Financial Analysis of Renewal Waste Treatment System with Hydrothermal Technology (A Case Study in Waste to Zero Project in a Cement Industry)

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***Abstract*— To decrease the amount of solid waste in Gresik city, a solid waste processing machine was installed in final disposal sites. One of the machine products, Refuse Derived Fuel (RDF), a kind of biomass that can be used as coal substitute in cement plants. This program will be implemented successfully if RDF is produced continually and also has lower moisture. The initial design of the machine yielded 3.3 tonnes of RDF per hour with 10% moisture content and caloric value more than 4800 kcal/ kg. Nonetheless, for subsequent process, the machine could produce only 3 tonnes of RDF per day with a significant increase of moisture content (around 30%) and caloric value less than 4800 kcal/ kg. This problem might appear due to the existence of impurity (sand, gravel) in RDF and waste in the wet condition. According to this issue, an alternative technology that could be applied to fix the problems is hydrothermal technology. To execute this idea, a feasibility study should be assessed, especially related to the financial aspect. The assessment would be analyzed by using calculation how much opportunity cost generated from substitution of coal with RDF, Net Present Value (NPV), Payback Period (PBP), and Internal Rate of Return (IRR) against Weighted Average Cost of Capital (WACC). The financial analysis shows that a renewal waste treatment system with hydrothermal technology could improve RDF production capacity and maximize the profit.**

***Index Terms*—Biomass, hydrothermal technology, financial aspect, Refuse Derived Fuel (RDF), Waste treatment.**

I. Introduction

PT. Semen Indonesia, as the biggest cement company in Indonesia has a program, namely Waste to Zero Project (WTZP). The function of this project is to utilize the waste into fuels. The company has a green policy to substitute 30% coal to alternative energy. This policy is regarding to the commitment of reducing CO2 emission and other pollutant [1], and also reduce the amount of waste in Gresik City. The average of waste sending to the landfill is 225 tonnes per day, and the deposit of waste in landfill area is about 210,000 tonnes in 2015. This amount will grow up in line with population growth and the increased of human activity each year.

In WTZP, there is a waste processing machine that converts waste material into three kinds of useful waste product, i.e. 35% reclamation material, 37% fertilizer, and 28% Refuse Derived Fuel (RDF). One of the products in WTZP, RDF, has higher caloric value than coal in an experiment. It is around 5178 kcal/ kg, while coal only has caloric value approximately 4800 kcal/kg. Based on this fact, substituting coal with RDF can be utilized in burner kiln of cement plant [2].

Unfortunately, in the operating phase, RDF production cannot run as expected. The subsequent waste processing performed a decrease in product quality and also quantity. Total amount of RDF produced is only 6% much less than the designed capacity. The machine in WTZP could not operate optimally due to the wet condition of waste. The machine stops frequently due to short circuit. Furthermore, the waste characteristic used as an input in this machine are also contained impurities (such as sand, and soil), which results in low RDF calorie. Regarding to this problem, an improvement in energy production technology should be considered.

The literature contains various investigations into the waste processing technology. For example is research conducted by Hadidi and Omer [3] in Saudi Arabia, which has the same conditions in undefinite waste sorting system, so the municipal solid waste is mixed up. In their research, two technologies were raised - gasification and anaerobic digestion. P. Prawisudha et al [4] stated that Hydrothermal Technology is suitable to be applied in developing countries, because Hydrothermal Technology is able to process mixed waste. Japan and Indonesia have applied this technology to processing the waste.

Among the various technologies of waste treatment mentioned before, Hydrothermal technology (HTT) is considered to improve WTZP. Output of HTT having combution characteristic similar to that of coal can be used as an alternative fuel in kiln burner of cement plant. Moreover, hydrothermal technology can reduce chlorine content generated by plastic waste [5]. The main component required in HTT is saturated steam. In the beginning of the process, the waste is fed into a stirred reactor and injected by saturated steam with a pressure of 25 - 28 bar and a temperature between 200°C to 250°C. The product contains 40% alternative fuel and 60% moisture content.

After determining the technology applied in WTZP, it is necessary to conduct a feasibility study. Actually, there are many aspects need to be studied, such as technical aspects, environmental aspects, economic aspects, financial aspects, risk aspects, and so forth. However, in this research focus on financial analysis to determine the feasibility of renewal waste treatment using hydrothermal technology. The indicators used as financial evaluation were Net Present Value (NPV), Payback Period (PBP), Internal Rate of Return (IRR) and Sensitivity Analysis.

II. Existing Condition

A. *Actual RDF Production*

In final disposal of waste site in Gresik city, east Java, a waste processing machine was installed in 2015. The machine was expected to reduce the amount of waste by separating three kinds of product, i.e. 35% reclamation material, 37% fertilizer, and 28% Refused Derived Fuel (RDF). The mechanism could be seen in Figure 1.

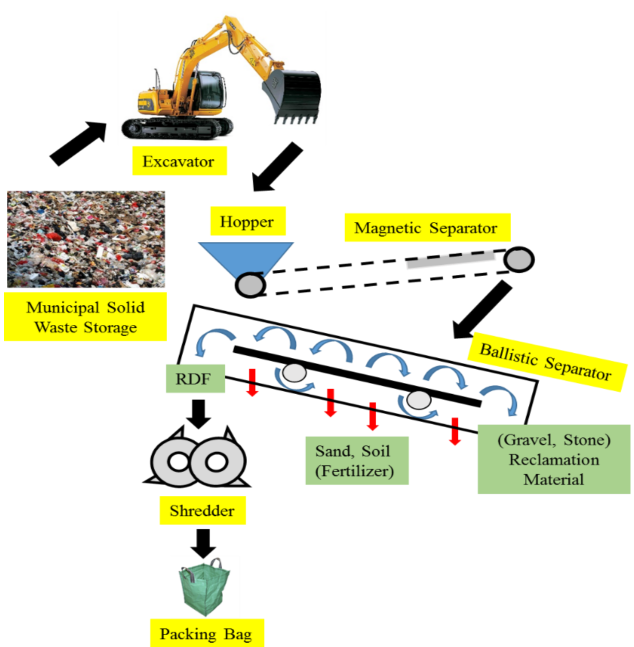

Figure 1. Actual RDF Production [6].

The first step, excavator moves Municipal Solid Waste from landfill to hopper. Then, a belt conveyor transports the MSW to ballistic separator. At ballistic separator, the MSW is sorted into three useful products, as mentioned above. Then, RDF is shredded into smaller part.

One of the product, RDF, contains caloric value more than 4800 kcal/ kg. It means that RDF could be used as a fuel in combustion process. The initial design of the waste processing machine yielded 3.3 tonnes of RDF per hour. On the other hand, PT Semen Indonesia as the biggest cement plant in Indonesia has a program using RDF to substitute a coal in rotary kiln. To support the program, RDF should be produced continually as needed. However, during the operation, the RDF production amount decreased and the quality also was very poor. It occurred since the machine could not operate optimally, i.e., the ballistic separator could not sort the waste, thus sand and soil were still found in RDF and also the shredder could not cut the RDF due to the waste jammed in the blade.

B. *Alternative Technology*

To improve the waste processing in Gresik landfill, several technologies could be added. For example, adding the rotary screen and drying equipment to minimize the moisture content of waste and prevent the waste jammed in shredder unit. Another idea is using a hydrothermal technology (HTT). Hydrothermal technology (HTT) is the most suitable method for replacing the existing technology (WTZP) since the output of HTT is almost the same as WTZP. The product of HTT can be used as an alternative fuel in kiln burner of cement plant. The HTT system can be seen in Figure 2. As shown, the main component required in HTT is saturated steam. In the beginning of the process, the waste is fed into a stirred reactor and injected by saturated steam with a pressure of 28 bar and a temperature of 250°C. The product contains 40% alternative fuel and 60% moisture content. The product is a dry fuel in pellet form called Pellet Solid Fuel. This technology has been successfully implemented by PT Shinko Indonesia to reduce the waste.

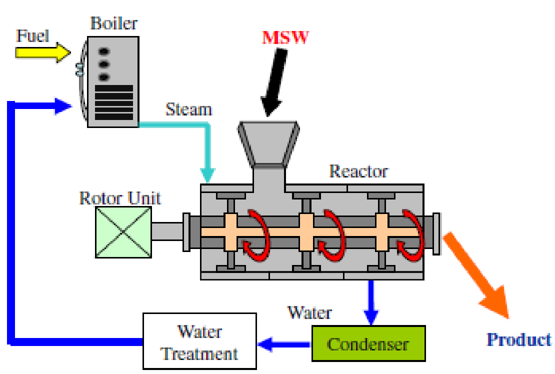

Figure 2. System Diagram of Hydrothermal Treatment Technology Process [4].

III. METHODOLOGY

The research flowchart is presented in Figure 3. In this research, observation and interview technique were used to gather the data at waste to zero program (WTZP) unit and PT Shinko Teknik Indonesia (PT STI) as a company that applied hydrothermal technology. Information obtained through participant observation were an existing condition of WTZP unit and PT STI. Meanwhile, interviews were done formally by gaining the information presented in Table 1. To complete the analysis, the supporting data were also required in this study, such as taxes, bank interest, the investment price of land in Gresik, and worker salary (these data depend on current condition).

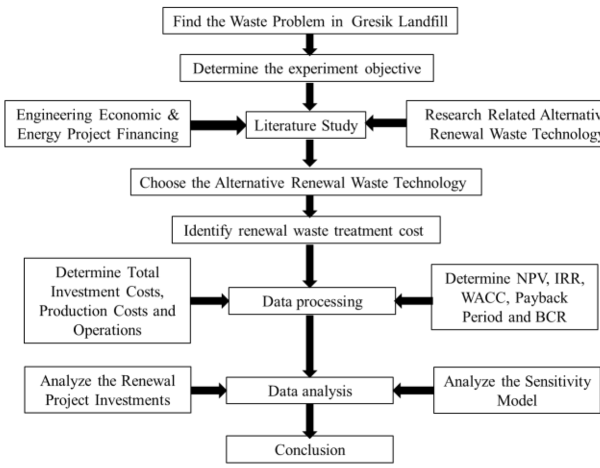

Figure 3. Flowchart methodology.

TABLE I. INFORMATION & DATA REQUIRED TO CONDUCT FEASIBILITY STUDY

Source	Information & data
Waste to Zero Program (WTZP) unit, Gresik, East Java	1. The amount of waste 2. Waste input characteristic 3. Waste processing machine specification 4. RDF production process 5. Waste product characteristic and price 6. Detailed information on waste processing machine investment and related financial 7. Operation and maintenance requirement for Waste Processing Machine 8. If the new machine is installed, how much landfill area is available
PT Shinko Teknik Indonesia, Summarecon Serpong, Scientia Garden, Banten	1. Hydrothermal technology machine specification 2. Municipal solid waste management process flow 3. Waste input and output characteristic 4. Waste product price 5. How much land is required to set up a hydrothermal technology 6. Operation and maintenance requirement 7. Detailed information on investment hydrothermal technology and related financial

After obtaining the data, financial study was conducted by calculating Net Present Value (NPV), Payback Period (PBP), Internal Rate of Return (IRR). Where the formulation is as follows [7]:

$$NPV = -\sum_{t=0}^{d-1} \frac{C_t}{(1+i)^t} + \sum_{t=d}^{n} \frac{B_t}{(1+i)^t} \quad (1)$$

$$0 = -P + \sum_{t=1}^{N^1} A_t \left({}^{P}\!/_{F}, i\%, t \right) \quad (2)$$

$$0 = \sum_{t=0}^{n} \frac{CF_t}{(1+IRR)^t} = CF_0 + \sum_{t=1}^{n} \frac{CF_t}{(1+IRR)^t} \quad (3)$$

where, Ct: cost at period t, Bt: benefit at period t, d: duration of studies, t: time, At: the cash flow that occurs in period t, N1: the return period to be calculated, n: Number of Cash Flow, t: Cash Flow Period, CFt: Cash Flow at Period t, CF0: Cash Flow at Period 0.

The calculation result would be analysed by using the indicators shown in Table 2. Subsequently, sensitivity analysis was assessed based on NPV of the changes in investment costs, bank interest rates, and labour costs. In this research, WACC (weight average cost of capital) or discount rate is assumed at 5.67%

TABLE II. PROJECT FEASIBILITY INDICATORS

Conditions	Conclusion
IRR > WACC NPV ≥ 0 Payback Period (PP) is less than long term	If the project is feasible, the renewal process can be implemented

IV. RESULT AND DISCUSSION

Financial analysis of renewal waste treatment using hydrothermal technology, requires calculation of the amount of total investment, total revenue that generates from the plant, and also total production cost incurred during the project.

A. *Total Capital Investment*

The overall investment cost is devided into the cost of equipment and installation of hydrothermal technology in WTZP, also all component needed in beginning of project. Table 3. shows the total Investment to install hydrothermal technology as renewal system in WTZP.

TABLE 3. TOTAL CAPITAL INVESTMENT OF WTZP RENEWAL PROJECT

No	Equipment	Quantity	Price of Material (Rp)
1	Hydrothermal Reactor, Boiler Combi, Condenser	1 unit	10,000,000,000
2	Water Pump	2 units	23,617,248
3	Pipe Installations	5 Metric/Ton	23,271,500
4	Water Tank	1 unit	20,597,500
5	Screw Conveyor	1 unit	56,703,183.72
6	Drying Equipment (Greenhouse)	120 Square Meter	159,576,000
7	Belt Conveyor	2 meter	46.596.000
8	Excavator (used)	1 unit	332,725,000
9	Warehouse	360 square meter	2,200,000,000
10	Civil Installations	1 work	382,812,500
TOTAL			**13,245,898,932**

B. *Total Production Cost*

Total production cost consists of all operation as labor cost, maintenances cost, electricity cost, and transportation, as shown in Table 4. Total maintenance cost is obtained from 11% investment, with the maintenance period is 3 months.

For one year, the WTZP working day is 300 days, with 2 shift machine performance (1 shift = 8 hours). Every month, WTZP is charged an electrical charge Rp10,000,000 per 40 hours of flame. After 40 hours of flame, WTZP pays electricity tariff based on kWh, at a rate of Rp1,467 per kWh. Meanwhile, transportation cost is cost to deliver alternative fuel - RDF to a cement plant.

TABLE 4. TOTAL OPERATION & MAINTENANCE COST OF WTZP RENEWAL PROJECT (PER YEAR)

Type of Cost	Unit	Total OperationCost (per year)
Maintenance	4 times per year	Rp728.524.441,00
Labor Cost		
a. Marketing	14 times	Rp398.483.960,00
b. Operasional	14 times	Rp507.348.954,00
Cost of Electricity	400 KW per hour	Rp123.157.478,00
Cost of Fuels	3,288 ton per day	Rp372.042.522,00
Cost of Transport		
a. Pellet Soil Fuels	12,56 ton per day	Rp527.520.000,00
b. Liquid Fertilizer	2 truck per day	Rp1.140.000.000,00
Operasional Liquid Fertilizer		
a. Bottles	3259 bottles per day	Rp4.887.955.968,00
b. Branding	3259 stickers per day	Rp4.887.955.968,00
c. Brochure	10.000 lembar per year	Rp10.000.000,00
d. Marketing Cost		Rp240.000.000,00
TOTAL O&M		**Rp13.822.989.296,00**

C. *Revenue*

Income generated from product sales, and opportunity cost that derived from saving cost of landfill and saving substitution of coal with alternative fuels. The details of revenue received appear in the Table 5.

TABLE 5. REVENUE OF WTZP AFTER RENEWAL (PER YEAR)

Description	Unit	Unit Price (Rp)	Total Revenue (Rp/Year)
Output Product			
a. **Refused Derived Fuels**	0,24 ton per day	290.000,00	20.880.000,00
b. **Pellet Solid Fuels**	12,56 tons per day	290.000,00	1.092.720.000,00
c. **Liquid Fertilizer**	3259 bottles per day	19.108,40	18.680.240.223,00
Opportunity Cost			
a. **Saving cost of Landfill**	6 ha		45.000.000.000,00
b. **Saving Cost for Coal**			2.677.925.760,00
		TOTAL INCOME	**67.471.765.983,00**

D. *Financial Analysis*

Based on previously data, financial indicator calculates for 20 years. With interest rate at 12.6%, tax about 25%. Percentage increase in cost and price such Electricity rates at 3,5%/year, Labor Cost at 7,0%/year, Cost of Transport at 5,0%/year, Maintenance at 6,0%/year, and Fuels at 5,0%/year.

Table 6 presents the results of the NPV, IRR, Payback Period.

TABLE 6. REVENUE OF WTZP AFTER RENEWAL (PER YEAR)

Financial Indicator	Renewal waste treatment with Hydrothermal	Feasibility
Net Present Value (NPV)	Rp128.958.401.177	Yes, NPV >0
Payback Period	4 years	Yes, Payback Period (PP) (4 years) is less than long term (7 years)
Internal Rate of Return (IRR)	0.45%	No, IRR<WACC
Weighted Average Cost of Capital (WACC), assumsed.	5.67%	

Based on the financial feasibility assessment for the waste treatment with Hydrothermal Technology, there is one of financial indicator that not meet with the requirements.

TABLE 7. COMPARISON OUTPUT BEFORE AND AFTER RENEWAL PROJECT

	Existing WTZP	After Renewal Project Using Hydrothermal
Input (ton per year)	10.000	48.000
Output (ton per year)	150	3840
Revenue per year	Rp43.500.000,00	Rp1.113.600.000,00

V. CONCLUSION

According to the financial feasibility assessment of the renewal municipal waste treatment unit project using Hydrothermal Technology, the project is feasible for public facilities, with the profit obtained 4 times in the form of increased production and revenues, saving costs for the opening of new landfills and saving costs for coal substitution.

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