

OPTIMIZATION AND TECHNO ECONOMIC STUDY OF PLASTIC WASTE BENEFICIATION WITH PRODUCTION SIMULATION APPROACH CASE STUDY AT CV. PANDU KENCANA JOMBANG, EAST JAVA

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Abstract

The problem of plastic waste is getting more and more worrying day by day. Meanwhile, the industrial demand for plastics is also increasing. So we need a recycling business that can bridge this. Plastic waste in the environment can be decomposed, and the industry fulfills plastic needs at low prices. This study aims to analyze and optimize the business of recycling plastic waste into plastic ore to reduce the amount of plastic waste in the environment and obtain material benefits. The research method used is a case study in a plastic waste processing company with the collection of data needed to determine the formulation of the problem so that a mathematical model of linear equations can be formed, which then, through production simulations, will be obtained optimization. The results are then analyzed with a techno-economic study to determine the feasibility of the business.

After optimization of production from simulations based on a mathematical model of linear equations, if the company wants to get maximum profit, then the company must produce PP Black A of 1022.73 kg, PP Black B of 852.27 kg, PP Gray of 625 kg. Meanwhile, PP Gray Large should not be produced. Based on the techno-economic study, the feasibility analysis before optimization was obtained as $ROI_a=23.40\%$, $ROI_b=23.24\%$, $POT_a=2.99$ years, $POT_b=3$ years, $BEP=36.07\%$, $SDP=23.98\%$, $LANG=4.1$, $DCFRR=18.8\%$. Then the feasibility analysis after optimization is $ROI_a=29.88\%$, $ROI_b=29.73\%$, $POT_a=2.5$ years, $POT_b=2.51$ years, $BEP=31.03\%$, $SDP=20.63\%$, $LANG=4.1$, $DCFRR=24.85\%$.

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1. Introduction

Waste recycling efforts in developing countries are conducted by the informal or individual/private sectors, while government involvement is still very limited. The process is done scavengers take materials that have economic value in TPS "Tempat Penampungan Sementara" or temporary shelter in landfill to be collected, then done sorting or sorting to group the materials according to the raw materials and each type (Street & Bernasconi, 2021). The result of sorting plastic materials can usually be grouped into seven groups and then sold to collectors. Special plastic materials are purchased from collectors for processing by plastic cutting businesses, with plastic products with the same type of material (Kumar et al., 2011). This product is then sold to the plastic ore manufacturing industry to make plastic ores. The resulting plastic ore is widely used to substitute some of the new raw materials (new plastic ore), which are quite expensive (Purwaningrum, 2016). Plastic ore is a raw material in the printing industry or manufacturing plastic goods with injection molding machines.

Based on the explanation above, the flow of plastic waste until it reaches the reprinting process is: by the producer of garbage dumped into the trash can or trash can, from the trash can dumped to the TPS or landfill (Wen et al., 2021). In the place of garbage or goods that have a selling value collected by scavengers and then sorted according to the type of material, then the materials are paid or sold to the collector (Gourmelon, 2015). Plastic materials are purchased from collectors by counter industry players for processing. Enumeration products are sold to the plastic ore

industry for processing and then sold to the plastic goods manufacturing industry (Suartika et al., 2015). Thus, when scavengers take plastic waste in mixed conditions with other garbage, it is dirty, shoulder-to-shoulder, and may also be mixed with toxic materials containing disease germs and sharp materials, broken glass (Duong et al., 2018). Such methods also result in not all plastic waste being taken for recycling. Therefore, there needs to be technological engineering and social engineering to shorten the flow of the process and avoid mixing types of garbage with sorting from the beginning of the waste produced (Ghosh et al., 2020).

The import of waste or waste is legal according to Regulation of the Minister of Trade No. 31 of 2016 concerning Provisions for Import of Non-Hazardous Toxic Waste. Data from the Ministry of Industry at Figure 1 shows the need for raw materials for the national plastics industry reaches 5.6 million tons per year. A total of 2.3 million tons were filled from pure plastic ore, 1.67 million tons of plastic ore imports, and 1.1 million tons of domestic recycled plastic material fulfillment. That is, the plastic industry still lacks material as much as 600,000 tons which for some time is filled from the import of plastic waste in the form of scrap as much as 110,000 tons.

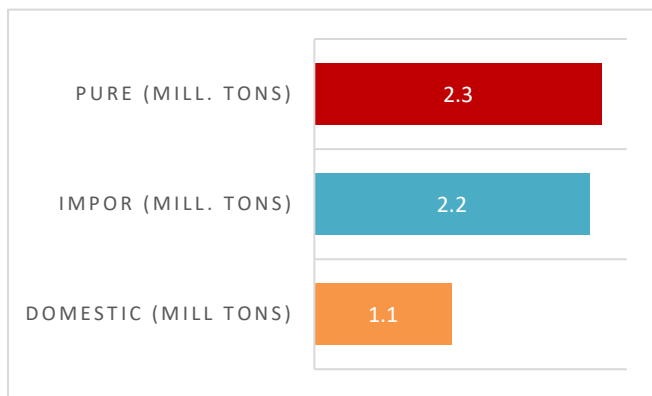


Figure 1. Graph of plastic waste allocation in Indonesia in 2019

Based on data from the Ministry of Environment and Forestry in Figure 2, in 2019, there were 175,000 tons of waste/day or 64 million tons/year. The composition of plastic waste reaches 15% or 9.6 million tons/year. The recyclable is only about 10% -15% or 960 thousand tons – 1,440 million tons/year. Then plastic waste as much as 15% - 30% or 1,440 million tons - 2,880 million tons/year wasted to rivers, lakes, and seas. The remaining 60% - 70% or 5.76 million tons – 6.72 million tons/year stockpiled in a landfill. While plastic waste is non-biodegradable or challenging to degrade, it is estimated to take 100 to 500 years to decompose (decompose) perfectly. So there will be a continuous buildup of plastic waste from year to year when not well regulated.

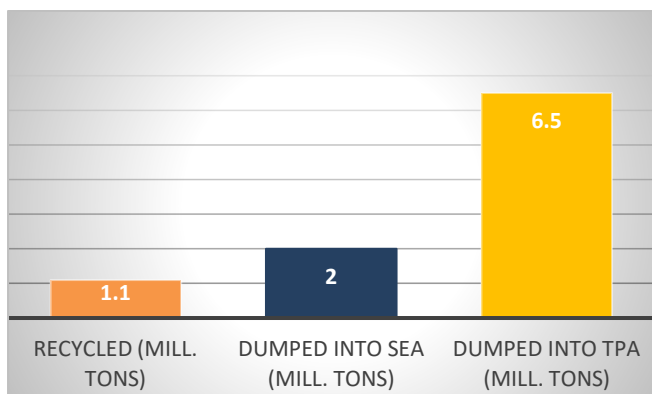


Figure 2. Graph of plastic waste allocation in Indonesia in 2019

Therefore, efforts are needed to regulate this plastic waste to be appropriately utilized and not even accumulate, which will cause many environmental and life problems. One of them is arranging the method of a plastic waste treatment system, starting from how to dispose of it, collect it, and multiply the units of recycling plastic waste treatment (Evode et al., 2021). It will bring a lot of profit by reducing the amount of plastic waste that can not be decomposed. In addition to bringing material benefits, the need to recycle plastic ore is still significant, which still has to be met from pure plastic ore and plastic ore from imports that cost more than domestic local production (Chen et al., 2021).

2. Methodology

A. Types of Research

This research is case study research on plastic waste treatment companies into plastic ore products to optimize product sales profit by managing raw materials.

B. Place & Time of Research

In this study, the selected location was on CV. Pandu Kencana, Jombang Regency, East Java Province. Research time of September 2020 to February 2021.

C. Data Source

The data source of this study is more to the primary data directly obtained from the first source that is the owner of the company.

D. Data Collection Techniques

The data collection techniques in this study consisted of :

- a. Interview
Conducting direct verbal communication to obtain information.
- b. Field Survey
Live survey in the field by recording report data, shooting, and video.
- c. Library Study
A library study is a method used to obtain supporting theory on research conducted. Through the study of this library, it is expected to know the position of research to be carried out there so that it can be a reference point for the implementation of research.

E. Stages of Research

The stages in Figure 4 carried out in the study are as follows :

- a. The data required for this study includes data on raw materials and main products. Raw materials form the purchase price of raw materials, composition of raw materials, supply of raw materials. The main products include the selling price, production costs, depreciation value, and market demand level. The material composition data for the four products produced :
 - PP Black A, composition : 70% black large sack; 30% (screen printing/HD/packing).
 - PP Black B, composition : 70% (sack+ tarpaulin+kresak) ; 30% (screen printing/HD/packing).
 - PP Gray Large, composition: 70% white large sack; 30% (screen printing/HD/packing).
 - PP Gray : 100% tissue.
- b. Do data collecting related to production costs for each main product, including operating costs.
- c. Define problem formulations based on the data collected.

In the modeling image of the plastic waste treatment system in Figure 3, it can be seen that the system can be optimized by adjusting the input parameters in the form of processed raw materials to

produce output in the form of products with the most optimal results.

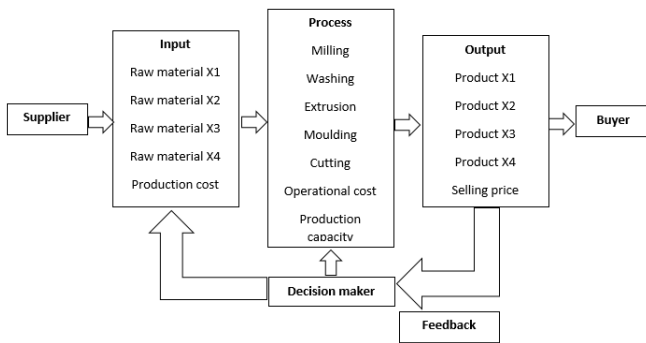


Figure 3. Plastic waste treatment system modeling

From the modeling of the plastic waste treatment system, it is hoped that optimization can be carried out in the form of an enormous profit by adjusting the input in raw material.

- d. Establish a mathematical model in a linear program model by determining the purpose and constraint functions based on the formulation of defined problems and previously collected data.

The stages of obtaining the mathematical model are:

A. Variable Isscan

The Company wants to maximize profits daily where the amount of production for each raw material can be distributed and provide income for the company. The variable is as follows :

X_i = the number of plastic ore products produced ($i=1-4$)

- X_1 =the amount of PP Black A plastic ore production produced.
- X_2 =the amount of PP Black B plastic ore production produced.
- X_3 =the amount of production of PP Gray Large plastic ore produced.
- X_4 = the amount of production of PP Gray plastic ore produced.

P_i = the price of each plastic ore product produced

- P_1 =price of PP Black A plastic ore products produced.
- P_2 =price of PP Black B plastic ore products produced.
- P_3 =price of PP Gray Large plastic ore products produced.
- P_4 =price of PP Gray plastic ore products produced.

a_i = average cost of production per product ($i=1-4$)

- a_1 =average production cost of PP Black A plastic ore.
- a_2 =average production cost of PP Black B plastic ore.
- a_3 =average production cost of PP Gray Large plastic ore.
- a_4 =average production cost of PP Gray plastic ore.

a_t = average total cost of production per day

b_i = average operating cost of each product ($i=1-4$)

- b_1 =average operating cost of PP Black A plastic ore products.
- b_2 =average operating cost of PP Black B plastic ore products.
- b_3 =average operating cost of PP Gray Large plastic ore products.
- b_4 =average operating cost of PP Gray plastic ore products.

b_t = average total operating cost of each product

c_i = average use of other raw materials for each product ($i=1-4$)

- c_1 =average use of other raw materials for PP Black A plastic ore products.
- c_2 =average use of other raw materials for PP Black B plastic ore products.
- c_3 =average use of other raw materials for PP Gray Large plastic ore products.
- c_4 =average use of other raw materials for PP Gray plastic ore products.

c_t = average total use of other raw materials every day.

D_i =average demand every day.

D_t =average total demand every day.

B. Linear Program Model

The general form of the linear program consists of 2 functions: the purpose function and the constraint function or limit requirement. The main purpose of this activity is to maximize profits so that what is desired is the number of raw materials produced in the process that is on-demand with the price weight of each type of process.

Constraint Function

Function constraints on average total demand every day, average production costs every day, average operational costs every day, the average number of other raw materials used every day, and average demand of product every day.

After getting the mathematical model, the most optimal product will be determined by simulation with software.

- e. Conduct Production Simulation using QM for Windows Version 5,3 program so that the most optimal results are obtained.
- f. Conduct analysis and study of economic techno based on company data that has been collected, comparing the results of the economic techno study before and after optimization with Production Simulation. Economic Evaluation Parameters are fixed capital investment, manufacturing costs, working capital, general expenses, and feasibility analysis. Manufacturing costs are direct manufacturing cost, indirect manufacturing cost, fixed manufacturing cost. Feasibility analyses are percent return of investment (ROI), Pay Out Time (POT), Break Event Point (BEP), Shut

Down Point (SDP), Faktor LANG, and Discounted Cash Flow Rate of Return (DCFRR).

Further explanation of feasibility analysis is,

A. Percent Return of Investment

Return of investment is the annual rate of return on investment, in this case, capital from profit. A good return of investment is > 1,5 bank interest rates.

B. Pay Out Time

The payout time is the period of return on investment in this capital-based profit, taking into account depreciation. A good pay-out time value is < 5 years.

C. Break Event Point

Break event point is a point of intersection of sales line with a total cost that shows the production level where the sale size is equal to the total cost. The plant below that capacity will result in losses, and operations above that capacity will bring profit.

C. Shut Down Point

Shut down point is a level of production wherein such conditions stop the operation of the plant is better than operating it. Operating the plant under the SDP capacity will result in more significant factory losses than when it is not running, so it would be better if the plant is not working. If the plant operates above the capacity of the SDP, then the losses resulting from the plant operating are less than the losses when the plant is not working. So the factory should continue operating despite suffering losses.

D. Faktor LANG

LANG factor is a value (factor) used to estimate fixed capital quickly without calculating the costs - costs that are classified as fixed capital. If the value of LANG Factor > 3.1 then it can be said that the factory to be established is quite good.

E. Discounted Cash Flow Rate of Return

If the value of DCFRR > 1.5 bank interest rates, then it can be said that the factory to be established is quite attractive or profitable.

F. Draw conclusions and suggestions from research results.

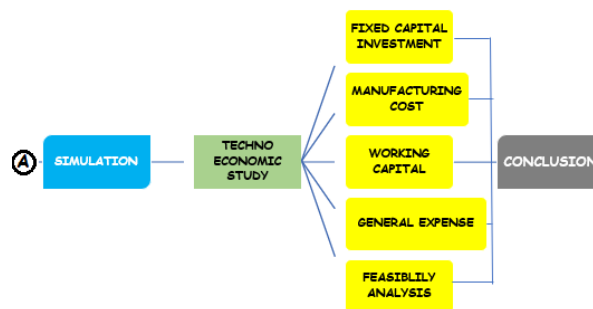
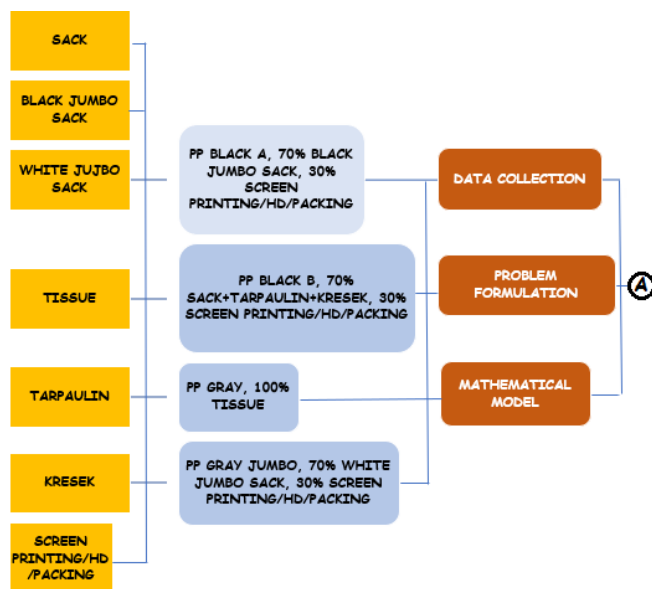


Figure 4. Research methodology

3. Result & Discussion

A. Company's Production Activities

• Milling Process

The milling process aims to destroy flaccid or soft plastic waste or hard plastic waste types such as avalan or clots or "prongkolan" into smaller parts. It is easier to be processed inside plastic pellet machines as usual raw materials are always weighed first before processing the mill. The raw materials will be ground and stored in sacks to be ready to be twisted following consumer demand if the condition is clean enough, but if the state, it will dirty, then it is necessary to wash. The machine used is a shredder machine capacity of up to 5 tons.

• Washing Process

This washing process aims to clean the number of plastic waste from dirt, soil, or other substances to make it easier to process when entering the plastic ore pellet machine. The number of plastic waste that is still dirty can produce avalan or "prongkolan".

The material to be washed has been ground first. Materials are always weighed in advance and recorded to control inventory in the warehouse. Once considered, the material is put in a washing machine large enough, and there is a serrated machine to smooth the pieces of plastic further and washed with a special soap. The machine used is a plastic waste washer with an hourly capacity of up to 0,5 m³.

• Drying Process

This drying process aims to dry the number of plastic waste so that it is easier to process when entering the plastic ore pellet machine. The number of plastic waste that is still wet can interfere with the process of processing plastic waste in plastic ore pellet machines.

The amount of plastic waste that has been washed will automatically enter into a large-sized tube that serves to dry the wet material after washing and then will be put in a sack and then weighed and stored in the warehouse. The material is ready to be inserted into the pellet machine. The machine used is a plastic waste washer with an hourly capacity of up to 1 m³.

• Pellet Process

Pellet process is the process of heating materials that have been through the process of enumeration and washing so that the material is ready to be twisted and plastic ore will be produced. Materials are taken from storage warehouses that are stored per sack and ready to be melted. The process of making plastic ore in this pellet machine goes through 3 stages; the melting stage in the

extrusion machine, the plastic ore printing stage in the printer, and the cutting stage with the cutting machine. The machine used is a pellet machine with a capacity of up to 3 tons per day.

B. Production Costs

1. PP Black A

The first type of plastic ore product is PP Black A. The primary raw material of PP Black A plastic ore product is Black Large Sack material. The details of raw materials for the manufacture of PP Black A plastic ore products are as follows, 70% Black Large Sack material and 30% Screen Printing/HD/packing material. From 1,000 kg (combined Black Large Sack material and Screen printing/HD/Packing material) will be obtained from the production of 875 kg of PP Hitam A plastic ore products (efficiency of 87.5%).

The main raw material of PP Hitam A plastic ore product is Sak material, and the supporting raw material is Sablon/HD/Packing material. Of the 875 kg of PP Hitam A plastic ore products produced, the largest supporting composition is the Black Large Sack material as much as 70% and additional materials in the form of Sak/HD/Packing as much as 30%. The production cost data in producing 875 kg of PP Black A plastic ore products from a combination of Black Large Sack material and Screen Printing/HD/Packing materials of 1,000 kg is Rp. 3,525,000.

2. PP Black B

The second type of plastic ore product is PP Black B. The main raw material of PP Black B plastic ore product is Sack material. The details of raw materials for the manufacture of PP Black B and 30% Screen Printing/HD/packing material. From 1,000 kg which is combined Sack+Tarpaulin+Kresek material and Screen Printing/HD/Packing material, the production of 900 kg of plastic ore products PP Black B (efficiency 90%) will be obtained. The main raw material of Black B plastic ore products is Sack+Tarpaulin+Kresek material, and the supporting raw material is Screen Printing/HD/Packing material.

Of the 900 kg of PP Black B plastic ore products produced, the most extensive supporting composition is Sack+Tarpaulin+Kresek material as much as 70% and additional materials in the form of Screen Printing/HD/Packing as much as 30%. Data on production costs in producing 893 kg of PP Black B plastic ore products from a combination of Sack+Tarpaulin+Kresek material and Screen Printing/HD/Packing material of 1,000 kg is Rp. 3,350,000.

3. PP Gray Large

The third type of plastic ore product is PP Gray Large. The primary raw material of PP Gray Large plastic ore products is the White Large Sack material. The details of the raw materials for manufacturing PP Grey Large plastic ore products are as follows; 70% White Large Sack material and 30% Bahan Sablon/HD/packing.

From 1,000 kg (combined White Large Sack material and Screen Printing/HD/Packing material) will be obtained

from the production of 850 kg of PP Gray Large plastic ore products (efficiency 85%). The main raw material of PP Gray Large plastic ore products is White Large Sack material and the supporting raw material is Screen Printing/HD/Packing material.

Of the 850 kg of PP Gray Large plastic ore products produced, the most extensive supporting composition is the White Large Sack material as much as 70% and additional materials in the form of Sak/HD/Packing as much as 30%. The production cost data in producing 850 kg of PP Gray plastic ore products from a combination of White Large Sack material and Screen Printing/HD/Packing material of 1,000 kg is Rp. 3,612,500.

4. PP Gray

The fourth type of plastic ore product is PP Gray. The main raw material of PP Gray plastic ore products is Tissue material. The details of raw material for the manufacture of PP Gray plastic ore products are 100% Tissue material. From 1,000 kg of tissue, the material will be obtained from 930 kg of PP Gray plastic ore products (efficiency 90%).

The primary raw material of PP Gray plastic ore products is Tissue material. Of the 900 kg of PP Gray plastic ore products produced, the composition is Tissue material as much as 100%. Data on production costs in producing 900 kg of PP Gray plastic ore products from Tissue material as much as 1,000 kg is Rp. 4,000,000.

C. Operational Costs of Plastic Ore Products

The operational cost component in production is not calculated for each type of process. This is because the utilization of production cost components such as electricity usage cannot be determined with certainty how much expenditure per day produces each product. The same is also the case for the transportation and packaging of products where utilization is used for all productions. Total operational costs for the production process each month reached Rp 120,000,000.00 with the following details in Table 1.

Table 1. Operational cost

No.	Operational Components	Average Monthly Expenses	Average Daily Expenses
1.	Operating Labor	Rp. 37,500,000	Rp. 1,250,000
2.	Supervisory	Rp. 20,500,000	Rp. 683,333
3.	Maintenance	Rp. 5,333,333	Rp. 177,778
4.	Utilities	Rp. 18,830,700	Rp. 627,690
5.	Payroll Overhead (BPJS)	Rp. 8,333,333	Rp. 277,778
6.	Packaging & Shipping	Rp. 13,916,667	Rp. 463,889
7.	Depreciation	Rp. 10,000,000	Rp. 333,333
8.	Tax	Rp. 833,333	Rp. 27,778
9.	Plant Overhead (THR)	Rp. 4,750,000	Rp. 158,333
	Total	Rp. 119,997,367	Rp. 39,999,122

D. Linear Program Model

The general form of a linear program consists of 2 functions; the purpose function and the constraint function or limit requirement. The main purpose of this activity is to maximize profits so that what is desired is the number of raw materials produced in the processed that is on-demand with the price weight for each kind of process. An objective function can be formed to maximize profit by selling the price/kg of products in Table 2.

Table 2. The selling price of products

No.	Product Type	Symbol	Selling Price/kg
1.	PP black A	X1	8000
2.	PP black B	X2	7500
3.	Gray large	X3	8250
4.	PP gray	X4	8500

Objective Function :

$$\text{Max } Z = 8,000X1 + 7,500X2 + 8,250X3 + 8,500X4$$

Average query constraint function per day. Many requests every day are indeed not fixed, so take the average daily request that regrets. The average daily total demand will not be more than 2.500 kg, according to the availability of raw materials and production capabilities so that the mathematical model is,

$$\sum_{i=1}^4 Di \leq Dt \text{ or } X1 + X2 + X3 + X4 \leq 2,500 \quad (1)$$

Function constraints on average production costs. With an average production cost for 1,000 kg of PP Black A plastic ore products is Rp. 3,525,000, for 1,000 kg of PP Black B plastic ore products is Rp. 3,350,000 for 1,000 kg of PP Gray Large plastic ore products is Rp. 3,612,500 and for 1,000 kg of PP Gray plastic ore products is Rp. 4,000,000.

Then for each 1.000 kg of raw materials produced 875 kg of PP Black A plastic ore products, 893 kg of PP Black B plastic ore products, 850 kg of PP Gray Large plastic ore products, and 930 kg of PP Gray plastic ore products. Thus it can be seen in Table 3. Each kg of PP Black A plastic ore products produced requires a production cost of Rp. 4,025. Each kg of PP Black B plastic ore product requires a production cost of Rp. 3,750. Each kg of PP Gray Large plastic ore product requires a production cost of Rp. 4,250. Each kg of PP Gray plastic ore product requires a production cost of Rp. 4,300.

Table 3. Depreciation & production cost/kg

Product Type	Depreciation	Production Cost/kg	Production Cost/ton
PP Black A	87,5%	Rp. 4,025	Rp. 3,525,000
PP Black B	89,3%	Rp. 3,750	Rp. 3,350,000
PP Gray Large	85%	Rp. 4,250	Rp. 3,612,500
PP Gray	93%	Rp. 4,300	Rp. 4,000,000

The total production cost incurred by the company every day to produce plastic ore products amounting to 2,500 kg is Rp. 10,000,000. The cost of production per kg denoted by ai can be written:

$$\sum_{i=1}^4 aiXi \leq at \text{ or } 4,025X1 + 3,750X2 + 4,025X3 + 4,300X4 \leq 10,000,000 \quad (2)$$

Function constraints on average operational costs. Operational costs are not calculated based on the production of each product, so it is assumed that all four products have the exact operating costs. The total operational cost spent every day is Rp. 4,000,000. Because the company produces each product based on the same portion of raw materials and the production can not be more than 2,500 kg, then each product per kg requires operational costs of Rp. 1,600. The operating cost of each kg denoted by bi can be written,

$$\sum_{i=1}^4 biXi \leq bt \text{ or } 1,600X1 + 1,600 X2 + 1,600 X3 + 1,600X4 \leq 4,000,000 \quad (3)$$

The average constraint function of the number of other raw materials used. Of the 875 kg of PP Black A plastic ore products produced, the largest supporting composition is the Black Large Sack material as much as 70% and additional materials in the form of Screen Printing/HD/Packing as much as 30%. Of the 900 kg of PP Black B plastic ore products produced, the largest supporting composition is Sack+Tarpaulin+Kresek material as much as 70% and additional materials in the form of Sack/HD/Packing as much as 30%. Of the 850 kg of PP Gray Large plastic ore products produced, the largest supporting composition is the White Large Sack material as much as 70% and additional materials in the form of Sack/HD/Packing as much as 30%.

Of the 900 kg of PP Gray plastic ore products produced, the composition is tissue material as much as 100%. This means for every 1 kg of PP Black A plastic ore products produced needed 0.3 kg Sack/HD/Packing material, 1 kg of plastic ore products PP Black B made requires 0.3 kg of Sack/HD/Packing material, and 1 kg of plastic ore products PP Gray Large produced requires 0.3 kg of material Sack/HD/Packing. The Company sets the total needs of Sack/HD/Packing materials at 22.5% of the total production capacity that can be done. Up to 22.5% of the total production capacity is 562.5 kg of additional materials per day. Thus the function of the average constraint of the number of other raw materials used is,

$$\sum_{i=1}^4 ciXi \leq ct \text{ or } 0.3X1 + 0.3X2 + 0.3X3 \leq 562.5 \quad (4)$$

It is assumed that raw materials are available daily, and demand is also present daily (except PP Gray Large products

limited to 1 ton). Thus Function constraints on average demand of product every day is,

$$X3 \leq 1,000 \tag{5}$$

The resulting mathematical model is,

$$Max Z = 8,000X1 + 7,500X2 + 8,250X3 + 8,500X4 \tag{6}$$

Constraints :

$$X1 + X2 + X3 + X4 \leq 2,500 \tag{7}$$

$$4,025X1 + 3,750X2 + 4,250X3 + 4,300X4 \leq 10,000,000 \tag{8}$$

$$1.600X1 + 1.600 X2 + 1.600 X3 + 1.600X4 \leq 4.000.000 \tag{9}$$

$$0,3X1 + 0,3X2 + 0,3X3 \leq 562,5 \tag{10}$$

$$X3 \leq 1.000 \tag{11}$$

E. Production Simulation

This model simulation uses the QM for Windows Version 5.3 program in Table 4.

Table 4. Linear programming result

	X1	X2	X3	X4		RHS	Dual
Maximize	8000	7500	8250	8500			
Constraint 1	1	1	1	1	<=	2500	681,82
Constraint 2	1	1	1	1	>=	0	0
Constraint 3	0	0	1	0	<=	1000	0
Constraint 4	1600	1600	1600	1600	<=	5000000	0
Constraint 5	.3	.3	.3	0	<=	562,5	0
Constraint 6	4025	3750	4250	4300	<=	10000000	1,82
Solution->	1022,73	852,27	0	625		19886360	

F. Interpretation of Results

With the help of one of the computer programs, the best solution for each product produced to obtain maximum profit is X1 for the production of PP Black A plastic ore is 1,000 kg; for the production of plastic ore PP Black B (X2) is 863.64 kg; for the production of PP Gray Large plastic ore (X3) is 0 kg; and for the production of PP Gray plastic ore (X4) is 636.36. If the company wants to get maximum profit, it does not need to produce PP Gray Large (X3) plastic ore because it will affect other production and profit earned.

G. Techno-Economic Study

Techno-economic studies after and before optimization have been carried out to determine the difference in profits obtained by the company, it can be seen in Table 5, Figure 5, and Figure 6.

Table 5. Feasibility analysis comparison

Feasibility Analysis	ROI a (%)	ROI b (%)	POT a	POT b	BEP %	SDP %	LANG	DCFR R %
Before Optimization	23.40	23.24	2.99 years	3 years	36.07	23.98	4,1	18,80
After Optimization	29.88	29.73	2.5 years	2.51 years	31.03	20.63	4,1	24,85

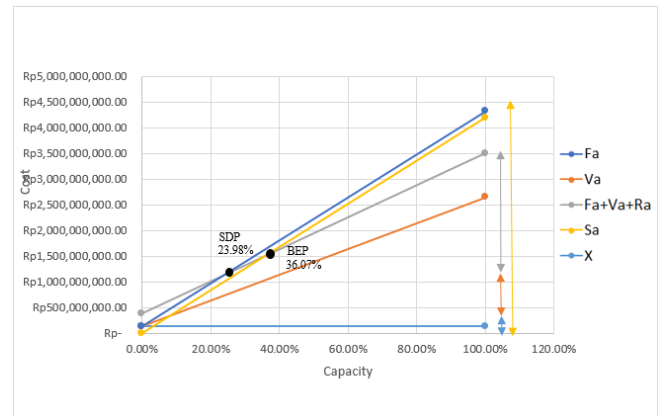


Figure 5. Graph of economy evaluation before optimization

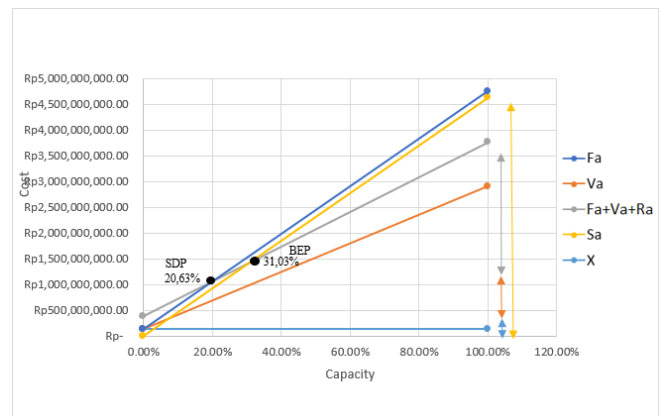


Figure 6. Graph of economy evaluation after optimization

Where,

Fa : Annual Fixed Expense.

Va : Annual Variable Expense.

Ra : Annual Regulated Expense.

Sa : Sales.

X : Fa + Sa.

4. Conclusion

The business of recycling plastic waste into plastic ore with a capacity of 2,500 kg per day can reduce the amount of waste in the environment and has economic value that provides material benefits. After optimizing production from production simulation based on linear equation mathematical model, if the company wants to get maximum profit, then the company must produce PP Black A of 1022.73 kg, PP Black B of 852.27 kg, PP Gray of 625 kg. At the same time, PP Gray Large should not be produced.

Based on the study of economic techno, obtained business feasibility analysis before optimization is ROIa=23.40%, ROIb=23.24%, POTa=2.99 years, POTb=3 years, BEP=41.8%, SDP=18.62% LANG=4.1, DCFRR=18.8%. Then the feasibility analysis after optimization is ROIa=29.88%, ROIb=29.73%, POTa=2.5 years, POTb=2.51 years, BEP=31.03%, SDP=20.63%, LANG=4.1, DCFRR=24.85%.

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