Simulation of generate value for development of biomass plants in Indonesia: a feasibility study

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Abstract. The main purpose of this paper is to define the generating value of biomass plants in Indonesia by a feasibility study. It is important to measure the optimal location to build biomass plants in Indonesia. Besides that, the need of supply of electrical energy in Indonesia is always increase in recent years. Based on data, three cities in Indonesia that potential become location to build those biomass plant from total organic wastes to generate total electricity through conversion of methane gas that produced from waste. In this paper, proposed method of feasibility study performed to achieve optimal value in the construction of biomass power plants and the optimal location to implant. The analysis through the data of total electricity generated from gas that calculated on feasibility aspect values on NPV, IRR, and PI. The result show, in three cities of Indonesia produce a positive feasibility value based on value of IRR that greater than 20% tax so that the Government of Indonesia can implementing biomass plants on those three cities

1. Introduction
In many countries, organic waste treatment has been carried out with the aim of utilizing organic waste that is converted into electrical energy. The development of environmentally friendly technology is a top priority in each country as the main manifestation in reducing organic waste and helping to reduce the greenhouse effect caused by polluted air from waste that decomposes in reservoirs. Sustainable waste management is an important part of general efforts to reduce pollution and greenhouse gas emissions and to reduce global climate change [1]. Anaerobic digestion has emerged as a successful and promising technology for organic waste management as part of a growing effort in developing alternative energy sources. and strengthening environmental regulations on waste disposal and policies around the world from reducing greenhouse gas emissions [2].

In Indonesia, the development of anaerobic organic waste management technology is one of the top priorities. The Indonesian government has planned the development of renewable technology as a supplier of additional electrical energy to various regions. Based on politics and economics is very worrying over trends in the use of fuel from petro-chemicals that are not sustainable. This gives more attention to the use of biomass as a renewable energy to produce a decrease in fossil fuels [3]. CO₂ in biogas comes from organic waste released into the atmosphere on a relatively short time scale [4]. To prevent this, the biogas production process by anaerobic fermentation from organic matter is the most widely used technology and has the highest popularity [5]. Biogas not only contains methane gas and
carbon dioxide. but also other gases such as hydrogen sulfide, siloxanes, halogenated hydrocarbons, or ammonia produced during the anaerobic digestion stage [6,7].

The application of anaerobic co-digestion technology for organic waste treatment has increased in recent years [8] and anaerobic waste treatment for solid waste co-digestion is considered a clean energy technology that is able to convert energy directly from organic waste by microorganisms [9,10]. Biogas technology as an organic waste treatment is an effort to help reduce water pollution at the concentration of polluted organic waste. Utilization of biogas technology refers to the process of mixing organic waste that is transformed by microorganisms in the absence of oxygen. so that it will produce methane gas which is expected to provide electrical energy through the conversion process.

2. Literature Review

In the application of biomass-based energy supply improvement activities. several countries have already done so. In Bolivia [11]. the development of the framework is prioritized as optimization in the transportation of biomass base materials to expand biomass applications in the energy in Bolivia. A critical review of the maturity status of the four most promising thermochemical conversion routes has been conducted in Malaysia [12] which has a very positive opportunity as a country in the tropics with abundant agricultural.

In Europe industries. the supply of biomass is the main focus because the production and consumption of biomass for the industry are quite balanced [13] where the opportunity to increase the supply of biomass production is the main point to maintain environmentally friendly sustainability. The application of biomass consumption in Indonesia is somewhat lacking due to the lack of biomass power plants in Indonesia. Related to power plants. it is necessary to have good planning in terms of location and implementation because it requires a considerable investment. For wide application in Indonesia. feasibility studies are needed. especially for big cities that can supply basic materials for biomass that will later be converted into electrical energy.

3. Method

In this research method. applying the mathematical model method to get the value of the net present value (NPV). Internal Rate Return (IRR) and Profitability Index (PI) with a tax value assumed to be 20%. In this paper. discuss and calculate the Pay Back Period (PP) and the Average Rate of Return (ARR). The data obtained is based on the organic waste treatment process through the digestive process. processed through fermentation to produce methane gas that is converted into electrical energy. Data processing uses input data based on the value of investment reduced by the value of expenses. the work process with an estimate of 3 working months and the results obtained are based on the benefits of processing waste into methane gas that is converted into electrical energy. The study made the cities of Jakarta. Bandung. and Surabaya in Indonesia as objects with total waste that can be seen in Table 1. Design of biomass reactor design by co-digestion treatment. with reactor design planning per unit of 1.050 m$^3$ and at each reactor construction issued costs 50 USD per m$^3$ [14].

Data is taken from the analysis process carried out from Farizal. et al. [15]. Where in it is known that the most total waste is generated in Jakarta City. ranked second is the most total waste generated in Bandung City and ranked third with the most total waste being in Surabaya City. The data obtained is based on the organic waste treatment process through the digestive process. processed through fermentation to produce methane gas that is converted into electrical energy. Data processing uses input data based on the value of investment reduced by the value of expenses. the work process with an estimate of 3 working months and the results obtained are based on the benefits of processing waste into methane gas that is converted into electrical energy. The total waste will affect the methane gas produced to be converted into electrical energy as the final results are shown in Table 1. In the digestive process of organic waste. methane is produced through the processing of organic waste in the reactor room. The total digester in the design of the reactor design is shown in Table 2.
Table 1. Data Collection of Organic Waste

| City       | Organic Waste | Methane kWh  | Methane kWh  |
|------------|---------------|--------------|--------------|
| Jakarta    | 13.902.789    | 302.251.383  | 2.446.477.101|
| Bandung    | 5.105.438     | 106.749.742  | 864.051.628  |
| Surabaya   | 4.787.838     | 104.696.554  | 847.432.750  |

Table 2. Reactor Design

| City       | Volume      | Digester | Total Digester |
|------------|-------------|----------|----------------|
| Jakarta    | 10.427.092  | 1.050    | 9.931          |
| Bandung    | 3.829.079   | 1.050    | 3.647          |
| Surabaya   | 3.590.879   | 1.050    | 3.420          |

The design of the digester in Jakarta City with a volume of organic waste of 10.427.092 m³ required 9.931 ≈ 10 reactors with the planning of one reactor with dimensions of 1.050 m³. Planning for reactor construction in Bandung City and Surabaya City with dimensions of 1.050 m³ so that it needs the construction of a chancellor about 3.647 ≈ 4 reactors for Bandung City and 3.420 ≈ 4 reactors for Surabaya City.

4. Result and Discussion

The data is processed using a mathematical model by planning in advance to find the value of initial investment and revenue obtained by the company based on electricity sales and waste transportation services. Planning on the design of biomass reactors in three cities. namely Jakarta. Bandung and Surabaya. based on the calculation. obtained the value of fund management shown in Table 3.

Table 3. Fund Management

| City    | Investment (USD) | Operational Cost (USD) | Value of receiving funds (USD) |
|---------|------------------|------------------------|-------------------------------|
| Jakarta | 522.285.727      | 316.401.360            | 598.788.102                   |
| Bandung | 191.775.680      | 138.977.904            | 223.565.806                   |
| Surabaya| 179.823.267      | 144.401.904            | 217.523.487                   |

The calculation of investment funds is carried out with the assumption of total expenditure in the construction of a biomass reactor of $ 50 per m³ and the average of Tax Object Sales Value assumption in each city:

(a) Tax Object Sales Value in Jakarta is 285.7 USD per m²,
(b) Tax Object Sales Value in Bandung is 39.3 USD per m²
(c) Tax Object Sales Value in Surabaya is 46.4 USD per m²

The revenue value is calculated based on the total sales of electricity to the State Electricity Company (PLN) with an average value taken from three cities in Indonesia around 0.07 USD per m².

Table 4. shows the value of EAT (Earning After Tax) calculated based on the value based on Table 3. The calculation is done with the assumption that the value of the tax or Degree of Freedom is 20%. Planning is calculated over the next 5 years with an increase in inflation estimated at 35% to 38% per year.
Table 4. Earning After Tax (EAT)

| Years | Jakarta      | Bandung      | Surabaya     |
|-------|--------------|--------------|--------------|
| 2020  | 225,909.393  | 67,670.321   | 58,497.266   |
| 2021  | 304,977.681  | 91,354.934   | 78,971.309   |
| 2022  | 414,769.646  | 124,242.710  | 107,400.981  |
| 2023  | 568,234.415  | 170,212.513  | 147,139.344  |
| 2024  | 784,163.493  | 234,893.268  | 203,052.294  |

Payback Period (PP) in the three cities obtained positive results that are estimated to not more than 5 years have earned income. In this case, the planning for building a biomass co-digestion reactor is feasible (Table 5.). Average Rate Return (ARR) obtained based on the results of calculations from data processing that has been described and known. The ARR value obtained during the Payback term expiration period shows a very favorable and feasible value (Table 5.).

The Net Present Value (NPV) in Table 5 shows a positive NPV value. Based on these results, it can be concluded that construction carried out in three cities will have a good and positive impact on the company. Profitability Index (PI) is considered positive if it is greater than 1 (one) time of receipt. In this case, the revenue obtained by the company must not be less than 1 time the receipt. When the receipt of less than 1 time the receipt occurs, the company will be considered a loss. However, in the calculation of the feasibility study of three cities in Indonesia showed acceptance more than once (Table 5.). The PI calculation results show that the construction of a biomass reactor is feasible. Internal Rate Return (IRR) is shown in table 5. The results show the IRR obtained a positive value by exceeding the assumed Degree of Freedom value of 20%. The calculation is obtained based on the interpolation of negative NPV and positive NPV.

Table 5. The Results of Calculations on Feasibility

| Value | Jakarta      | Bandung      | Surabaya     |
|-------|--------------|--------------|--------------|
| PP    | 4.7 years    | 4.7 years    | 3.11 years   |
| ARR   | 101,114,290.50 | 24,708,994.08 | 19,691,435.43 |
| NPV   | 91,241,119.74 | 18,543,072.10 | 32,547,994.86 |
| PI    | 1.17         | 1.10         | 1.18         |
| IRR   | 25.00        | 23.00        | 25.01        |

The results show that Jakarta has the potential to get the most profitable among the three cities. For the initial implementation, it is recommended to build a power plant in Surabaya. Due to Surabaya City has the fastest PP so that it can be a more precise depiction and pilot project.

5. Conclusion
The feasibility study in three major cities in Indonesia, namely Jakarta, Bandung, and Surabaya, produced several conclusions with different values in its application. Jakarta City has a payback period of 4.7 years and will experience a return on capital or after that generate a net profit. ARR value of 101,114,290 USD. NPV 91,241,119 USD and PI of 1.17 times in the receipt of profits from the construction of a biomass power plant reactor with an IRR value of 25% greater than the tax determination of 20%. Based on the value of the IRR, it can be concluded that the feasibility study in Jakarta City is considered positive and feasible to be implemented.
In Bandung City, it is known that the value of the payback period is 4.7 years smaller than 5 years, so it is considered feasible to apply. Furthermore, the ARR value of 24,708,994 USD, the NPV of 18,543,872 USD and the IRR value of 23% are greater than the tax determination of 20%. In the construction of biomass reactors with organic waste as raw material to produce methane gas to be converted into electrical energy with Profitability Index of 1.10 times acceptance. It can be concluded that the construction of biomass reactors in Bandung City is considered feasible to apply.

Based on data processing in Surabaya City, the result show obtained number of values that were considered positive. Payback Period in 3.11 years were considered positive because less than 5 years. Obtained ARR 19,691,435 USD was positive. NPV 32,547,994 USD was stated positively. PI that more than 1 times. 1.18 > 1 times in development the reactor is considered feasible and IRR is 25% > 20% that it is declared positive. Data processing in three cities in Indonesia concludes that a feasibility study on the construction of a biomass reactor with organic waste as raw material is considered feasible in implementation and the city suggested as the initial implementation is Surabaya city in terms of speed in the payback period.

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