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A Study of Sugarcane Waste for Biomass Energy in the Supply of Electrical Energy

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Abstract - *This paper presents a study of sugarcane waste for biomass energy in the supply of electrical energy. Biomass is a renewable energy source derived from organic matter such as wood and sugarcane waste. As much as 30 per cent of sugar cane raw material for sugar production is in the form of sugar cane waste. This sugarcane waste is very potential to be developed as a biomass energy raw material. In this study, an analysis of the potential of sugarcane waste at the Madukismo Yogyakarta sugar mill was carried out. Observations made to record how much cane waste is produced by the sugar factory every day of the year. Furthermore, these data are analyzed using Homer Energy software to obtain the potential of electrical energy produced during a year. The analysis was also carried out on the amount of electricity demand in the sugar factory. This study is done to calculate how much the contribution of electrical energy from biomass as a provider of electricity supply. The results of the analysis showed that sugarcane waste as much as 1.035 tons/day on average was able to meet all the electrical energy requirements for the operation of the Madukismo sugar factory.*

Keywords*: Biomass, sugarcane waste, electrical energy, renewable energy*

I. Introduction

Now it is very easy to find an industry even though it is located close to densely populated settlements. The location of a factory adjacent to residential areas can certainly cause bad impacts, either through solid, liquid or gas waste—especially solid waste which requires a large enough shelter [1]. The activity of industry in Indonesia cannot continue without a process that can reduce the negative impacts caused by the manufacture of products in an industry. Waste or garbage is indeed a material that is meaningless and worthless, but we do not know that waste can also be something useful and beneficial if it is processed properly and correctly.

Several factories in Indonesia have now started implementing a waste treatment system to reduce the impact of pollution from these wastes, and some even use their factory waste to be used as new, useful products which of course are processed through certain processes. One of them is processing the residual waste from making sugar into compost, concrete blocks and others. Utilization of waste is currently very important, especially in overcoming the problem of garbage accumulation in big cities, industrial organic waste, and agricultural and plantation waste [2].

Biomass is organic material produced through photosynthetic processes, either in the form of products or waste [3]. Examples of biomass include plants, trees, grass, sweet potatoes, agricultural waste, forest waste, faeces and livestock manure.

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Apart from being used for the primary purpose of food, animal feed, vegetable oil, building materials and so on, biomass is also used as a source of energy (fuel). Commonly used as a fuel is biomass which has low economic value or is waste after the primary product has been taken [4].

The potential for biomass in Indonesia which can be used as an energy source is very abundant. Wastes originating from animals and plants are all potential to be developed. Food crops and plantations produce substantial waste, which can be used for other purposes such as biofuel. The use of waste as a biofuel provides three immediate benefits. First, increasing overall energy efficiency because the energy content contained in waste is quite large and will be wasted if not utilized. Second, cost savings, because disposing of waste can often be more expensive than utilizing it. Third, reduce the need for landfills because providing landfills will be more difficult and expensive, especially in urban areas [5].

There is also gasification technology as one of the biomass energy conversion technologies, but this technology has very limited development in Indonesia. Less research related to gasification technology is also being conducted. This technology includes technology that is relatively simple and easy to operate and is technically or economically feasible to develop. Thus, this gasification technology is very suitable to be developed in Indonesia, but basic research is needed so that this technology is ready to circulate.

Biomass gasification technology is a form of energy conversion contained in biomass. The gasification process takes place in a reactor called a gasifier. In this tool, biomass fuel is broken down in a reactor (combustion chamber) with limited air [6]. In other words, the biomass gasification process is a process of incomplete combustion of solid biomass raw materials, involving a little reaction between oxygen and solid fuel in the form of biomass. Water vapour and carbon dioxide from combustion are reduced to flammable gases, namely carbon monoxide (CO), hydrogen (H_2) and methane (CH_4).

The sustainability of biomass lies in the fact that this type of energy does not burden the environment with additional CO_2 emissions because the amount released during its use as a fuel can be reabsorbed only by replanting these types of crops. In fossil fuels, CO_2 was captured and stored millions of years ago, so when it was released back to where it is today, it harmed the environment [7].

Based on these facts, it is very interesting to conduct a study on the utilization of sugar factory waste for biomass. Sugar factory waste in the form of bagasse is very potential to be used as raw material for biomass. In this research, a case study was conducted at the Madukismo sugar factory located in Bantul Regency, Yogyakarta Special Region Province, Indonesia.

The purpose of this study was to determine the availability of sugarcane waste at the Madukismo sugar factory. The next goal is to determine the potential of sugarcane waste in providing electrical energy from sugarcane waste. The final objective is to analyze the biomass energy of sugarcane waste as an environmentally friendly source of electrical energy in the community.

II. Literature Study

II.1 Literature Study About the Sugarcane Waste

Saputra [8] examined sugarcane plants in Indonesia which are used as raw material for making sugar by sugar factories. The remains of the mill in the form of bagasse are usually not fully utilized. Indeed, in most sugar factories, bagasse has been used as fuel in boilers, but because of its large quantity and fruitful nature, it causes storage problems in sugar factories and is flammable because it contains water, sugar, fibre and microbes, so excess bagasse is burned excessively.

Hugot [9] researched that each kilogram of bagasse with a sugar content of about 2.5% will have a heat of 1825 kcal. The fuel value will increase with decreasing the water and sugar content in the waste. With the application of dregs drying technology that utilizes heat energy from the flue gas of the boiler chimney, where the water content of the dregs drops to 40%, it can increase the value of the fuel per kg of dregs to 2305 kcal.

Rifai [10] observed that the amount of pulp available in sugar factories depends on the amount of milled sugarcane and the coir content of the sugarcane varieties. The amount of pulp available in the sugar factory varies between 25-34% of the weight of the milled sugarcane. So, if the amount of bagasse is an average of 30% of the weight of sugarcane and the milling capacity of a PG is 5,000 tons of sugarcane per day (TCD), then the amount of pulp available is around 1,500 tons/day. A sugar factory whose energy processing is efficient, the potential for a surplus of waste can reach 10% of the weight of sugarcane or around 500 tons of dregs per day for a sugar factory with a capacity of 5,000 TCD.

The caloric value of bagasse in the form of net calorific value (NCV) is around 7,588 kJ/kg at 50% moisture content; this caloric value is lower than the wood calorific value of 12,500 kJ/kg at 30% moisture content. However, bagasse is a potential source of energy in large quantities if energy use in sugar factories is efficient and renewable [11].

From the results of the literature review above, this research will discuss how to process the potential of sugarcane waste biomass as alternative energy that is friendly to the environment.

II.2. Biomass

Biomass in the energy production industry refers to living or recently dead biological material used as a fuel source or for industrial production. Biomass generally refers to plant matter that is maintained for use as a biofuel but can also include plant or animal matter used to produce fiber, chemicals, or heat. Biomass can also include biodegradable waste, which can be burned as fuel. Biomass does not include organic matter that has been transformed by geological processes into coal or petroleum substances [12].

Biomass is organic material produced through photosynthetic processes, either in the form of products or waste. Examples of biomass include plants, trees, grass, sweet potatoes, agricultural waste, forest waste, feces, and livestock manure. Apart from being used for the primary purpose of fiber, foodstuffs, animal feed, vegetable oil, building materials, and so on, biomass is also used as a source of energy (fuel). Commonly used as fuel is biomass, which has low economic value or is waste after the primary product has been taken.

The source of biomass energy has several advantages. Among others, it is a renewable energy source to provide a sustainable energy source. In Indonesia, biomass is a very important natural resource with various primary products as fiber, wood, oil, foodstuffs, etc. Biomass can be used for direct energy sources or can be processed or converted into fuel. Biomass energy utilization technology that has been developed consists of direct combustion and conversion of biomass into fuel. This biomass conversion results can be in the form of biogas, bioethanol, biodiesel, or charcoal. Bioethanol and biodiesel are expected to be used as a substitute fuel for oil in the long term.

Biomass energy is a type of fuel made by converting it with biological materials such as plants. Biomass energy is important compared to renewable energy because the conversion process into electrical energy has a cheaper investment than other types of renewable energy sources. This is the advantage of biomass compared to other energies. The absorption is still very simple; biomass is immediately burned and produces heat. When biomass is burned, energy will be released. In modern times, the heat from combustion is converted into electrical energy through turbines and generators. The heat from the combustion of biomass will produce steam in the boiler. The steam will be transferred into the turbine so that it will produce rotation and move the generator. The turbine rotation is converted into electrical energy through the magnets in the generator. Direct combustion of biomass has disadvantages so that in current applications, several technologies are starting to increase the benefits of biomass as a fuel [13].

Gasification is a process that uses heat to convert solid biomass or other carbonaceous solids into synthetic gas, such as flammable natural gas. Through the gasification process, all solid organic matter can become a clean and neutral fuel gas. The gas produced can be used for electricity generation as well as for heating. In order to carry out gasification, a reactor is required. The reactor is where the gasification process takes place and is known as a glacier. Most of the biomass is wood. Besides, gasification can use raw materials from plantation waste.

The gasification process is a gradual combustion process. This process is done by burning solids such as wood and coal that have been known for centuries. The gasification process can be said to be a chemical reaction at high temperatures between biomass and air. Gasification consists of several separate stages as follows [14]:

1. Drying Stage

The water content of the solid fuel is evaporated by heat absorbed from the oxidation process. Biomass is drying at a temperature of 100°C.

2. Pyrolysis Stage

When the temperature reaches 250°C, biomass undergoes a pyrolysis process, which is the fracturing of large molecules into small molecules due to the influence of very high temperatures. Separation of volatile matters (water vapor, organic liquids, and uncondensed gases) from charcoal or fuel carbon solids also uses heat absorbed from the oxidation process.

3. Oxidation Stage

Combustion oxidizes the fuel's carbon and hydrogen content by an exothermic reaction, whereas gasification reduces the combustion product to gas by an endothermic reaction. Oxidation or charcoal-burning is the most important reaction that occurs in a gasifier. The results of the reaction are CO_2 and H_2O, which are reduced respectively, when in contact with the char produced during pyrolysis.

4. The Reduction Stage

The reduction stage involves a series of endothermic reactions supported by the heat produced from the combustion reaction. At temperatures above 600oC, charcoal reacts with water vapor and carbon dioxide to produce H_2, CO, and CH_4.

II.2. Biomass Potency in Indonesia

The potential for renewable energy, which is large and not widely used, is energy from biomass. The biomass energy potential of 50,000 MW is only 320 MW, which has been utilized or only 0.64% of its potential. The potential for biomass in Indonesia comes from waste products from palm oil, cashew nuts, rice mills, wood, sugar factories, cocoa, and other agricultural, industrial waste (http://www.ipard.com). Based on previous research, many have been done to study the potential for energy in solid form from various agricultural wastes such as bagasse, rice husks, and agricultural corn waste [15].

The potential for biomass in Indonesia, which can be used as an energy source, is very abundant. Wastes originating from animals and plants are all potential to be developed. Food crops and plantations produce substantial waste, which can be used for other purposes such as biofuel. The use of waste as a biofuel provides three immediate benefits. First, increasing overall energy efficiency because the waste's energy content is quite large and will be wasted if not utilized. Second, cost savings, because disposing of waste can often be more expensive than utilizing it. Third, reduce the need for landfills because providing landfills will be more difficult and expensive, especially in urban areas.

Apart from utilizing waste, biomass as the main product for energy sources has recently been developed rapidly. Oil palm, jatropha, and soybean are several types of plants whose main products are raw materials for biodiesel. Meanwhile, cassava, corn, sorghum, and sago are plants whose products are often used to make bioethanol.

The energy needs are none other than the energy needed to produce and evenly distribute basic human needs. Various forms of energy have been used by humans, such as coal, oil, and natural gas, non-renewable fuels. Apart from that, other resources such as firewood are still being used, but this firewood is limited with the diminishing forest as a wood source. With the increasing number of people, especially those living in rural areas, household energy needs are still a problem that must be resolved. The problem of rural energy needs can be overcome using alternative energy sources that are environmentally friendly, cheap, and easily obtained from the surrounding environment and are renewable. One of the environmentally friendly energies is biogas produced from the fermentation process of organic materials due to anaerobic bacteria's activity in an environment without free oxygen. Biogas energy is dominated by methane gas (60% - 70%), carbon dioxide (40% - 30%), and several other gases in smaller amounts.

New research has suggested that bagasse can be used as a substitute for electricity. Seeing the extent of sugarcane plantations in Indonesia, which is expected to continue to grow along with national sugar self-sufficiency, the utilization of bagasse waste will certainly become a new potential for energy development in the country.

The potential for bagasse in Indonesia is quite large. This potency is associated with an increase in sugarcane production. In 1999, it was recorded that it reached 2,270,623 tons, so the bagasse produced ranged from 340,593 tons to 711,614 tons. People's tendency to make bagasse only as animal feed turns out that behind the bagasse, waste can be transformed into a new material with a higher economic value. One of them is organic materials in making alternative electricity sources. Dried bagasse contained 24.64 of hemicellulose and cellulose, respectively; 54.4; and 45.60%.

The Indonesian Sugar Plantation Research Center also states that the bagasse produced in a factory is 30 percent of milled sugarcane weight with a moisture content of about 50 percent. Based on dry matter, bagasse consists of the element C (carbon) 47%, H (hydrogen) 6.5%. O (oxygen) 44% and ash 2.5%. According to the Pritzelwitz formula (Hugot, 1986), each kilogram of bagasse contains about 2.5 percent sugar with a heating value of 1,825 kcal. The fuel value will increase with decreasing the water and sugar content in the waste. So that the potential for sugarcane waste/bagasse is very good to be developed in Indonesia because it can produce a large amount of electrical energy using the MFC tool, which is a device that uses bacteria to generate electric power from organic and non-organic compounds.

III. Methodology

This research was conducted in the Madukismo Padokan Sugar factory, Tirtonirmolo, Kasihan, Bantul, Yogyakarta, Indonesia. Figure 1 shows a plan of the location of this study.

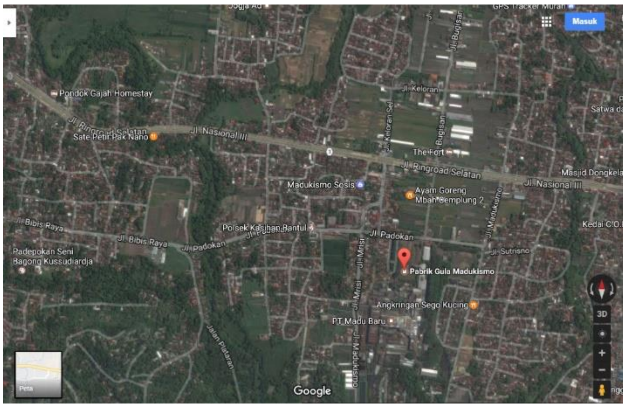


Figure 1. Location of this study in google maps

The Madukismo sugar factory was founded in 1995 on the initiative of Sri Sultan Hamengkubuwono IX. After that, on May 29, 1958, it was inaugurated by President Ir. Soekarno. This sugar factory started production in 1958, while the alcohol and spirits factory only started production in 1959. The main contractor at the Madukismo Sugar Factory is Machine Fabriek Sangerhausen, East Germany. The company status is a Limited Liability Company (PT), which has two factories, namely the Sugar Factory (PG) and the Madukismo Spirit Factory (PS). The 65% shareholder is Sri Sultan Hamengkubuwono X, and 35% belongs to the Republic of Indonesia's government.

The research steps are described as follows.

a. Location selection

The location chosen as the research site was the Madukismo Padokan Sugar factory, Tirtonirmolo, Kasihan, Bantul, Daerah Istimewa. This location was chosen because it has a renewable source of biomass energy that can be used as an electric energy generator.

b. Preliminary study

It is a stage of observation and data collection in the writing methodology. Observations and data collection were carried out regarding the biogas in the Madukismo Sugar factory.

c. Problem identification and formulation

The process is a stage of identification and formulation of problems that exist in the Madukismo Sugar factory. The process of problem identification was carried out by direct observation and interviews with the Madukismo Sugar factory's management.

In writing this final project, the problem raised is the optimization of the existing biomass at the location to generate electricity with great power.

d. Literature review

It is a stage that is carried out to find information, theories, methods, and concepts relevant to the problem. The information obtained can be used as a reference to solve the problems in the Madukismo Sugar factory. A literature study is carried out by looking for information and references in textbooks, online media, discussions with lecturers, and various sources.

e. Data collection

It is a stage carried out by observing and collecting data directly at the Madukismo Sugar factory. Observations are made directly. The results of these observations and data collection are in photos, videos, textbooks, etc. used for analysis materials in solving existing problems.

f. Data processing

The data that has been obtained during the observation will be selected as needed in order to solve existing problems. This data processing is done by manually calculating and simulating the use of HOMER software.

g. Data analysis.

At this stage, data processing results will be analyzed in more detail to obtain conclusions from the research conducted. After obtaining the results of the analysis, the discussion stage was carried out. At this stage, the analysis and data processing results will be discussed in more detail so that data conclusions will be generated that will prove the success or failure of the proposed hypothesis.

IV. Results and Discussion

IV.1 Electrical System at Madukismo Sugar Factory

The Madukismo Sugar Factory continues to subscribe directly to electricity from PLN and is assisted by an electricity generation system that can accommodate the entire industry's total load. The production and sugarcane processing factories are supplied through 3 generators with a capacity of 1280 kW and a capacity of 1600 kW to accommodate the burden of the production sector and the domestic sector of 3000 kW. This factory is in production for 24 hours from May to October. During the non-milling season and the milling season, the Madukismo factory uses PLN 4000 kW power and, besides, uses a biomass generator because the power from PLN is not sufficient. This generator works with steam, which is produced from burning in a boiler with bagasse and wood.

To obtain electricity data by conducting a visit, analyzing all activities at the Madukismo factory, analyzing company manual data, and directly processing it.

The production sector and sugarcane processing factory are supplied through 3 generators with 1280 KW and a capacity of 1600 kW to accommodate the load of the production and domestic sectors of 3000 kW. The Madukismo Sugar Factory produces 24 hours of production from May to October 2016. During the unmilled or milled season, the Madukismo Sugar Factory uses PLN's power of 4000 KW plus a biomass generator because the power from PLN is not sufficient. This generator works with steam generated from burning in a boiler with bagasse and wood.

IV.2 Biomass Potential Analysis Using Homer Software

Figure 2 shows the average amount of biomass feedstock in a year in Madukismo Sugar Factory. A feedstock is a bulk raw material which is the main input for industrial processes. The feedstock here is sugarcane waste. It can be seen as the highest in June and the lowest in July. Based on the biomass potential at the Madukismo Sugar Factory, the average amount of feedstock, is taken from 30% of daily production for one year. There is no milling season from November to April, so there is no production process and empty biomass feedstock.

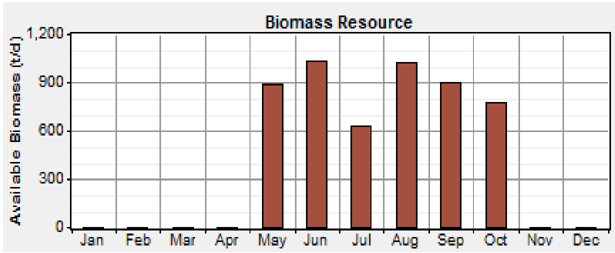


Figure 2. The average amount of biomass feedstock in a year in Madukismo Sugar Factory

Figure 3 shows the bagasse data, which has been calculated as 30% of the daily production for one year. There is no milling season from November to April, so there is no production process and empty biomass feedstock. It can be seen in June bagasse up to 1,034,950 tons/day. Moreover, the lowest stock is in July, only producing bagasse of 628,110 tons/day.

Month	Available Biomass (tonnes/day)
January	0.000
February	0.000
March	0.000
April	0.000
May	892.440
June	1,034.950
July	628.110
August	1,019.310
September	898.230
October	773.980
November	0.000
December	0.000
Annual average:	440.349

Figure 3. The bagasse data of 30% of the daily production for one year

In designing the Homer system, it will analyze the design connected to the PLN grid. The image provided below shows the Homer component window used in this study. Various special system components were selected, namely primary load 1, Generator 1 (fuel curve setting as biomass), Generator 2 (fuel curve setting as biomass), and Generator 3 (fuel curve setting as biomass). Figure 4 shows the component selection in the Homer software.

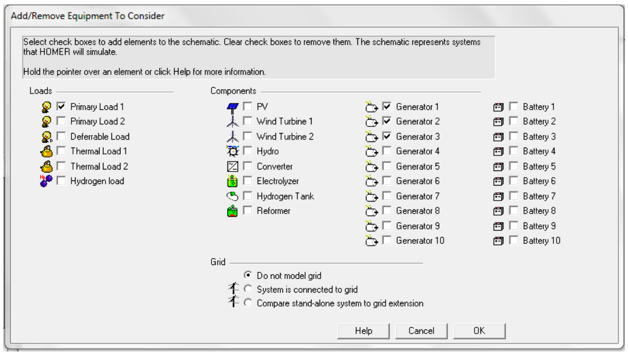


Figure 4. The component selection in the Homer software

Figure 5 shows the primary load simulation image from November to April at Homer Energy, where the power used is relatively small because, in that month, Madukismo factory is not producing. Hourly data collection from November to April. So from November to April, it is assumed that the average industrial load is 148 kW.

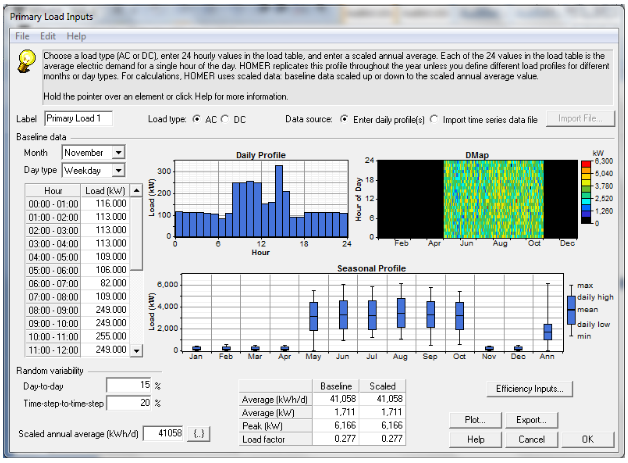


Figure 5. The primary load simulation image from November to April at Homer Energy

Figure 6 shows the primary load simulation results from May to October, wherein that month, Madukismo was in production, and the power load was quite large. So Homer can accommodate changes in the profile of the electric generator every month. However, in this study, the tropics' load profile can be considered the same for each month. This profile is due to the absence of significant climatic differences in the one year.

In the power simulation, Homer Energy software only requires total active power data. The electric load simulation used in this generating system is assumed to be 15% random variability and 20% time to step according to the conditions used.

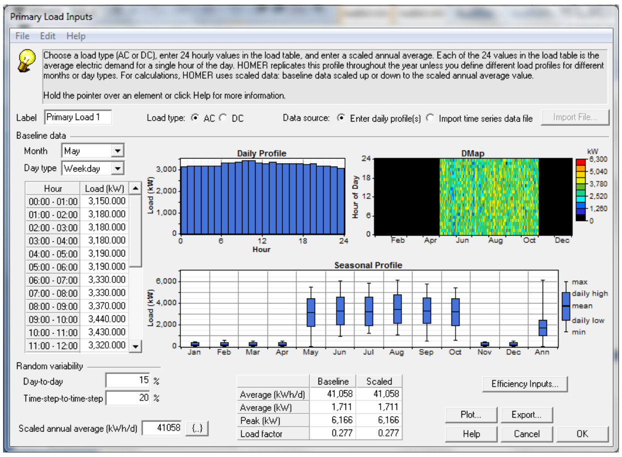


Figure 6. The primary load simulation results from May to October

Figure 5 and Figure 6 show that from November to April, this company did not process sugarcane milling and did not produce. So, from November to April, it is assumed that the average industrial load is 148 kW. Meanwhile, from May to October, the company has a process of milling sugarcane and producing. So, from May to October, it is assumed that the average industrial load is 3256 kW.

Figure 7 shows a graph of the electricity load profile per hour per month in one year. The daily profile of industry electricity, according to Homer Energy, is almost the same as a whole, but still varies. Likewise, each month of the year's profile also varies, but the amount is the same.

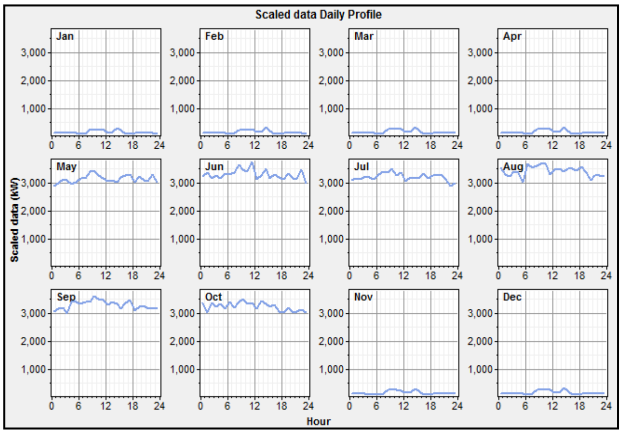


Figure 7. A graph of the electricity load profile per hour per month in one year

Generator simulation 1 (biomass resource-bagasse) is a simulation of supplying electrical power and a device that can convert mechanical power into electrical energy. The energy produced by turbine steam from the boiler with bagasse fuel. Utilization of bagasse by 30%. This fuel depends on the construction of the generator used by the electric power plant. In this study, a generator is used using AC. This generator has a power capacity of 1280 kW. This generator has a power of 1600 kW, 2000 kVA. In Figure 8, the homer system design also explains that the efficiency is 50%, and the replacement cost is assumed to be 50% or US$ 250000 of the purchase price and O&M costs of US$ 0.050.00 per hour.

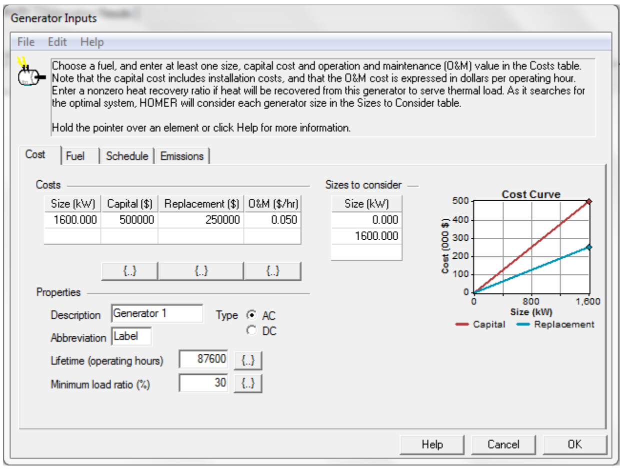


Figure 8. The homer system design also explains that the efficiency is 50%

Figure 8 describes the initial purchase price (capital) of a 1600 kW generator of US $ 500,000 and for replacement costs of US $ 250,000. Figure 9 explains that the generator work schedule 1, 2, 3 is only from May to October for 24 hours. Due to that month, the company is in production.

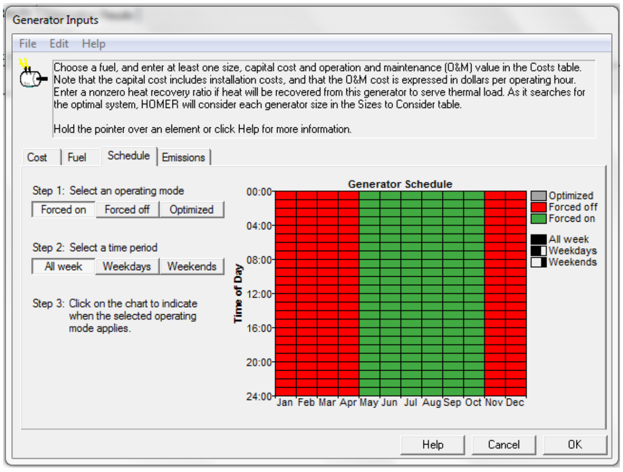


Figure 9. The generator work schedule 1, 2, 3 is only from May to October for 24 hours

Generator simulation 2 (biomass resource-bagasse) is a simulation of providing electrical power and a device that can convert mechanical power into electrical energy. The electrical energy generated by the steam alternator turbine stimulates the steam turbine from the boiler with bagasse fuel. The utilization of bagasse by 30% depends on the generator construction used in the electric power generator. In this study, a generator is used using AC. This generator has a power capacity of 1280 kW.

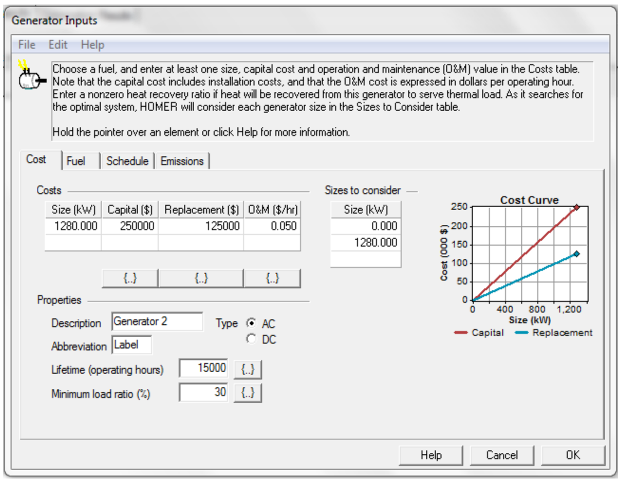


Figure 10. The homer system design shows the maximum efficiency of 50%, and the replacement cost is assumed to be 50% or US$ 150,000 of the purchase price

In Figure 10, the homer system design shows that the maximum efficiency is 50%, and the replacement cost is assumed to be 50% or US$ 150,000 of the purchase price. Moreover, O&M routine maintenance costs US$ 0.050 per hour.

Figure 10 also explains the initial purchase price (capital) of a 1280 kW generator of US$ 250,000 and for replacement costs of US$ 120,000.

In the homer system design, it is determined that generators 1, 2, and 3 will work from May to October for 24 hours because the factory is in the process of grinding and producing. From this production system it generates power to fulfill electricity in Madukismo for the month. Meanwhile, from November to April, the generator does not work because, in that month, it uses power from PLN. Figure 11 shows the generator work schedules 2 and 3 in Homer software.

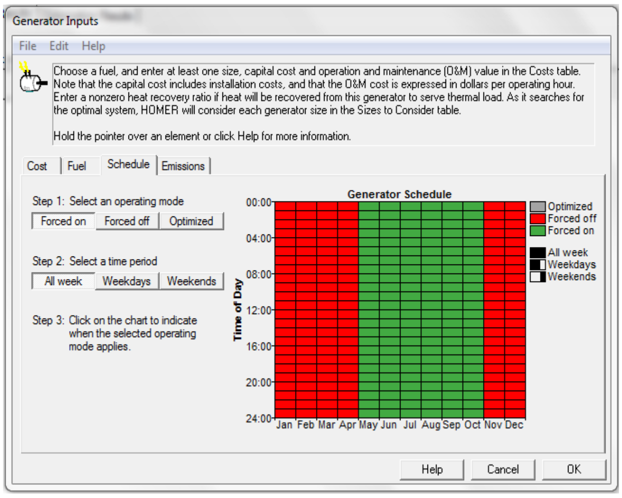


Figure 11. The generator work schedules 2 and 3 in Homer software

In Figure 12, it is shown that data processing using Homer software gets the results of the power produced by a biomass generator of 7,065,600 kWh/year, 1280 kW biomass generator 5,652,480 kWh/year, and 5,652,480 kWh/year with the use of the company's production load of 19,015,288 kWh/year. With the purchase of power from PLN of 644,727 kWh/year. The capacities produced by the biomass generator are 1600 kW and 1280 kW.

Homer Energy software does not require load sampling every minute, but every hour. This load data is taken from interviews with Madukismo factory employees.

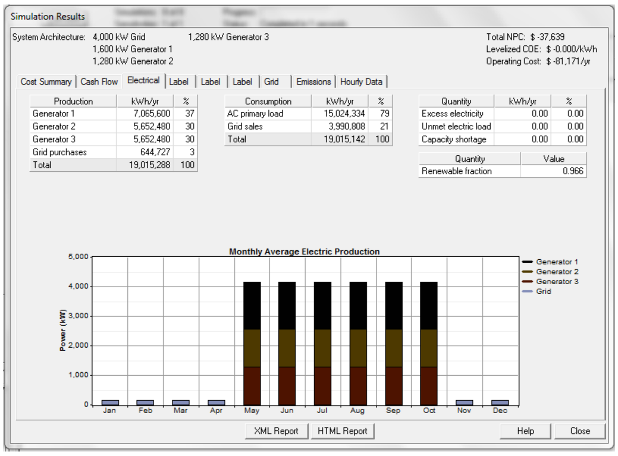


Figure 12. Simulation results of the power generated by the generator

Figure 13 shows the design of a grid system for the biomass system produced by the Madukismo factory. The grid is a network that provides electrical energy from PLN, for a system connected to the grid will get a supply of electrical energy. In the simulation and design of this system, Maduksimo is interconnected to meet November's needs to April. The purchase price of electrical energy from PLN for Outside Peak Load Time is the US $ 0.070/kWh while for Peak Load Time is the US $ 0.12/kWh, and for sales to PLN, the company issues a price of US $ 0.05/kWh, but in this simulation, the company does not sell to PLN.

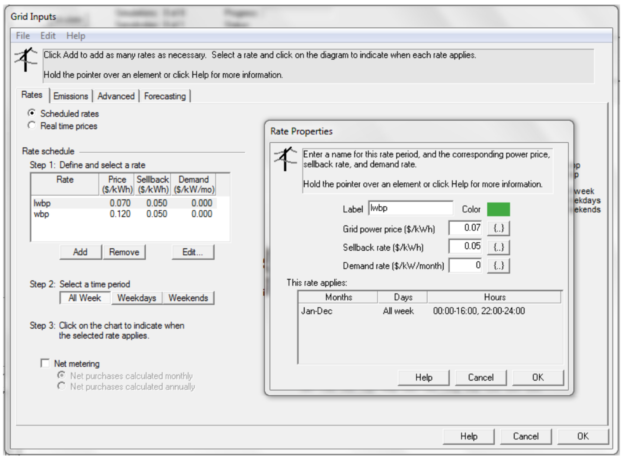
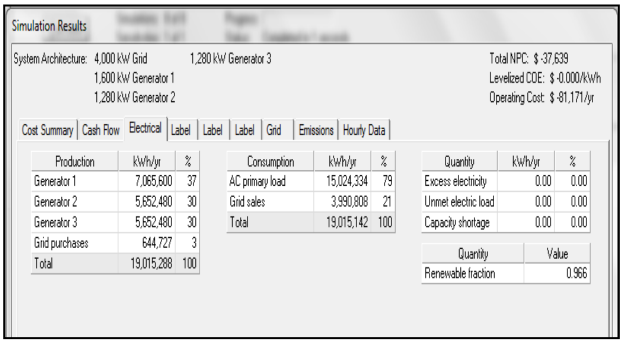


Figure 13. Design of a grid system for the biomass system produced by the Madukismo factory

Homer has done several simulations on the system configuration. The best configuration is one that has the lowest Net Present Cost (NPC). NPC is the present value of all costs incurred over the lifetime minus all revenue earned over the lifetime. Simultaneously, the Cost of Energy (COE) is the average per kWh of electrical energy generated by the system.

The best generator system design for Madukismo is with a biomass generator with specifications of 1600 kW and 1280 kW connected to a 4000 kW grid. This result is the most optimal industrial plant system configuration. The advantages of the above configuration at this time are better and result in higher production capacity. Generator capacities 1, 2, and 3 can accommodate energy capacities of 1,600 kW and 1280 kW with a grid-connected of 4000 kW.

In the system analysis that has been assumed with the Homer program, it is found that the Madukismo system for May to October, with the production of logistical energy utilizing bagasse, can meet the needs of electrical energy optimally for that month. Meanwhile, from November to April, to meet the company's electricity needs, the company receives electricity supply from PLN. To optimize the system at the company obtained from the use of bagasse, which is processed into electrical energy and supply from PLN.



Simulation Results

System Architecture: 4,000 kW Grid 1,280 kW Generator 3
1,600 kW Generator 1
1,280 kW Generator 2

Total NPC: $ -37,639
Levelized COE: $ -0.000/kWh
Operating Cost: $ -81,171/yr

Cost Summary | Cash Flow | Electrical | Label | Label | Label | Grid | Emissions | Hourly Data

Production	kWh/yr	%
Generator 1	7,065,600	37
Generator 2	5,652,480	30
Generator 3	5,652,480	30
Grid purchases	644,727	3
Total	19,015,288	100

Consumption	kWh/yr	%
AC primary load	15,024,334	79
Grid sales	3,990,808	21
Total	19,015,142	100

Quantity	kWh/yr	%
Excess electricity	0.00	0.00
Unmet electric load	0.00	0.00
Capacity shortage	0.00	0.00

Quantity	Value
Renewable fraction	0.966

Figure 14. The power generated by the biomass generator configuration 1, 2, 3

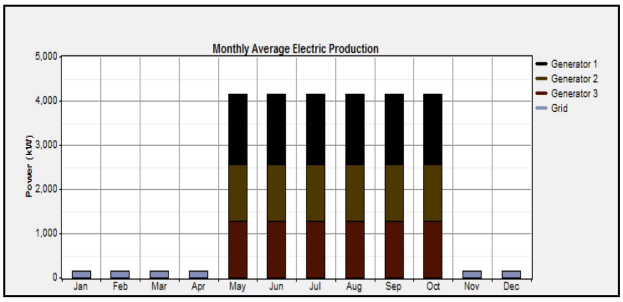


Figure 15. Electricity production per month resulting from the configuration of the biomass generator in optimum conditions

In Figure 14, it can be seen that the total power generated by the generator is 19,015,288 kWh/year. With industrial electricity consumption of 15,024,334 kWh/year (79%). Sales to PLN are 3,990,808 kWh/year (21%) operating costs or operating costs of US$ - 81,171 per year, and the quantity renewable fraction is 0.966.

The chart shown in Figure 15 explains that electricity production is only from May to October in a year. Because in that month, Madukismo is in the season for sugarcane grinding and production. Meanwhile, from November to April, Madukismo did not produce, and its power supply was using PLN.

V. Conclusion

Based on the simulations and analyses carried out using Homer software, the following data are obtained. The best and most optimal configuration for designing a biomass generator at the Madukismo sugar factory is when using three generators and connecting them to the PLN grid. The electricity yield at the Madukismo sugar factory within one year is 7,065,600 kWh produced by generator 1, 5,652,480 kWh produced by generator 2, and 5,652,480 kWh produced by generator 3. Thus the Madukismo sugar factory can meet the electricity needs independently. The electrical energy generated by the biomass generator is 19,015,288 kWh in 1 year. The potential of sugarcane biomass has met the needs of electrical energy, while the community uses the remaining biomass in the Madukismo sugar factory as a material for making bricks and bio briquettes.

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