 watts. The benefit of electricity sales is 85% of the BPP tariff used in each scenario because the magnitude of the two BPP tariffs in each scenario is above the national BPP tariff [8].

2.1. General variables
General variables in the PPA project have a period of thirty (30) years with Commercial Operational Date (COD) in year one (see table 1). Each scenario uses the assumption of using ten (10) ESS battery units, where each village has three (3) ESS battery units with a total of nine (9) used and one (1) ESS battery becomes a backup unit if there is a problem in one unit battery in one of the villages. There are twenty (20) workers in the two scenarios, with a division of two (2) shifts consisting of two (2) ESS battery operators and one (1) truck driver in each village and one (1) daily operating supervisor.
Furthermore, to expedite the charging process on the ESS battery, each village has prepared one (1) unit of battery transport truck from each village to the South Sulawesi PLN charging depot using a ferry from Pasi Island to Sulawesi Island through Bira Port, Bulukumba Regency. Each battery has a capacity of 100 kV so overall for one year all battery units can produce 8,760,000 kWh. Finally, the discount rate assumption used is 10%.

2.2. Benefit variables
In the benefits variable, there are four (4) variables, namely the BPP Selayar Islands Regency tariff; small subsystem BPP rates; electrification benefits; and the residual value of the project (see table 2). Tariff BPP Kepulauan Selayar Regency is used in scenario I with a magnitude of Rp 2,445 per kWh. In scenario II, the electricity sales tariff used is a small subsystem BPP tariff with a value of Rp 3,041 per kWh. Because both of these rates are above the national BPP tariff, and also considering that ESS batteries are included in renewable energy, therefore the maximum sales tariff percentage used is 85% of the BPP tariff used in each scenario.

Table 2. Benefit variables

| Variable            | Value     | Unit         |
|---------------------|-----------|--------------|
| BPP Tariff of Selayar Regency | 2445 | Rupiah/kWh   |
| BPP Tariff of Small Sub-system | 3041 | Rupiah/kWh   |
| Electrification Benefit | 2,012,931,737,76 | Rupiah/year |
| Residual Value      | 10        | %            |

In addition to the benefits received from the sale of electricity, there are benefits from fulfilling electrification on Pasi Island, because these benefits are not value that has real money, so it needs to be quantified into the applicable monetary value. In economics, this quantification is called a shadow price. Shadow prices are prices of components that do not have real value but have value in terms of economic analysis so that shadow prices can also be called social prices.

Because the price is valued by the community, therefore the amount of the shadow price is based on the assumption of people's willingness to pay both benefits and costs [9] [10]. Therefore, we can calculate the amount of the shadow price of the benefits obtained by the community if a reliable electricity infrastructure can enter the 3T region. This benefit can also be borne by a fee that the community is willing to pay so electricity can enter the 3T region.

We assume that all households on Pasi Island subscribe to electricity using PLN's diesel, then combine it with preliminary data which states that PLN's services on Pasi Island only last a maximum of six (6) hours. Then both scenarios use the depreciation value of the residual value at the end of the project with a large percentage of 10%. The value of electrification benefits can be obtained by combining the two variables above into mathematical formula as in equation (1).

\[ B = ((k \times P \times t)^{1/3} \times p) \times 365 \text{ hari} \]  

\[ B = \text{diesel savings benefit (rupiah)} \]
k = fuel specific consumption of diesel generators (liters / kWh)
P = diesel generator power (kVA)
t = generator daily operation (hours)
p = price of diesel fuel (rupiah)

Small-scale PLN diesel generators under 250 KW with 75% to 100% load have an SFC value of 0.273 liters / KWh. The generator in Pasi Island has a capacity of 235 KW with a long time the community enjoys electricity generated from the PLTD is only six (6) hours. The P-value of the generator is 261.11 KVA, this value is obtained by multiplying the magnitude of the generator power that is 235 KW to the value of the power factor (power factor) with a general assumption of 0.8. Pertamina's high speed diesel (HSD) for the industry as of August 2019 has a price of Rp 12,894.33 after VAT, PPh and PBBKB for Area III or Sulawesi and NTB Areas. By distributing known variables into the equation (1), the resulting B-value is

\[
B = ((0.273 \times 261.11 \times 6) \times 12.894.33) 365 \text{ days}
\]

\[
B = (427,698 \times 12,894.33) \times 365 \text{ days}
\]

\[
B = 5,514,879.15 \times 365 \text{ days}
\]

\[
B = Rp 2,012,931,737.76 \text{ per year}
\]

2.3. Cost variables
2.3.1. Fixed costs
Fixed costs are costs incurred either in one time or in a certain period with the same amount of value or static. In the fixed cost parameters, there are six (6) parameters (see table 3). The cost of procurement and construction of ESS batteries is the US $ 900 per kWh, these costs include land acquisition, equipment and material procurement, construction and network construction. In addition to CapEx costs, another procurement cost is the cost of procuring trucks for mobility from the village to the charging depot assuming a procurement cost of Rp. 400,000,000.00 per truck. The type of truck needed is the type that is capable of carrying trailers or battery containers in off-road conditions. The types of trucks that fit the needs above such as the Mitsubishi Colt Diesel 74 Long with a price range of 328-360 million rupiahs, Hino Dutro Cargo 130 MD with a price range of 312-330 million rupiahs and Tata Ultra in the price range of 400-430 million rupiahs.

| Variable             | Value     | Unit       |
|----------------------|-----------|------------|
| Capital Expenditure  | 900       | US Dollar/kwh |
| Truck Procurement Cost | 400,000,000 | Rupiah/truk |
| ESS Charging Cost    | 1.115     | Rupiah/kwh |
| Ferry Cost           | 1,280,000 | Rupiah/trip |
| Truck Fuel Cost      | 12,240,000 | Rupiah/tahun/truk |
| Corporate Overhead   | 0.5 % dari capex |

The next fixed cost parameter is the charge for charging the ESS battery, charging costs using class I-3 tariffs as of August 2019, which is Rp 1,115, because the power needed to charge three (3) batteries every day is 375 kVA. This figure is obtained through multiplication of factors of the number of batteries 3 units x 100 KW with also the power factor (PF) of batteries 0.8. Other fixed costs incurred in the process of the charging location are the cost of the ferry crossing from the Selayar Regency to Bulukumba Regency amounting to IDR 1,280,000 per trip. The ferry that serves the Selayar Islands Regency route and the Bulukumba Regency is KMP Bontoharu with the intensity of traveling two (2) times a day. The annual fuel cost of the transport truck is Rp 12,240,000, assuming a full tank of Mitsubishi Colt FE 74 L fuel tank with a capacity of 100 liters. Fully refueling is done monthly using Dexlite diesel at a fixed price of Rp 10,200 as of August 2019. Finally, on administrative or corporate overhead variables, assuming the annual costs incurred are 5% of the total CapEx costs.
2.3.2. Variable costs
Maintenance costs use an assumption of 0.5% of capital expenditure and increase every ten years by 0.5%. So in scenarios, I and II, the maintenance costs needed in the first ten years amounted to Rp 63,900,000, in the second ten years amounted to Rp 127,800,000 and in the last ten years amounted to Rp 191,700,000. As for salaries using the South Sulawesi provincial minimum wage (UMP) of Rp. 2,860,382 [11] with an increase of 8% every five (5) years.

Table 4. Var. cost variables

| Variable       | Value  | Unit       |
|----------------|--------|------------|
| Maintenance    |        |            |
| Year 1-9       | 0,5    |            |
| Year 10-19     | 1      | % of CapEx |
| Year 20-29     | 1,5    |            |
| Wages          |        |            |
| Year 1-4       | 2.860.382 |          |
| Year 5-9       | 3.089.213 |          |
| Year 10-14     | 3.336.350 | Rupiah/worker/month |
| Year 15-19     | 3.603.258 |          |
| Year 20-24     | 3.891.518 |          |
| Year 25-29     | 4.202.840 |          |

In the first five years, the worker's wages were IDR 2,860,382 per worker/year, increasing in the second five years to IDR 3,089,213. In the next five years, the wages of each employee increased again to Rp 3,336,350. In the fourth five years, namely the years 15-19, employee wages to Rp 3,603,258. In the fifth and sixth years, employee salaries increased respectively by 8% to Rp 3,891,518 and Rp 4,202,840. Both of these parameters are included in the variable cost parameter because their properties change, whether they go up or down, in this case, the value rises dynamically (see table 4).

3. Cost-Benefit Analysis
Economic cost-benefits analysis is an analysis from a macro point of view so that the benefits and costs arising from a policy or project have an impact on society, both positively and negatively. In this study, a cost-benefit analysis is carried out by utilizing Microsoft Excel to make it easier to find the value of NPV, IRR and its cost-benefit ratio. Similar to financial appraisal, some of the components or variables calculated are the same, but in economic calculations, variables that are genuine money transfers between two sides without goods or services, such as taxes, are not counted in the economic cost-benefit calculation. This is because the movement of money does not reduce the resources or wealth that exists in the community.

In the cost-benefit analysis, there are three (3) things that are used as a benchmark in the comparison between alternatives, namely the NPV value, the percentage of IRR and also the cost-benefit ratio. The alternative with the highest NPV, IRR and cost-benefit ratio is the most viable option to be carried out, continued or further calculated. In general, if the NPV value of a project or alternative shows a positive number, then the value of the IRR and B / C ratio will also follow, so it can be concluded if in the two alternatives there is one that has the highest NPV, it is certain that the cost-benefit ratio and the IRR percentage is also high.

3.1. Scenario I
The cost-benefit calculation results in the scenario I show good NPV, IRR, and B / R ratio results. Scenario I using the Selayar Regency BPP tariff as the basis for electricity sales generates an NPV value of Rp. 74,900,608,862.00. There are two (2) main benefit components in the calculation of these cost-benefits, namely the benefits of electricity sales and the benefits of electrification (see table 5).
Table 5. Scenario I cost-benefit analysis

| Variable                  | Value               | Unit      |
|---------------------------|---------------------|-----------|
| Capital Expenditure       | 12,780,000,000      | Rupiah    |
| Power Sales Benefits      | 18,205,470,000      | Rupiah/year |
| Electrification Benefits  | 2,012,931,738       | Rupiah/year |
| Discount Rate             | 10%                 |           |
| Present Value of Bt       | 88,880,608,862      | Rupiah    |
| Present Value of Ct       | 13,980,000,000      | Rupiah    |
| Net Present Value         | 74,900,608,862      | Rupiah    |
| Payback                   | Year 2              |           |
| IRR                       | 68.56%              |           |
| B/C Ratio                 | 6.358               |           |

In the electricity sales benefit component, each year after entering the Commercial Operation Date (COD), the benefits received from electricity sales amount to Rp 18,205,470,000. In the electrification benefit component, the benefit received by the community from the inclusion of electricity using an ESS battery as a baseload every year is Rp. 2,012,931,738.00. The cost-benefit calculation in the scenario I use a discount rate of 10%. Overall, the present value of all benefits after deducting the discount rate is IDR 88,880,608,862 and the present value of all costs after deducting the discount rate is IDR 13,980,000,000.00.

NPV value is obtained by reducing the value of the present value of Bt with the value of the present value of Ct so that the results obtained are Rp. 74,900,608,862.00. Payback from the scenario I occur at the point of the second year after the COD (see figure 1). The value of the cost-benefit ratio can be determined by using equation (2)

\[
\text{B/C} = \frac{\text{PVbt}}{\text{PVct}}
\]  

So that the known PVbt and PVct values can be distributed into the formula so that the scenario I cost-benefit ratio value of 6.358 is obtained. The value of IRR can be determined by utilizing the net benefits from each of the available years, then utilizing the formula features in Microsoft Office Excel in the Finance sub-menu section. The results of calculations from Excel show the IRR value of the scenario I is 68.56%.

Based on the scenario I graph (see figure 1), the NPV value in scenario I in the first ten years the value rises quite rapidly, this is seen in year 0 where the NPV value is at a negative rate of 13.9 billion rupiahs and rises significantly to the point of 40 billion rupiahs in year 9. In the next ten years, the value of the NPV began to experience a slight slowdown, the lines on the graph began to slope. At year 10, the NPV is in the range of 45 billion rupiahs and at the end of the second ten years, it is at 66 billion rupiahs. In the final ten years of the project, the increase in NPV was very slow with the accumulation of the last ten years of only around 10 billion, with the 20th year at the point of 68 billion rupiahs and closing at 75 billion rupiahs at the point of 29.
3.2. Scenario II

Scenario II using the Small Sub-system BPP tariff of Rp 3,041.00 as the electricity sales price generates an NPV value of Rp 116,481,195,900.00 (see table 6). Annual power sales in scenario II are Rp. 22,643,286,000.00. The benefits of electrification in scenario II also have the same amount as in scenario I, which is Rp. 2,012,931,738.00. The cost of CAPEX and discount rate used in scenario II also have the same amount as scenario I. This is because the parameters or variables that affect are generally the same, only differing in terms of power sales tariffs. So that there are differences in the present value of costs and benefits, net present value, IRR and also the cost-benefit ratio.

In scenario II, the project reaches a break-even point in the second year after COD. The present value of Bt is IDR 130,461,195,900.00 and Ct is IDR 13,980,000,000.00. The present value of Ct from the scenario I and II has the same value because the largest expenditure is in year 0 at the time of development (before the COD point), and after COD, the benefits received are far above the costs incurred. The net present value of Bt is reduced by the present value of Ct, so the NPV value from scenario II is Rp. 116,481,195,900.00.

With the amount of benefits received in scenario II, the project reaches a break-even point in the second year (2). The present value of Bt and the present value of Ct known above can be used again to calculate the cost-benefit ratio value from scenario II. The present value of Bt is divided by the present value of Ct, resulting in a ratio value of 9.332. The percentage of IRR can be found easily using the "formula" feature in Microsoft Office Excel. First, select the "formula" tab, then select the "financial" sub-menu, finally select "IRR". The percentage value of IRR generated using the excel calculation in this scenario shows an amount of 100.33%.

| Variable                  | Value     | Unit       |
|---------------------------|-----------|------------|
| Capital Expenditure       | 12,780,000,000 | Rupiah    |
| Power Sales Benefits      | 22,643,286,000 | Rupiah/year |
| Electrification Benefits  | 2,012,931,738 | Rupiah/year |
| Discount Rate             | 10%       |            |
| Present Value of Bt       | 130,461,195,900 | Rupiah  |
| Present Value of Ct       | 13,980,000,000 | Rupiah  |
| Net Present Value         | 116,481,195,900 | Rupiah  |
| Payback                   | year 2    |            |
| IRR                       | 100.33%   |            |
| B/C Ratio                 | 9.332     |            |
Based on the coordinates of the graph in scenario II (see figure 2), the NPV value in scenario II rises significantly from the negative point to the range of years 15-17, and then the increase starts to slow down. In general, in the first ten years, the NPV value moved up very significantly, with the initial value at a negative point until in the tenth year it reached a positive point at 66 billion rupiahs. In the second ten years, the graph still shows an increase but starts to slow down, precisely at the point between the 15-17 curve lines start to show a greater slowdown. At the end of ten, the movement of the NPV value was slow with a margin of difference in year 21 and year 30 of only 14 billion rupiahs. This is very different from the first ten years which had a margin of difference of nearly 80 billion rupiahs.

3.3. Analysis

Decisions about the feasibility of a project based on several alternatives can only be based on the NPV value, although the percentage of IRR shows a positive value, sometimes it can result in inconsistencies in the alternative ranking. However, several large corporations and well-known financial institutions prefer IRR because it is easier to compare in terms of capital expenditure alone [12]. In scenario I, with a CAPEX of Rp. 12,780,000,000.00 an NPV result of Rp. 74,900,608,862.00, while in scenario II, with the same amount of CAPEX can produce a much larger NPV value of Rp. 116,481,195,900.00. This shows that with a small subsystem BPP tariff as a benchmark price of electricity sales to PLN will greatly benefit the ESS battery project in three (3) villages located on Pasi Island.

Although the best alternative selection can only use NPV as a benchmark, the authors will also use the IRR percentage and cost-benefit ratio values to strengthen the basis of the selection. In scenario I, the percentage value of IRR is 68.56% and in scenario II the value of the percentage of IRR is at 100.33%, this shows that scenario II is again superior to scenario I. Similarly, the value of the cost-benefit ratio, scenario II has a superior result at 9,332 level than scenario I at point 6,358.

The conclusion of the three comparisons between NPV value, IRR percentage and also the cost-benefit ratio value shows that scenario II is the optimal choice that can be implemented as a project to fulfill electrification ratios in three (3) in the Pasi Island region, South Sulawesi. After the best choice has been determined, each component or variable that influences the NPV value is tested for sensitivity to mitigate the volatility of NPV values that are too extreme or that risks making the project not viable.
4. Sensitivity Testing with Switching Value Table and Break-Even Analysis

Break-Even Analysis (BEA) is a method of analysis used to see the relationship between fixed costs, variable costs and also revenue so that an investment or project can reach break-even point [13]. This method can also be used to compare several alternatives to find the most optimal one to be implemented [14].

Furthermore, this analysis method can be used to see how the changes in fixed costs, variable costs, commodity prices or income can affect the level of profit and the break-even point of the project or policy. Switching Value (SV) is a change in the value of each variable that affects the break-even point or NPV = 0 with a predetermined discount rate and SV value expressed in percentage [15]. Mathematically, the equation (3) can be used to find the SV values

\[ SV = 100\% \times \frac{(vt - v0)}{v0} \]  

SV = switching value
vt = final value
v0 = initial value

| Table 7. Switching value table |
|-------------------------------|
| NPV 116,481,195,900           |
| Initial Value | Switching Value | Percentase | Sensitifitas |
|----------------|-----------------|------------|--------------|
| Small Sub-system BPP         | Rp 3,041,00     | Rp 1,371,40 | -55%         |
| Electrification Benefits     | Rp 2,012,931,737,76 | Rp -10,418,882,041,00 | -618%        |
| Residual Value               | 10%             | -14.448%   | -144.580%    |
| CapEx                        | Battery ESS unit price | $ 900 | $ 8,286,88 | 821%     |
| Charging Cost                | The Amount of ESS unit | 10 | 92 | 821%     |
| Annual Power Production      | Charging Cost   | Rp 1,115,00 | Rp 2,534,00 | 127%     |
| Transportation               | Annual Power Production | 8,760,000 kwh | 302,120,78 kwh | -97%     |
| Dexlite Price                | Ferry Cost      | Rp 1,280,000,00 | Rp 2,073,248,963,00 | 161,873% | 33,856% |
| Corporate overhead           | CapEx           | 0,50%      | 97,78%      | 19,456% |
| Truck Price                  | Battery ESS unit price | Rp 400,000,000,00 | Rp 39,227,065,300,00 | 9,707% |
| Annual Maintenance           | 0,50%           | 65,67%     | 13,034%     |
| Annual Wages                 | 8%              | 193,71%    | 2,321%      |

But to ease the calculation, we can use the function of excel, ‘what-if analysis’ by targeting NPV cells with a value of 0 and correlating with the initial value of the variable you want to test. The smaller the percentage value that comes out, the higher the sensitivity value. The results of the SV which show the highest sensitivity value indicate that these parameters greatly affect changes in NPV and break-even points, making it easier for stakeholders to take preventative actions.

The sensitivity test shows the two components that have the most sensitive value for changes in NPV values, with the SV percentage below 100%, namely the BPP tariff component and also the annual power generation (See table 7). At the BPP tariff (small sub-system BPP), if the tariff reduction is greater than 55%, the battery ESS project is not feasible to proceed. The second variable that is sensitive to changing the NPV value is the amount of annual electricity production by battery ESS. If the annual power production drops to > 97%, the electrification of the Pasi Island project with an ESS battery will not be feasible.

As one of the most sensitive variables, the BPP rate has a very small probability of decreasing, because the large BPP rate has been determined and agreed before the signing of the PPA between the IPP and PLN. However, if there is a change in policy in the future or there are discussions such as BPP tariff adjustments, a reduction may occur but still has a very small percentage. One of the reasons for the BPP tariff adjustment is the increase in the level of the economy in the Selayar Regency so that it is
no longer classified as a 3T region. Another factor that might occur is the decrease in the variable costs of the operating tariff compiler so that the magnitude of the sub-system BPP also decreases to adjust.

In the annual electricity production variable, a significant reduction in electricity production has a very low likelihood ratio. This is because the shape of the ESS battery itself is in the form of a modular unit so that if there is damage to one unit, it will not affect the overall electricity production. Also, in this scenario, the procurement of extra ESS battery units has been carried out to mitigate the possibility of damage by preparing one (1) reserve in each village and one (1) main reserve if damage occurs to more than one (1) unit in the village certain. But seeing the possibility of force majeure or natural disasters and riots can occur, the operator can prepare a backup plan to mitigate these possibilities. The mitigation effort can be in the form of a contract with the procurement of ESS batteries so that if many units are damaged, it can immediately (under a span of one (1) week) be replaced by a new unit.

In general, other components besides the two components above do not greatly affect changes in NPV value due to the very high SV percentage, above or below 100%. The ferry tariff component and the residual value are the two components that have the least influence, with the SV percentage at the residual value of -144,580% and the ferry rate of 161,873%. Seeing the number of components that have a very large percentage change in variables, then these components can be removed from the SV table. The use of sections to divide the text of the paper is optional and left as a decision for the author. Where the author wishes to divide the paper into sections the formatting shown in table 2 should be used.

5. Conclusion and Recommendation

5.1. Conclusion

Three (3) villages in Pasi Island need 4,632,638.4 KWh / year in the first five (5) years assuming a load of 30% which has an installed capacity of 1300 Watt per customer with a total of 1356 households. Customer load increases by 5% every five years until assuming a maximum load of 50% in the last ten (10) years at the PPA with the amount of electricity demand each year of 7,721,064 KWh. Therefore ten (10) ESS battery units are the optimal amount to meet the needs of each year with a maximum potential annual electricity production of 8,760,000 KWh / year.

Existing power on Pasi Island has a capacity of 235 KW with a peak load of 116 KW and a reserve load of 119 KW which serves a total of 638 households. However, this power plant is only able to supply a maximum of six (6) hours, so it can be assumed that the average per house uses 200 watts/day/household. Battery ESS with scenario II or a small sub-system BPP rate of Rp 3,041.00 is the optimal choice for the electrification of Pasi Island. This is indicated by the largest NPV value, along with the IRR percentage and the cost-benefit ratio. Scenario II shows the results of the calculation of the NPV value of Rp 116,481,195,900.00, the percentage of IRR 100.33% and the cost-benefit ratio at the level of 9,332. Besides, with scenario II, the battery ESS project reaches a break-even point in the second year after COD.

There are two (2) variables that are most sensitive to affect the NPV value, this is indicated by the value of switching values with a percentage in the range of -100% to 100%, namely the BPP rate with -55% and annual electricity production with -97%. However, both components can be mitigated well with the certainty of the basic tariff on the PPA and the advantages of the modular ESS battery itself.

5.2. Recommendation

Author recommend more studies to see the probability of risk occurring for each component that is sensitive to the amount of NPV. Probability testing of each risk can be carried out using a risk simulation program such as Monte Carlo. Seeing the possibility of developing discourse of distribution through submarine cables by PLN, further research can see a comparison between electrification using
submarine cable lines or with ESS batteries. This advanced study can use a financial analysis or analytic hierarchy process or decision matrix.

The development of renewable energy (EBT) in Indonesia is more concrete with the issuance of regulation [2] on RUEN, which is part of the National Energy Policy (KEN), in addition to the National Electricity General Plan (RUKN). RUKN downgraded the Electricity Supply Business Plan (RUPTL). Utilization of EBT has the aim of creating energy independence and energy security. Energy security is the ability to answer the dynamics of global (external) energy changes, as well as the ability to guarantee the availability of energy at a fair price (internal), while energy independence consists of the elements of Availability, Accessibility, Affordability, Acceptability, and Sustainability (4A + S). Indonesia has a great opportunity to develop EBT. This is not only due to the large potential of resources, but also its varied types (Indonesia has almost all types of EBT).

EBT development has also been included in the EBT Roadmap in 2025 and 2050. The electricity utility sector has a major role in the development of EBT. But now, the development of EBTs still seems expensive because they have not included environmental costs in the calculation of energy production costs in Indonesia. Another challenge is the economics of EBT which still cannot compete with fossil energy. EBT has not fully met the 4 A + S criteria, especially Accessibility and Affordability. While fossil energy subsidies are a strong barrier to the development of EBT, because it creates a huge price gap, it is politically difficult to eliminate because it is related to industry and consumers. President Joko Widodo has only succeeded in eliminating subsidies for fuel prices.

EBT development in Indonesia is still Adhoc, so it requires "Political Will". The problem of EBT will be more complicated in the future because globally it will still depend on fossil energy, especially petroleum, while the future trend of gas and EBT consumption will increase. National energy security needs to be improved in the form of operational policies and strategies and requires a New and Renewable Energy Agency (EBT Agency) that has the main tasks and functions (tupoksi) at the micro-management level (operational) of new and renewable energy. His job is to supervise and implement micro regulations on the EBT power plant. On the other hand the Ministry of Energy and Mineral Resources (ESDM), in this case the Directorate General of New and Renewable Energy (EBT) has its duties and functions at the macro-management level (policy) of EBT, carries out policies and the implementation of macro regulations on the EBT sector.

EBT Agency is a State-Owned Legal Entity (BHMN) as is the case with Non-Departmental Government Institutions (LPND) reporting directly to the President of the Republic of Indonesia. Coordination with various sectors is carried out according to the main tasks and functions of each sector, including the Ministry of Energy and Mineral Resources in energy policy, the Ministry of Finance in financial policy, the Ministry of Environment and Forestry in terms of the EBT operations in forest areas.

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