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To cite this article: F F Nugroho and M L Singgih 2021 *IOP Conf. Ser.: Mater. Sci. Eng.* **1072** 012039

IOP Conf. Series: Materials Science and Engineering 1072 (2021) 012039 doi:10.1088/1757-899X/1072/1/012039

Feasibility study of waste utilization facilities in cement factory for spent bleaching earth

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Abstract. In this paper, the problem to be solved is a feasibility study for waste utilization facilities development, especially for spent bleaching by considering the market, technical, and economic aspects. The amount of spent bleaching produced by the palm oil industry in Indonesia reaches 750000 tons/year. Government regulation number 101 2014 categorized spent bleaching earth as hazardous waste with a code B 413. Therefore, the companies must carry out environmental protection and management for spent bleaching earth. This facility built to capture the market of spent bleaching earth waste disposal service, raw material substitution, and alternative fuel (coal). From the market perspective, the facility will capture about 7% market shares. Based on the technical aspect, the calcination process, kiln operational, and quality of clinker won't be disrupted if the capacity of waste facilities is 7-8 tons per hour. Based on the Payback Period calculation, it needs 5.4 years to return the investment. From the Net Present Value and Internal Rate of Return, it can be concluded that the development of waste utilization facility for spent bleaching is feasible. Based on sensitivity analysis the facilities must run above 60% capacity to make sure the facilities still feasible. Further research is expected to analyze the potential for other B3 waste which can managed by the facility and potential to enter end to end waste management business so it can have a greater impact to the company and society.

1. Introduction

Spent bleaching earth (SBE) is a waste product of palm oil bleaching process, which contains 20-30% weight of palm oil. The amount of SBE produced by the palm oil industry in Indonesia reaches 750000 tons/year. Government regulation number 101 2014 categorize SBE as hazardous waste with a code B 413. Therefore, the companies must carry out environmental protection and management for SBE. According to the national vegetable oil industry organization, 17 units of integrated SBE utilization are needed to be Recovered Oil (R-oil) and De-Oiled Bleaching Earth (OBE). However, due to high investment, there are only three utilization units with a production capacity of 300 tons per day. According to research [1], the percentage of residual CPO oil in spent bleaching earth can reach 20-30% and is difficult to separate without special handling.

Waste utilization at PT A, which is a cement factory in East Java, has been carried out since 2017. But, its utilization is limited due to constrained facilities. Since 2017 until now the waste processing has been carried out by putting waste in mixed pile facilities that enter the raw mill. The process limited due to dust collector performance (electrostatic precipitator): if the waste volume increased above standard, it effects dust emission. In 2017 the total waste that successfully utilized was 4348 tons. In 2018, it increased by 76% to 7675 tons. PT D, which is a subsidiary of PT A that newly acquired in 2019, has better waste utilization facilities. The waste facility put waste directly into the kiln inlet. According to the company's annual report in 2018 [2], the total waste treated is 537161 tons with contributing to increase profit (Gross Added Value) of IDR 180 billion.

To solve the problems in disposing of SBE as well as the potential revenue obtained from SBE waste disposal services, the authors intend to analyze the feasibility of SBE waste utilization development facilities in Tuban Plant based on the market, technical, and economic aspects. The result of the feasibility analysis expected to be considerations for decision making by the management of PT A.

2. Literature Review

Indonesia remains the largest palm oil producer in the world, with total production in 2019 is 47.2 million tons. With increasing domestic CPO production, demand for bentonite (bleaching earth) will automatically increase. The composition of bleaching earth consists of SiO_2, Al_2O_3, Fe_2O_3, CaO, and MgO. The amount of bentonite needed as an oil purifier will be the same as 1% - 3% of the amount of palm oil.

Spent bleaching earth (SBE) is industrial waste, mainly produced from vegetable oil processing. It was noted that SBE could present a fire (e.g., spontaneous combustion) because it contains 20-30% by weight of oil. So far there have been several methods to utilize SBE such as 1) recycling as landfills; 2) recycling as palm oil fertilizer; 3) reuse spent bleaching earth as an adsorbent again in the process of bleaching CPO in the cooking oil industry; 4) recovery of CPO residues with porous metal filters into low-quality palm oil and its derivatives; 5) recovery of CPO residues with solvent extraction and supercritical fluid extraction into methyl esters as biofuel feedstocks; 6) reuse SBE to obtain its caloric value and used as briquettes.

2.1. Utilization of waste in the cement industry

Research conducted to utilize biomass waste (rice husks, sawdust, and peanut shells) used as co-processing included in Separated Line Calciner (SLC) [3]. The purpose of the research is to utilize the caloric value of biomass waste as coal substituted.

2.2. Demand aspect

Demand analysis conducted PT A as an SBE waste disposal service from CPO producers in Indonesia. The purpose of the analysis is:

a. To find SBE volume projection from 2020 – 2030 using correlation of population projection and CPO demand projection.
b. Competitor mapping (Company that has business in waste disposal in Indonesia).

2.3. Technical aspect

Technical analysis is needed to determine the capacity of SBE's waste management facility by considering technical process analysis, design analysis, and project schedule. Technical Process analysis is carried out to find out how much capacity of the kiln could burn waste, especially SBE without disrupting calcination process, kiln operational, and clinker quality by simulation of process calculation and operasional. Design analysis is conducted to determine process flow and identify the equipment needed to build SBE waste utilization facilities.

2.4. Economical aspect

Economical aspect is carried out to determine the feasibility of waste utilization facilities development by conducted analysis of cost, revenue, and economic analysis.

2.4.1. Cost analysis (investment & operational cost)

2.4.1.1. Investment cost

Total investment cost to build waste utilization facilities until the commercial. It consists of: preparation and engineering, heavy equipment, civil works, leading equipment, mechanical and electrical work, erection, and commissioning.

2.4.1.2. Operational cost

Total operational costs also called the Cost of Good Sold (COGS). COGS consists of the Cost of Good Manufactured (COGM) and Operating Expense.

2.4.2. Weight average cost of capital

To discount the company's net cash flow annually, the relevant discount rate is the Weighted Average Cost of Capital (WACC), which reflects the weighted average cost of the overall capital used within the company to generate the net cash flow [4]. WACC is determined by using the equation as follows:

$$WACC = (k_e \times W_e) + (k_d[1 - T] \times W_d) \quad (1)$$

with:
ke : Cost of equity capital
kd : Cost of debt capital
We : Weight of equity in capital structure
Wd : Weight of debt in capital structure
T : Corporate income tax

Discount rate for equity is obtained by applying Capital Asset Pricing Model (CAPM). This model states that the cost of equity is risk-free interest plus premium to cover the systematic risk of stock securities [4], with a formula as follows:

$$k_e = R_f + \beta(R_m - R_f) \quad (2)$$

with:
Rf : Risk-free investment rate of return
ß : Systematic risk
Rm : Rate of return expected by equity market

Rf (Risk-free rate), is interest rates for instruments considered not to have possible defaults. In Indonesia's case, a risk-free instrument that can be chosen is interest rates on government bonds for long term. Beta is a measurement of the sensitivity rate of stock return towards overall stock market return.

2.4.3. Economic analysis

Investments that are projected to obtain sustainable income for a certain period, the calculation is carried out with a discounted cash flow.

2.4.3.1. Payback period

The payback period describes the period needed to get back the funds that have been invested in a project. Payback Period is determined by using equation as follows:

$$Payback\ Period = \frac{IO}{CFt} \quad (3)$$

with:
IO : Initial Outlay / Investment Cost
CFt : Generated annual cash flow

2.4.3.2. *Net present value /present worth*

NPV is based on the concept of equivalence in which all cash inflows and cash outflows are calculated towards the present time. If NPV is positive, it means the investment can be accepted, or the investment will increase the value of the company, conversely, if the NPV obtained is negative then the investment proposal for the project is rejected, or it can be said that the investment will reduce the value of the company. NPV is determined by using equation as follows:

$$Net\ Present\ Value = \sum_{t=1}^{N} \frac{CFt}{(1+K)^t} - IO \quad (4)$$

with:
IO : Initial Outlay / Investment Cost
CFt : Generated annual cash flow in year t

K : Required rate of return
N : Investment life
t : time period

2.4.3.3. Internal rate of return
The Internal Rate of Return (IRR) is the discount rate that makes the net present value (NPV) of a project zero. In other words, it is the expected compound annual rate of return that will be earned on a project or investment.

$$IO = \sum_{t=1}^{N} \frac{CFt}{(1+IRR)^t} - IO \quad (5)$$

with:
IO : Initial Outlay / Investment Cost
CFt : Generated annual cash flow in year t
N : Investment life
t : period

2.4.4. Sensitivity analysis
Sensitivity analysis determines how different values of an independent variable affect a particular dependent variable under a given set of assumptions. Sensitivity analysis will focus on the minimum utilization of facility and revenue compare to investment cost.

3. Research Methodology
The following are the stages of the research which is implemented.

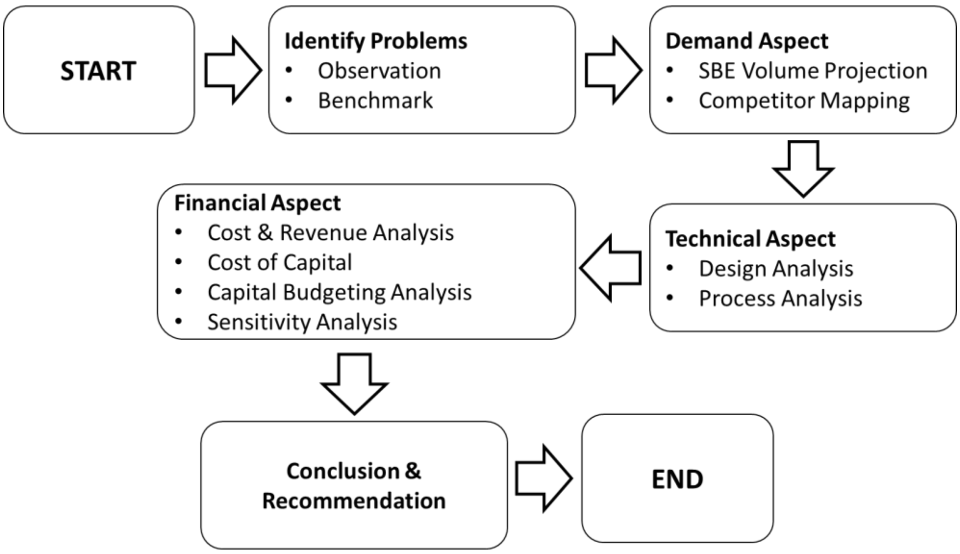

Figure 1. Flowprocess of research method implementation.

4. Results and Discussions
4.1. Demand Analysis
4.1.1. CPO Demand Projection
In projecting CPO demand in 2020 - 2030, this research uses correlation regression analysis. Regression analysis using the form of the relationship between one or more variables / independent variables (X) with one dependent variable (Y) has the equation:

$$Y = a + bX \quad (6)$$

with:
Y : Demand CPO (Dependent Variable)
X : Population (Independent Variable)
a,b : Coefficient

BPS data [5] for Indonesian population and projection from 2010-2030 shown in table 1 below.

Table 1. Indonesian population 2010 – 2030 (based on BPS report 2013).

Year	Population ('000)	Year	Population ('000)
2010	238519	2020	238519
2011	241810	2021	273777
2012	245147	2022	276515
2013	248530	2023	279280
2014	251960	2024	282073
2015	255462	2025	284829
2016	258502	2026	287108
2017	261578	2027	289404
2018	264691	2028	291720
2019	267840	2029	294053
		2030	296405

Historical CPO demand data Indonesian Palm Oil Association [6] shown in table 2 below.

Table 2. Indonesian CPO demand 2010 – 2019 (based on GAPKI report 2019).

Year	CPO Demand ('000)
2010	21800
2011	23500
2012	26500
2013	30000
2014	31500
2015	32500
2016	33637
2017	38166
2018	43108
2019	47180

The results of the regression correlation in table 1 and table 2 show that the population has a positive relationship with CPO demand in Indonesia. This is shown in table 3 where the value of Multiple R and R square is valued above 0.95, while the test result is explained in table 4.

Table 3. Indonesian CPO demand 2010 – 2019.

Regression Statistic	
Multiple R	0.97683
R Square	0.95421
Adjusted R Square	0.94848
Standard Error	1852.11
Observations	10

Table 4. Statistical test result.

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	-171165.11	15806.7394	-10.8286	4.6708E-06	-20761	-134715	-20761	-13471
X Variable 1	0.80485811	0.062334805	12.9118	1.2242E-06	0.6611	0.9486	0.6611	0.9486

The correlation formula between population and CPO demand become:

$$Demand\ CPO\ = -171{,}165.11 + 0.805\ Population \quad (7)$$

From the equation 7 above, Indonesia CPO projection demand shown in table 5.

Table 5. Indonesian projection CPO demand 2020 – 2030.

Year	**CPO Demand ('000)**
2020	47005
2021	49187
2022	51390
2023	53616
2024	55863
2025	58082
2026	59916
2027	61764
2028	63628
2029	65506
2030	67399

4.1.2. SBE volume projection

Base on research, the amount of bentonite needed as an oil purifier will be the same as 1.5% - 4.0% of the amount of palm oil [2]. And it was noted that SBE could present a fire because it contains 20 - 40% by weight of oil [3]. From the research, the formula to calculate SBE volume is:

$$Volume\ SBE\ = (Demand\ CPO\ .\ 1{,}5\%)\ x\ 120\% \quad (8)$$

The result showed that in 2020 total volume SBE is 846000 ton/year, which means there are 110 ton/hour SBE in Indonesia. The SBE projection volume for 2020 – 2030 shown in table 6.

Table 6. SBE volume projection 2020 – 2030.

Year	**CPO Demand ('000)**
2020	846
2021	885
2022	925
2023	965
2024	1006
2025	1045
2026	1078
2027	1112
2028	1145
2029	1179
2030	1213

It can be concluded that if the waste utilization facility has a capacity of 8 tons/hour, it will consume 7% of SBE waste in 2020. In other words, the market share target for SBE utilization facilities development in the Tuban plant is 7%.

4.1.3. Disposal cost

Disposal costs are costs incurred by companies that produce B3 waste to companies that manage or dispose of the waste. Some of SBE producer near Tuban Plant such as PT Wilmar, PT Barata Elok, PT Bina Karya Prima (Gresik Area), PT Salim Invomas, PT Sinar Mas, PT Ikan Dorang, PT Damai Sentosa (Surabaya & Sidoarjo Area) etc, which has potential SBE waste 500 ton per day. In this research, the assumption of disposal cost is only the disposal cost of SBE based on a contract that has been received previously from PT D. The contract of disposal cost between Rp350,000 – Rp425,000 /ton and assumed that transportation cost from SBE producer to SBE storage is handled by third parties transporter which has waste transport permit. This research assumes that disposal cost is Rp350,000 /ton for the beginning year and increase 1% per three years. The disposal cost assumption shown in Table 7. below.

Table 7. Assumption of SBE disposal cost.

Year	Disposal Cost (Rp/ton)
1	350,000
2	350,000
3	350,000
4	353,500
5	357,035
6	367,746
7	378,778
8	397,717
9	417,603
10	438,483

4.1.4. Competitor mapping

The mapping is focused on well-known companies which have B3 waste processing business, both cement companies (exclude PT D) and non-cement companies. Due to the limitations of data to find a specific type of waste by each company, the waste data presented is all of the B3 waste that includes: medical waste and industrial waste.

Table 8. Competitor mapping.

Company	Type of Waste	Location	Capacity / Strenght
PT. PPLI	Medic & Industry	West Java Batam	600,000 ton/year (20 ton/day)
PT Semen Baturaja	Fly ash and Bottom Ash	South Sumatera	Fokus on fly ash and bottom ash, 3 ton/hour
PT. Waste International	Medic & Industry	Banten Centra Java	3 x 36 ton/day
PT. Tenang Jaya Sejahtera	Medic & Industry	West Java	7,2 ton/day
PT. Putera Restu Ibu Abadi	Medic & Industry	Mojokerto	16,8 ton/day
PT. Pengelola Limbah Kutai Kartanegara	Medic & Industry	East Borneo	12 ton/day
PT Arah Environmental Indonesia	Medic & Industry	Solo	12 ton/day
PT Indocement Tunggal Perkasa	Industry	West Java	1 line kiln for industrial waste, 5 ton/hour
PT Cemindo Gemilang	Industry	West Java	1 line kiln for industrial waste, 3 ton/hour

From Table 8 above, there aren't a company that focused on managed and utilized SBE. The total volume of well-known companies above had total capacity about 500 ton per day or 21 ton per hour. So, it can be concluded that PT A still could enter the market, especially for SBE.

4.2. Technical analysis

4.2.1. Process analysis

Technical Process analysis is carried out to find out how much capacity of the kiln could burn waste, especially SBE without disrupting calcination process, kiln operational, and clinker quality. Process analysis determined by simulation of process calculation and operational simulation based on historical data of PT D waste facility.

4.2.1.1. Process simulation

Simulations are carried out to determine the operational impact in the kiln based on the amount of SBE. From the simulation are obtained:

a. SBE input must be maintained in a pre-processing facility to prevent Sulfur (S) level above 1%
b. SBE input of 6 tph impact on decreased of LSF, but it still met the requirement.
c. SBE input of 8 tph requires an increase in raw meal LSF settings so that clinker quality standards are met.

4.2.1.2. Operational simulation

Operational simulations are carried out with reference to the PT D waste facility operational. The parameters of the kiln taken at the time of operation with a feed rate: 7 tph (limitation CO ILC ~ 0.9% fan ID 86% at 500tph kiln feed), it obtained:

a. CO ILC increased from 0.1% to 0.9% at seven tph feed rate (with the same coal rate).
b. There is no impact on the SLF clinker for the short term (for the long term it is necessary to pay attention to the raw mix design).
c. The temperature in ILC Calciner has increased.
d. There was no increase in amps Kilns.

Based on the results of operational and process simulation, the volume of SBE that can be burned into kiln inlet without disrupting the operation and quality of the clinker is between 7-8 tph, on condition that SBE must through a pre-processing process and meet the Service Level Agreement (SLA). The SLA parameter is shown in Table 9 below.

Table 9. Service level agreement of SBE.

Parameter	Unit		Value
GHV (AR)	Kcal/kg		2000±500
Sulfur (S)	%	Max	1
Total Chlor (Cl)	%	Max	0,6
Ash Content	%		40-70
Size	mm	Max	40

4.2.2. Design Analysis

The purpose of design analysis is to determine process flow and identify the equipment needed to build SBE waste utilization facilities. The process is devided into 2 major activities pre-processing and co-processing. Pre-processing activities is all activity to prepare raw waste became processing waste. The process mostly conducted in waste storage facility. Co-processing is all activity or equipment needed to make sure the processing waste is transported and burned into kiln. Figure 2. Shown the flow process of SBE waste utilization facilities.

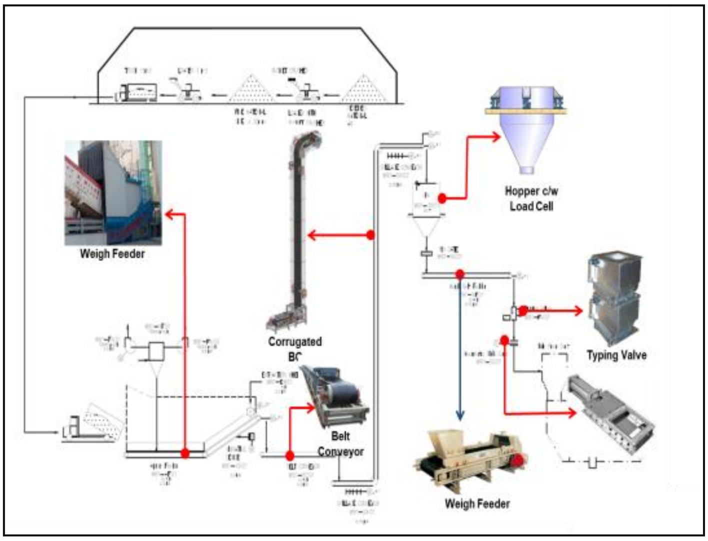

Figure 2. Flow process of SBE waste utilization facility.

Based on Figure 2 flow process diagram, the identification of the work and equipment needed is shown in the Table 10.

Table 10. Work and equipment list.

Item	Amount	Unit
Engineering	1	lot
Pre - Processing		
Waste Storage 8000 Ton (70 m x 36 m)	1	lot
Truck 15 Ton	1	ea
Loader 2 m3	1	ea
Loader with Bucket Crusher	1	ea
Co - Processing		
Civil Work	1	lot
Samson Feeder	1	ea
Corrugate BC	1	ea
Weigh Feeder	1	ea
Double Flap	1	ea
Safety, Fire suppression & Environment	1	lot
Electrical Equipment	1	lot
Commissioning	1	lot

4.2.3. Project schedule

Schedule of the project is last for 18 months from June, 2020 until December, 2021 and devided into 4 milestone. First milestone is completion of the business study, engineering study and feasibility study approval which targeted at Januari, 2021. Second milestone is start construction of the project that targeted in April, 2021. Third milestone is commissioning phase of the project which targeted on December, 2011 and the last milestone is commercial phase which targeted in January 2022.

4.3. Cost analysis

4.3.1. Investment cost

Investment costs are calculated based on the reference price of facilities that have been built by PT D, offers from vendors, company catalogs and other relevant sources by considering of foreign exchange and inflation. Based on Table 10. total investment cost can be seen in Table 11 below.

Table 11. Investment cost.

Item	Amount	Unit	Total Price (Rp)
Engineering	1	lot	300,000,000
Pre - Processing			
Waste Storage 8000 Ton (70 m x 36 m)	1	lot	5,500,000,000
Truck 15 Ton	1	ea	595,000,000
Loader 2 m3	1	ea	423,000,000
Loader with Bucket Crusher	1	ea	752,500,000
Co - Processing			
Civil WorkInvestment	1	lot	11,053,687,000
Samson Feeder	1	ea	5,685,897,000
Corrugate BC	1	ea	6,660,016,000
Weight Feeder	1	ea	2,438,875,000
Double Flap	1	ea	5,799,320,000
Safety, Fire suppression & Environment	1	lot	2,010,602,000
Electrical Equipment	1	lot	5,065,275,000
Commissioning	1	lot	500,000,000
Investment Cost			46,784,172,000
Contingency (5%)			2,339,208,600
Total Investment Cost			**49,123,380,600**

4.3.2. Operational Cost
Operational Cost or Cost of Good Sold (COGS) consists of Cost of Good Manufactured (COGM) and Operating Expense.

4.3.2.1 Cost of Good Manufactured (COGM)
Assumptions for Cost of Good Manufactured can be seen in Table 12 below.

Table 12. Assumptions for cost of good manufactured.

Cost Component	Description				
Labor	7 people/shift	2 Shift/day	Total 17 people; 14x	4 categorized labor	5% increased/y
Electricity	160 kwh total	996 rp/kwh	300 days/year		1% increased/y
Maintenance	6% of investment cost				5% increased/y
Fuel	25 l/hour	12 hour/day	300 days/year	5040 hours/year	1% increased/y

Based on an assumption on table 12 the result of calculation Cost of Good Manufactured can be seen in Table 13 below.

Table 13. Cost of good manufactured.

Cost Component	Year (Rp. Million)									
	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Total Direct Labor	2,226	2,337	2,454	2,577	2,706	2,841	2,983	3,132	3,289	3,453
Electricity	1,147	1,159	1,172	1,184	1,196	1,209	1,221	1,234	1,247	1,260
Fuel	986	995	1,005	1,015	1,026	1,036	1,046	1,057	1,067	1,078
Maintenance	2,947	2,977	3,007	3,037	3,067	3,098	3,129	3,160	3,192	3,224
Total Man. Ovrhd	5,080	5,132	5,183	5,236	5,289	5,342	5,396	5,451	5,506	5,562
Total COGM	**7,306**	**7,469**	**7,638**	**7,813**	**7,995**	**8,183**	**8,379**	**8,583**	**8,795**	**9,015**

4.3.2.2 Operating expense
Assumptions for operating expenses can be seen in Table 14 below.

Table 14. Assumptions for operating expense.

Cost Component	Description				
Labor	2 people/shift	2 Shift/day	Total 4 people ; 14x	Marketing & Sales	5% increased/y
Transportation	Accommodation Cost	Lot	5 mill /month		5% increased/y
Office Supply	1	Lot			5% increased/y
Car Rental	1 ea		3 mill/month		5% increased/y
Marketing Expenses	1	Lot			5% increased/y
Depreciation					
Heavy Equpmt	8 years				
Building & Civ. Work	20 years				
Mechanical	15 years				
Electrical	10 years				

Based on the assumption in Table 14. the result of operating expenses can be seen in Table 15. below.

Table 15. Operating expense and cost of good sold.

Cost Component	Year (Rp. Million)									
	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Salaries	560	588	617	648	681	715	750	788	827	869
Transportation	60	63	66	69	73	77	80	84	89	93
Marketing Expnse	200	210	221	232	243	255	268	281	295	310
G&A Expense	80	84	88	93	97	102	107	113	118	124
Depreciation	5,080	5,132	5,183	5,236	5,289	5,342	5,396	5,451	5,506	5,562
Heavy Equpmt	232	232	232	232	232	232	232	232	232	232
Building & Civ.	869	869	869	869	869	869	869	869	869	869
Mechanical	1,441	1,441	1,441	1,441	1,441	1,441	1,441	1,441	1,441	1,441
Electrical	827	827	827	827	827	827	827	827	827	827
Total Oprt. Expense	4,269	4,314	4,362	4,411	4,463	4,518	4,575	4,636	4,699	4,765
Cost Of Good Sold	**11,576**	**11,783**	**11,999**	**12,224**	**12,458**	**12,701**	**12,955**	**13,219**	**13,494**	**13,780**

4.3.3. Weighted Average Cost of Capital (WACC)
4.3.3.1 Cost of debt
Cost of Debt is calculated using highest interest between short term, long term loan, and bonds payable [8]. The highest interest / coupon is obligation shelf II 2019 B with 9.1% interest rate. Therefore:

$$\boldsymbol{k_d = 7.1\%}$$

4.3.3.2 Cost of equity
For Cost of Equity (k_e) calculation, the data is as follows:

a. Beta = 1.499, in accordance to levered business beta PT A.
b. R_f value = 8.2771%, comes from government bond yield FR0083 series with 20.02-year time to maturity as of April 14, 2020 from http://www.ibpa.co.id/DataPasarSuratUtang/ HargadanYield Harian/tabid/84/Default.aspx.
c. R_m value = 14.5532%, comes from Compound Annual Growth Rate (CAGR) IHSG from January 1, 2009 until January 1, 2020.

According to point 1,2 and 3, equation 2.11 is used and thus **k_e value =17.687%** is obtained as shown in table 16 below.

Table 16. Calculation of k_e value.

R_f	Beta	R_m	k_e
8.2771%	1.499	14.5532%	**17.687%**

4.3.3.3 Weighted Average Cost of Capital (WACC)
For WACC calculation, the data is as follows:

a. k_d value = 7.1%, k_e 17.68% according to the calculation above.
b. Tax (T) = 22%
c. Debt (D) = 45,915 (billion); Equity (E) = 23,892 (billion).

According to point a, b and c, so WACC value is obtained as shown in Table 17 below.

Table 17. Calculation of WACC value.

Debt (D)	Equity (E)	D+E	k_e	W_e	k_d	Tax	W_d	WACC
45.915	33.892	79.807	17,687%	0,425	7,10%	22%	0,58	11,59%

4.4. Revenue Analysis
Revenue analysis from SBE waste utilization facilities calculated by direct revenue and indirect added value or saving. Direct revenue calculated from waste disposal services / disposal cost payed by SBE produced. Indirect added value or savings calculated from raw material substitution, and alternative fuel (coal substitution). Assumptions for revenue analysis can be seen in Table 18. below.

Table 18. Assumptions for revenue component.

Revenue Component	Description		
Revenue			
Disposal Capacity	8 ton/hour		
Working Hour	24 hour/day	300 days/year	
Utilization	70% for y1		5% increased/2y
Disposal Cost	IDR 350,000/ton		2% increased/3y
Saving			
Iron Sand	IDR 286,808/ton		1% increased/y
Silica Sand	IDR 60,627/ton		1% increased/y
Limestone	IDR 37,771/ton		1% increased/y
Clay	IDR 37,233/ton		1% increased/y
Coal	IDR 454,000	4000 Kcal	-2 – 2% / y

4.4.1. Revenue
Based on the assumption in Table 18, the result of the revenue calculation shown in Table 19 below.

Table 19. Revenue projection for Y1-Y10.

Cost Component	Year (Rp. Million)									
	Y1	**Y2**	**Y3**	**Y4**	**Y5**	**Y6**	**Y7**	**Y8**	**Y9**	**Y10**
Disposal Cost	0.35	0.35	0.35	0.35	0.36	0.36	0.37	0.39	0.40	0.42
SBE Vol ('000 ton/year)	57.6	57.6	57.6	57.6	57.6	57.6	57.6	57.6	57.6	57.6
Utilization (%)	70	70	75	75	80	80	85	85	90	90
SBE Revenue	**14,112**	**14,112**	**15,120**	**15,120**	**16,451**	**16,780**	**18,185**	**18,912**	**20,826**	**21,659**
Saving (Indirect Added Value)										
Iron Sand	4,290	4,290	4,643	4,689	5,052	5,102	5,475	5,530	5,914	5,973
Silica Sand	543	543	587	593	639	645	693	700	748	756
Limestone	367	367	397	401	432	436	468	473	506	511
Clay	66	66	71	72	78	79	84	85	91	92
Total Raw Mat Subs	**5,266**	**5,266**	**5,698**	**5,755**	**6,200**	**6,262**	**6,720**	**6,787**	**7,259**	**7,331**
Alternative Fuel	**2,396**	**2,396**	**2,516**	**2,466**	**2,630**	**2,656**	**2,879**	**2,936**	**3,140**	**3,172**
Total Revenue	**21,774**	**21,774**	**23,334**	**23,341**	**25,281**	**25,698**	**27,784**	**28,636**	**31,225**	**32.162**

4.4.2. Income Statement
Based on Table 15 and Table 19, an income statement can be shown as follows:

Table 20. Income statement projection for Y1-Y10.

Cost Component	Year (Rp. Million)									
	Y1	**Y2**	**Y3**	**Y4**	**Y5**	**Y6**	**Y7**	**Y8**	**Y9**	**Y10**
Net Sales	**21,774**	**21,774**	**23,334**	**23,341**	**25,281**	**25,698**	**27,784**	**28,636**	**31,225**	**32,162**
Cost of Goods Manfc,	7,306	7,469	7,638	7,813	7,995	8,183	8,379	8,583	8,795	9,015
Gross Profit	**14,468**	**14,305**	**15,697**	**15,528**	**17,286**	**17,515**	**19,405**	**20,053**	**22,430**	**23,147**
Gross Profit Margin (%)	*66.44*	*65.70*	*67.27*	*66.53*	*68.38*	*68.16*	*69.84*	*70.03*	*71.83*	*71.97*
Operational Expenses										
Marketing Expenses	820	861	904	949	997	1,047	1,099	1,154	1,212	1,272
GA Expenses	80	84	88	93	97	102	107	113	118	124
Depreciation	3,369	3,369	3,369	3,369	3,369	3,369	3,369	3,369	3,369	3,369
Total Opr. Exps.	**4,269**	**4,314**	**4,362**	**4,411**	**4,463**	**4,518**	**4,575**	**4,636**	**4,699**	**4,765**
Operating Profit	**10,198**	**9,991**	**11,335**	**11,117**	**12,823**	**12,997**	**14,829**	**15,417**	**17,731**	**18,381**
Operating Margin (%)	*46.84*	*45.88*	*48.58*	*47.63*	*50.72*	*50.58*	*53.37*	*53.84*	*56.78*	*57.15*
EBIT	**10,198**	**9,991**	**11,335**	**11,117**	**12,823**	**12,997**	**14,829**	**15,417**	**17,731**	**18,381**
Tax Rate (%)	22	22	22	22	22	22	22	22	22	22
Income Tax	2,244	2,198	2,494	2,446	2,821	2,859	3,262	3,392	3,901	4,044
Net Income	**7,955**	**7,793**	**8,841**	**8,671**	**10,002**	**10,138**	**11,567**	**12,026**	**13,830**	**14,337**
Net Income Margin (%)	*36.53*	*35.79*	*37.89*	*37.15*	*39.56*	*39.45*	*41.63*	*41.99*	*44.29*	*44.58*
EBITDA	**13,568**	**13,360**	**14,704**	**14,486**	**16,192**	**16,366**	**18,199**	**18,787**	**21,100**	**21,751**
EBITDA Margin (%)	*62.31*	*61.36*	*63.02*	*62.06*	*64.05*	*63.69*	*65.50*	*65.61*	*67.58*	*67.63*

4.5. Calculation of Net Present Value

According to Table 20 and Table 11, Net Present Value and Internal Rate of Return can be calculated as shown in table 21 below.

Table 21. Net Present Value (NPV).

Cost Component	Year (Rp. Million)									
	Y0	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Y6**	**Y7**	**Y8**	**Y9**
Net Income	-	7,955	7,793	8,841	8,671	10,002	10,138	11,567	12,026	13,830
Depreciation	-	3,369	3,369	3,369	3,369	3,369	3,369	3,369	3,369	3,369
Change in Net Work. Cap.	-	-	-	-	-	-	-	-	-	-
Capital Expenditure	49,123	-	-	-	-	-	-	-	-	-
Free Cash Flow to Firm	**(49,123)**	**11,324**	**11,162**	**12,211**	**12,041**	**13,371**	**13,507**	**14,936**	**15,395**	**17,199**
Cumulative of FCFF	**(49,123)**	**(37,799)**	**(26,637)**	**(14,427)**	**(2,386)**	**10,985**	**24,492**	**39,428**	**54,823**	**72,022**
Payback Period	**4.2 Year**									
WACC	**11.60 %**									
NPV	**19,746**									
IRR	**22.58 %**									

From the calculation in the table above, it is concluded that the NPV is Positive and IRR > WACC so the development of waste utilization facilities in Tuban Plant is **feasible**.

4.6. Sensitivity Analysis

Sensitivity analysis conducted to determine the minimum utilization of facility, change of disposal and investment cost.

4.6.1. Utilization changes

From table 22 below, it can be seen that on 60% utility, the project won't be feasible with negative NPV and IRR < WACC.

Table 22. Sensitivity to Utility Changes

Utility	Net Present Value (Rp. Million)	Internal Rate of Return (%)	Conclusion
70%	19,746	22.6	Feasible
67%	6,697	16.7	Feasible
63%	1,899	14.1	Feasible
60%	**(1,698)**	**12.0**	**Not Feasible**

4.6.2. Disposal cost changes
Table 23 below shows that if disposal cost reduced by 65% from initial cost or became Rp 245.000,- the waste facilities won't be feasible with negative NPV and IRR < WACC.

Table 23. Sensitivity to Annual Cost Changes

Disposal Cost	Net Present Value (Rp. Million)	Internal Rate of Return (%)	Conclusion
100%	19,746	22.6	Feasible
90%	13,641	19.8	Feasible
80%	7,537	16.8	Feasible
75%	4,484	15.3	Feasible
70%	1,432	13.7	Feasible
65%	**(1,620)**	**12.1**	**Not Feasible**

4.6.3. Investment changes
Table 24 shows that the project won't be feasible if investment cost increases to 40 % from the initial project cost.

Table 24. Sensitivity to Annual Cost Changes

Δ Investment Cost	Net Present Value (Rp. Million)	Internal Rate of Return (%)	Conclusion
0 %	19,746	22.6	Feasible
10 %	14,594	19.6	Feasible
20 %	8,764	16.7	Feasible
25 %	6,018	15.5	Feasible
30 %	3,273	14.3	Feasible
35 %	527	13.3	Feasible
40 %	**(2,217)**	**12.2**	**Not Feasible**

5. Conclusion
This study has analyzed feasibility study of waste utilization facilities based on demand, technical and financial aspect. The result is we recommended to management of PT. A to invest and built the facilities in Tuban Plant with Service Level of Agreement (SLA) for the facilities is to run with a minimum 60% utilization. The analysis in this study is limited to spent bleaching earth waste management and only for waste processing facility (transportation assumed by third party transporter) further research is expected to analyze the potential for other B3 waste which can be managed by the facility and potential to enter end to end waste management business with applying for waste transport permit so it can have a greater impact to the company and society.

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