The Effectiveness of Development Bamboo Biomass Power Plant (Case Study: Siberut Island, The District of Mentawai Islands)

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Abstract. Electricity has an important role to improve economy in a region. However, currently, part of the people Indonesia still have lack access electricity, especially those in the backward, outer, and advance areas (called 3T in Indonesia mean tertinggal, terluar, dan terdepan), that one of which is in uninhabited islands. Increasing the target of the electrification ratio in the regions, Government of Indonesia has responsibility to power that area. One of ways is to work with private parties to build renewable energy power plant by utilizing the potential of local natural resources. The development of power plant in Siberut Island, West Sumatera utilizes bamboo resources in the local area. This development will be done by private parties in three villages namely Madobag, Matotoan Village in South Siberut District, and Saliguma Village in Central Siberut District. This research uses mixed method, qualitative method using descriptive approach, while quantitative method using Cost Benefit Analysis approach. The cumulative Net Cash Flow generated from the bamboo Biomass Power Plant project is Rp 144,287,730,000 in the 30th year with a payback period of the 16th year. The IRR of the project, if not using grant, is 4.7%.

1. Introduction

Equity of electricity will encourage economic progreses in one area, but electricity distribution is one of the biggest problems in Indonesia and the electrification ratio gap is increasingly felt by people in remote area, advanced, outer, and small islands inhabited. the provision of elecricity is still dominant in the development and accessible areas. Thus, the area that has been difficult to reach, in terms of access, for transportation and lack of infrastructure further lags behind the economic side. Most areas that are rarely or utterly unutilized are in the backward, outer and advance regions (3T), which are generally located in eastern Indonesia and small islands that are difficul to access.

Data from The Ministry of Energy and Mineral Resources of Republic of Indonesia said that Indonesia electrification ratio up to 2017 has reached 91.1%. This achievement is greater than the Strategic Plan of The Ministry of Energy and Mineral Resources in 2015-2019 by 90%. To make realize the electrification target of 100%, the most severe work is to provide electricity for outermost area, advance, and drop behind. There are at least 2,519 villages which have not been powered by electricity at all. Thus, it takes a variety of efforts to provide electricity in that all area. In order to
increase the electrification ratio, the Government of Indonesia, through the Ministry of Energy and 
Mineral Resources has also issued Minister of Energy and Mineral Resources Regulation No.38 of 
2016 on the acceleration of electrification in rural undeveloped, remote, border, and small islands with 
number of population through implementation of small-scale power supply business.

Nowadays, planning of electricity in Siberut Island by using Biomass Power Plant (PLTBm). The 
Biomass Power Plant developed using bamboo raw materials. This is due to the area that is in tropical 
rainforest so that the development of bamboo seedling in the area becomes easier and can be a source 
of income for the surrounding community and improve the regional economy. The Development of 
PLTBm in Siberut is obtained from grant of Millenium Challenge Account (MCA)-Indonesia and will 
be built in three villages named Madobag Village, Matotoan in South Siberut Districh, and Saliguma 
Village in Central Siberut District. The three villages were selected through a planning process 
organized by Mentawai Islands Regional Development Planning Board (Bappeda). Based on the 
feasibility study for the construction of Biomass Power Plant (Bamboo), the need for land to be used 
for growing bamboo is 300 hectares. Electrical capacity to be produced is 700 KW with an investment 
of USD 12 million. The next three villages will be developed in the next 17 villages in Siberut Island 
[1].

The development of PLTBm in Siberut Island began in early 2016. The development is targeted to 
be completed within one year. In accordance with the MCA-Indonesia grant receipt contract, Green 
Prosperity Mentawai will help operate PLTBm Bambu in Siberut Island, as well as to prepare the 
Mentawai Community to take over the operation of electricity in mutual cooperation, and maximize 
the ownership of the PLTBm. Currently, the development of biomass power plants (bamboo) is still in 
the construction phase.

Based on the background that has been mentioned before, the the problems are:

a. As many as 2,516 villages are still not yet powered by electricity, generally the village is located 
in the eastern part of Indonesia, the border, and small, inhabited, islands.

b. The village electricity program that initiated by Government of Indonesia, the Ministry of 
Energy and Mineral Resources, has not been able to, maximally, electricity in the village that 
location in outer, advance, and drop behind islands by the inability of the people in their 
economy to be able to buy and have benefit from electrification.

c. The role of the private sector in the development of electricity derived from international grants 
is expected to be able to stimulate the regional economy and can provide the socio-economic 
impact of the development and supply of power plants.

2. Methodology

This research uses mixed method. It is to support processing quantitative data and also it is needed 
qualitative data. Mixed method is one of the research method that combining and integrating between 
quantitative and qualitative method to be used in research activities, so that obtained data more 
comprehensive, valid, reliable, and objective. Research design that used is Sequential Explanatory, 
collecting data and analysing quantitative data in the first stage and followed by collecting and 
analyzing qualitative data in the second stage, in order to strengthen the result of quantitative research 
that has been done in the first stage [2].

This research uses Cost Benefit Analysis (CBA) to analyze quantitative data. CBA or Cost Benefit 
Analysis is an approach to policy recommendations that allows analysts to compare and advocate a 
policy by calculating total costs in terms of money and total profits in money. Cost Benefit Analysis 
can be used for recommends policy actions, in the sense of application (ex ante), Cost Benefit 
Analysis is also used to evaluate policy performance. Many modern Cost Benefit Analysis are based 
on an economic field that treats the issue of how to maximizing social welfare, it is the economic 
aggregate satisfaction that can be fulfilled for community members [3].

Research on the cost and benefit analysis of biomass power plant development plans is done by 
looking at the cost of benefits obtained from the private side of the international grant funds. The cost
of international grant is USD 12 Million. The fund developed in three villages located on Siberut Island for the construction of the plant and the provision of land for the development and planting of bamboo as raw materials from biomass power plant.

3. Research interview

In conducting interviews in each village, we used informants by doing snowball techniques in which samples were rotated from one informant to another. In an interview conducted in Matotonan Village, all hamlets in Matotonan Village are now enjoying electricity coming from Centralized PLTS, operating at the end of 2016 built by the ESDM Ministry. With the centralized PLTS, the community can save expenses for lighting that previously people use the togok lights which cost per month can reach Rp 30,000/Month. The fee for electricity contribution with PLTS in only Rp 5,000,- Which money is used for maintenance costs. However, electricity for household needs that exist today can only be used for lighting only. Each house only gets a quota of 300 Watts per day at 6 PM to 6 AM to enjoy electricity with each house can only install as many as three pieces of LED lights each 10 Watts. The electricity still has problems, technicians who are not always in the village as Centralized PLTS technicians are also traveling around to help the Centralized PLTS are experiencing the disruption. Although people in Matotonan Village have been able to use electricity for limited time lighting, people also hope that electricity can be used for 24 hours for other activities such as cutting wood, sewing, and others. Biomas Power Plant under construction can distribute electricity for 24 hours. The payment of electricity can use as much as 2 cigarettes per day or pay Rp 40,000/month. However, there is no agreement between the project owner and the surrounding community. The benefits felt by current village community of Matotonan are the villagers involved in the Rp 80,000,- per day, in accordance with the village regulations wage standards. Aside from being freelancer who takes care of bamboo seeds, villagers are also involved in the construction of power plants with a total of 13 people. Losses felt by the Matotonan village community to date have not been feasible, the construction of this solar power plant is strongly supported by the community to operate immediately.

Furthermore, in an interview conducted in the village of Madobag, in this village there is also Centralized PLTS built by the Ministry of Energy and Mineral Resources at the end of 2016. Electricity supplied from Centralized solar panel can be owned by the Society Madobag for 24 hours continuously with sunny weather conditions. However, electricity in Madobag village can only be had by 4 hamlets. 8 other hamlets have not been able to have electricity due to the location of the hamlet is far from 4 hamlets that are close together and access to power line mast is difficult to reach the 8 hamlets. Electricity from PLTS can be owned by people with a capacity of 300 Watts per day with installation of LED lamps maximum 3 pieces with a capacity of 10 watts. With the Centralized PLTS, the community can save expenses for lighting that previously people use to togok lights whose cost per month can reach Rp 30,000/month. Payment of electricity can use bamboo as much as 2 cigarettes per day or pay with cash but its cost can not be determined. Then, the benefits felt by the Madobag Village Community today is that local labor can be absorbed in project development both as bamboo seed managers and project workers. The losses felt by Madobag villagers to date have existed, so the construction of biomass power plants is also supported by the community to operate immediately.

And lastly, in an interview conducted in the village of Saliguma, this village does not have access to electricity on a large scale either from PLN or from Centralized PLTS. This village has an adjacent hamlet that is on the edge of the sea. The other hamlets located in the far-flung plains have a PLTS Panel in each of their homes. From the electricity generated from the PLTS Panel can use 1 (one) 10-watt LED light bulb. The PLTS panel in a hamlet far from the seafront was a grant from Japan in 2003. In the hamlet close to the seafront, the hamlet community utilizes the togok lamps. And for middle and upper society, they use generators and rechargeable batteries through the PLTS Panel as their source of illumination. For those who can not buy generators and batteries, people use toggle lights as their enlightenment at night. Expenditures for lamp lights per month can reach Rp.30,000/month. The benefit felt by the Saliguma villagers is that local labor can be absorbed in project development as both bamboo seeds and project workers. The losses felt by the people of Saliguma
village to date have not existed, so the construction of this biomass power plant is also supported by the community to operate immediately.

### 4. Research analysis

The electrification ratio of Mentawai Island is currently at 28.43% [4] and 42.3%B (West Sumatera Province data after being added with non PLN households). Electricity needs of Mentawai Island Regency is still dependent on the provision of PLN that relies on diesel (Diesel Power Plant). Based on Data from PLN for Sipora Island, 9 of 13 villages have been electrified which reached by PLN and another four villages have not been electrified. There is Diesel Generator Power Plant Pejat with 2,370 kW and peak load is 1,633 kW. There are 5 Diesel Generator Power Plant in Siberut Island to power 8 villages and 12 other villages have not been electrified from 20 villages. There are 3 Diesel Generator Power Plant to be electrified 3 villages from 10 existing villages.

The Biomass Power Plant from Bamboo is currently under construction in three villages in Siberut Island, Madobag Village, Matotonan Village (South Siberut) and Saliguma Village (Central Siberut). The power plant we built with a total capacity of 700 kW for 3 villages. The development target of PLTBM in 3 villages is estimated completed by February 2018. In addition to the power plant development project, the private sector also prepares the bamboo seeds, which when grown will be ready to be harvested for the fuel needs of the power plant, so the power plant will not be short of supply fuel and do not make the amount of bamboo thinned due to existence of this Biomass Power Plant.

In the construction of biomass power plants in Siberut, the community is very supportive because the amount of electricity generated can stimulate the village community to improve the regional economy. Comparison of Costs and Benefits from biomass power plants and other plants used by the community can be seen in the following table 1.

Based on the comparison of benefits and costs in table 1, biomass power plants have far more advantages than others. After looking at the Costs and Benefits from the villagers side, then look at the Costs and Benefits from the Local Government side. From the views of local governments that were successfully interviewed by researchers, the South Siberut District government on the construction of biomass power plants from bamboo did not incur the costs associated with the construction of biomass power plants from this bamboo. In an interview conducted to the ESDM Department said that for the biomass power project does not incur any cost or fund related to this project. And the last interview conducted to the Regional Development Board (Bappeda) West Sumatra Province, the Bappeda also did not pay for the construction of biomass power plants in Siberut.

| No | Type                  | Cost (Rp)/month | Production (watt) | Benefit                                                                 |
|----|-----------------------|-----------------|------------------|-------------------------------------------------------------------------|
| 1  | Togok Lamp (Petromax) | 30000           | 0                | Only for lighting                                                       |
|    |                       |                 |                  | Only lighting and electric device with power and limited time           |
| 2  | Centralised PLTS      | 5000            | 300              | Lighting Only with limited time                                         |
| 3  | Solar Home System (SHS)| 0               | 100              | For Lighting and production equipment with limited time                 |
|    |                       |                 |                  | Lighting, Household appliance, Machine Production of machine with limited time |
| 4  | Genset                | 500000          | < 5 Kw           |                                                                         |
| 5  | PLTBM                 | 40000           | 700 Kw           |                                                                         |
In terms of Costs incurred by Private, these development funds come from Foreign grants granted to private parties to run programs that have a positive impact on the environment and social. If the project is assumed to be borrowed to a bank for investment (not a grant) then the average interest rate used is 11%, Payout Time from this power plant development project is available in the 16th year with NCF in the 30th year of USD 10,687,980. If the funding comes from a business fund that aims to make a profit, then the investment funds spent on a biomass power plant project can be feasible to build because the investment target for 30 years can provide a return on capital in the 17th year.

The costs and benefits of building biomass power plants need to be looked at from the government and the company side. Costs and benefits received from the government side can be seen in table 2.

Table 2. Costs and benefits from government side.

| No. | Cost                        | Total   | Benefit                                                                 |
|-----|-----------------------------|---------|-------------------------------------------------------------------------|
| 1.  | Grant                       | Rp 0    | Jobs Creation (Rp 80.000 x 1429 pekerja x 365 days x 30 years) Rp 1,251,804,000,000 |
| 2.  | No cost for not contaminating environment |         | Pollution (2.5 lt x 90 genset x 2,6413 kg/lt x 30 x 365 x $40 x Rp 13,500) Rp 3,514,051,552,500 |
|     | Total Cost                  | Rp 0    | Total Benefit Rp 4,765,855,552,500 |

Table 2 describe, the jobs can provide benefits to the population in 3 villages of Rp 1,251,804,000,000 for 30 years through daily wage of Rp 80,000,00 to 1,429 villagers involved in the operation of biomass power plants and management of bamboo fields.

Reduced pollution generated from the use of generators is divaluated in the form of rupiah will provide benefits amounting to Rp 3,514,051,552,500 for 30 years through the calculation of the number of generators in 3 villages as much as 90 genset multiplied by the use of diesel in the generator as much as 2.5 liters / day multiplied by the pollution cost of USD 40 multiplied by the dollar exchange rate at Rp. 13,500. At a cost that comes from the government side, the government in the construction of a biomass power plant on Siberut island does not incur any cost to support the project. Then the cost listed does not exist or Rp. 0. The government does not incur any costs because the development project uses grants originating from abroad. Instead of using loan from a bank or from a company that requires a payback within a certain period of time and can provide a large interest as a benefit from the borrower of funds. Costs and Benefits should also be viewed from the company side (private), because the company in doing project development needs to get a profit. Costs and Benefits from the Company side can be seen in table 3.

Table 3 describe, the side of the company / private benefits or profits derived from the cost of construction of power plants assumed by 30% of investment funds or grants of Rp. 48.6 billion. Then from the operational and maintenance of the power plant over the next 30 years, the private sector also gets a assumed profit of 25% of the electricity revenues agreed over the next 30 years. And the value of the company is in valuation assuming Rp. 500,000,000,000 because the private sector can have a high value of the company with the construction of biomass power plant with the first bamboo in Indonesia which affects the name of the company to be good because of PT. CPI became a pioneer in building biomass power plants with bamboo in Indonesia. The private sector can have a great opportunity to see more projects in building biomass power plants with bamboo in other areas because it already has a portfolio of biomass power projects with bamboo. Next look at the cost, private has 3 points of cost ie investment, operational & maintenance, and taxes. The source of investment is funds derived from foreign grants of USD 12 million or Rp. 162 billion. In the
operational & maintenance fund the amount of Rp. 167,065,740,000 derived from the assumption of 30% of electricity revenues for 30 years. And on tax the amount of Rp. 83,532,870,000, this amount comes from the assumption of 15% of electricity revenues for 30 years. From the comparison of costs and benefits of the private side can be seen that the total benefits greater than the total cost. It can be concluded that the development of this project also provides more benefits from the private sector with large valuation of high value of the rupiah.

Table 3. Costs and benefits from government side.

| No. | Cost                      | Total              | Benefit                        | Total       |
|-----|---------------------------|--------------------|--------------------------------|-------------|
| 1   | Investment                | Rp 162,000,000    | Power Plant fee                | Rp 48,600,000,000 |
|     |                           | ($12,000,000,000 x Rp 13,500) | ($12,000,000,000 x Rp 13,500 x 30%) |
| 2   | Operational & Maintenance | Rp 167,065,740,000| Operational Fee & maintenance | Rp 139,221,585,000 |
|     |                           | ($412,508 x Rp 13,500 x 30 years) | ($1.375,028 x 30 x Rp 13,500 x 25%) |
| 3   | Tax                       | Rp 206,254 x Rp 13,500 x 30 years | Valuation   | Rp 500,000,000,000 |
|     |                           | Total Cost Rp 412,598,610,000 | Total Benefit Rp 687,821,585,000 |

Table 4. Calculation of cost benefit of PLTBM Development for 30 years.

| Years | Total Revenue | Operation and Maintenance | Tax | Net Cash Flow | CUM NCF % |
|-------|---------------|----------------------------|-----|---------------|-----------|
| 1     | 1.375,028     | 412,508                    | 206,254 | 56,266        | -11,243,734 |
| 2     | 1.375,028     | 412,508                    | 206,254 | 56,266        | -10,487,468 |
| 3     | 1.375,028     | 412,508                    | 206,254 | 56,266        | -9,731,202  |
| 4     | 1.375,028     | 412,508                    | 206,254 | 56,266        | -8,974,936  |
| 5     | 1.375,028     | 412,508                    | 206,254 | 56,266        | -8,218,670  |
| 6     | 1.375,028     | 412,508                    | 206,254 | 56,266        | -7,462,404  |
| 7     | 1.375,028     | 412,508                    | 206,254 | 56,266        | -6,706,138  |
| 8     | 1.375,028     | 412,508                    | 206,254 | 56,266        | -5,949,872  |
| 9     | 1.375,028     | 412,508                    | 206,254 | 56,266        | -5,193,606  |
| 10    | 1.375,028     | 412,508                    | 206,254 | 56,266        | -4,437,340  |
| 11    | 1.375,028     | 412,508                    | 206,254 | 56,266        | -3,681,074  |
| 12    | 1.375,028     | 412,508                    | 206,254 | 56,266        | -2,924,808  |
| 13    | 1.375,028     | 412,508                    | 206,254 | 56,266        | -2,188,542  |
| 14    | 1.375,028     | 412,508                    | 206,254 | 56,266        | -1,412,276  |
| 15    | 1.375,028     | 412,508                    | 206,254 | 56,266        | -656,010    |
| 16    | 1.375,028     | 412,508                    | 206,254 | 56,266        | 100,256     |
| 17    | 1.375,028     | 412,508                    | 206,254 | 56,266        | 856,522     |
| 18    | 1.375,028     | 412,508                    | 206,254 | 56,266        | 1,612,788   |
| 19    | 1.375,028     | 412,508                    | 206,254 | 56,266        | 2,359,054   |
| 20    | 1.375,028     | 412,508                    | 206,254 | 56,266        | 3,125,320   |
| 21    | 1.375,028     | 412,508                    | 206,254 | 56,266        | 3,881,586   |
| 22    | 1.375,028     | 412,508                    | 206,254 | 56,266        | 4,637,852   |
| 23    | 1.375,028     | 412,508                    | 206,254 | 56,266        | 5,394,118   |
| 24    | 1.375,028     | 412,508                    | 206,254 | 56,266        | 6,150,384   |
| 25    | 1.375,028     | 412,508                    | 206,254 | 56,266        | 6,906,650   |
| 26    | 1.375,028     | 412,508                    | 206,254 | 56,266        | 7,662,916   |
| 27    | 1.375,028     | 412,508                    | 206,254 | 56,266        | 8,419,182   |
| 28    | 1.375,028     | 412,508                    | 206,254 | 56,266        | 9,175,448   |
| 29    | 1.375,028     | 412,508                    | 206,254 | 56,266        | 9,931,714   |
| 30    | 1.375,028     | 412,508                    | 206,254 | 56,266        | 10,687,980  |
The calculation of Cost Benefit Analysis of PLTBM development for 30 years, Payback Period in year 16. While Net Cumulative Net Cas Flow obtained until the year 30 is USD 10,687,980 or equivalent to Rp 144,287,730.000 This project is a grant of the MCA so that the calculation of cost benefit analysis is not affected by the Interest Rate. If the project is implemented without the support of the grant, the calculation of Cost Benefit Analysis is presented in table 5.

The interest rate used in the calculation of Cost Benefit Analysis of PLTBm development project if it is assumed not to use grant fund from MCA is 11% because in general, Based on the narrative from Deputy Minister of EMR, Local Bank gives Interest Rate about 10-11% (Detik.com, 2017). The result is that the company will suffer a loss up to 30 years, so it does not appeal to investors. The value of Internal Rate of Return on Siberut PLTBm project is 4.7%. From observations conducted in the field the researcher saw that in line with the power plant development process, each village established a special business entity owned by the village which aims to manage the biomass power plant that will operate in the future because the power plant built is currently owned by the village whose funding comes from foreign grants. This business entity is called a Village Owned Enterprise or abbreviated as BUMDes. Members of business entities consist only of village communities, not from some communities outside the village. It is intended that BUMDes can be managed independently by the community and the benefits can be enjoyed directly by the community and village government. However, the researcher sees that the village community has not yet comprehensively comprehended the management of power plants and other assets. Villagers and village government officials are not ready to manage the power plant directly and are still in the future in planning and management, it also takes years for villagers to be able to fully manage the power station independently. If BUMDes managed by the villagers directly, managing the power plant can have an impact on the ineffectiveness of electricity management that impacts on power supply can not run properly. If this power plant is held by the private sector in full and direct, it is also not feasible and may violate existing Government Regulations and Government Policies because power plants and other assets are owned by the local government and can not be managed by a purely private enterprise.

| Years | Total Revenue | Total Cost | Tax   | Net Cash Flow | Interest Rate 11% | Cumulative Net Cash Flow 11% |
|-------|---------------|-----------|-------|---------------|-------------------|-----------------------------|
| 1     | 1,375,028     | 412,508   | 206,254 | 756,266       | 681,321           | -11,318,679                 |
| 2     | 1,375,028     | 412,508   | 206,254 | 756,266       | 613,802           | -10,704,877                 |
| 3     | 1,375,028     | 412,508   | 206,254 | 756,266       | 552,975           | -10,151,902                 |
| 4     | 1,375,028     | 412,508   | 206,254 | 756,266       | 498,176           | -9,653,726                  |
| 5     | 1,375,028     | 412,508   | 206,254 | 756,266       | 448,807           | -9,204,919                  |
| 6     | 1,375,028     | 412,508   | 206,254 | 756,266       | 404,331           | -8,800,588                  |
| 7     | 1,375,028     | 412,508   | 206,254 | 756,266       | 364,262           | -8,436,326                  |
| 8     | 1,375,028     | 412,508   | 206,254 | 756,266       | 328,164           | -8,108,162                  |
| 9     | 1,375,028     | 412,508   | 206,254 | 756,266       | 295,643           | -7,812,519                  |
| 10    | 1,375,028     | 412,508   | 206,254 | 756,266       | 266,345           | -7,546,174                  |
| 11    | 1,375,028     | 412,508   | 206,254 | 756,266       | 239,951           | -7,306,223                  |
| 12    | 1,375,028     | 412,508   | 206,254 | 756,266       | 216,172           | -7,090,052                  |
| 13    | 1,375,028     | 412,508   | 206,254 | 756,266       | 194,749           | -6,895,303                  |
| 14    | 1,375,028     | 412,508   | 206,254 | 756,266       | 175,450           | -6,719,853                  |
| 15    | 1,375,028     | 412,508   | 206,254 | 756,266       | 158,063           | -6,561,790                  |
| 16    | 1,375,028     | 412,508   | 206,254 | 756,266       | 142,399           | -6,419,391                  |
5. Conclusion

The conclusions of this research is:

Comparison of Costs and Benefits between Biomass Power Plant (PLTBm) from bamboo with other energy in the village then PLTBm can provide more benefits because the production of electricity produced is much greater than the others. Based on private cost benefit analysis, the total cost of this Biomass Power Plant is Rp 412,598,610,000, while the benefits are Rp 687,821,585,000. While the cost benefit analysis from the side of the Government, the resulting cost is 0 rupiah, while the benefits obtained in terms of Government is Rp 4,765,855,552,500. By comparing the benefits and costs of both the private and the local government side, this Biomass Power Plant (PLTBm) with bamboo can provide more benefits than the costs incurred..

6. References

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