Jurnal Ekonomi dan Pembangunan Vol. 29 No. 1 Tahun 2021
Journal homepage: https://jurnalekonomi.lipi.go.id/JEP
ISSN 0854-526x (print) | e-ISSN 2503-0272 (online) DOI: 10.14203/JEP.29.1.2021.27-40

The economic assessment on the utilizing of bottom ash as the bio coal fuel

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Abstract

Coal ash was included in Hazardous and Toxic Waste (LB3). It required manage seriously so it was not warm to environment and human's health. LB3 management becomes an obligation for the industry which producing itself. This condition becomes a burden to industry itself due to the waste utilization project often regarded as the high-cost investment projects or less profitable. This study aims to conduct an economic assessment of pilot-scale projects in bottom ash utilizing to support the clean industry strategy. The study mixed coal bottom ash with biomass from municipalities solid waste (MSW), called bio-coal fuel (BCF). These raw materials were combined by a composition of 60%:40% weight (bottom ash: biomass) to be briquette by adding amylum as a binder. This study used the benefit-cost analysis approach to assess economic feasibility. Tree indicators used in this study were net benefit-cost ratio, payback period, and return on investment. These indicators provided the company policy to continue or stop this project. The finding study showed air emission test under emission standard and burning test did not disturb to boiler perform. Financial calculation showed that the company got a payback period and net benefit from ninth year. The company also achieved a net B/C ratio was more than one, and ROI was 1.09 times in ninth year. The other beneficiaries acquired by the company was included external costs, such as risks from commitment failure by third parties in coal waste management, costs rising risk of purchasing coal, and given a positive value for providing employment.

Keywords: benefit, cost, pilot project, waste

JEL Classification: A19, Y40, Y80

Abstrak

Abu dasar batu bara termasuk dalam Limbah Bahan Berbahaya dan Beracun (LB3) yang memerlukan penanganan serius agar tidak membahayakan lingkungan dan kesehatan manusia. Pengelolaan LB3 menjadi kewajiban bagi industri penghasil LB3 dan menjadi beban tersendiri industri tersebut sehingga proyek pemanfaatan LB3 sering kali dianggap sebagai proyek investasi mahal atau kurang menguntungkan. Penelitian ini bertujuan untuk melakukan kajian ekonomi pada proyek skala pilot dalam pemanfaatan bottom ash untuk mendukung strategi industri bersih. Abu dasar batu bara dicampur dengan biomassa dari limbah padat perkotaan (MSW), yang kemudian disebut bahan bakar bio-batu bara. Bahan baku teresebut dicampur dengan komposisi 60%:40% berat (abu dasar:biomassa) menjadi briket dengan menambahkan amylum sebagai bahan pengikat. Studi ini menggunakan pendekatan analisis biaya-manfaat untuk menilai kelayakan ekonomi. Tiga indikator yang digunakan dalam penelitian ini adalah net benefit-cost ratio, payback period, dan return on investment. Indikator-indikator ini memberikan dasar kebijakan bagi perusahaan untuk melanjutkan atau menghentikan proyek tersebut. Hasil studi menunjukkan bahwa emisi udara di bawah baku mutu dan uji pembakaran tidak mengganggu kinerja boiler semula. Perhitungan finansial menunjukkan bahwa perusahaan mendapatkan payback period dan keuntungan bersih pada tahun kesembilan. Perusahaan juga mencapai rasio B/C bersih lebih dari satu, dan ROI sebesar 1,09 kali pada tahun kesembilan. Manfaat lain yang diperoleh perusahaan termasuk biaya eksternal, seperti risiko kegagalan komitmen pihak ketiga dalam pengelolaan limbah batu bara, risiko biaya pembelian batu bara, dan juga nilai positif dalam penyediaan lapangan kerja.

Kata kunci: *biaya, keuntungan, limbah, proyek pilot*

Klasifikasi JEL: *A19, Y40, Y80*

Dikirim : 12 September 2020
Direvisi akhir : 6 April 2021
Diterima : 6 April 2021

INTRODUCTION

Almost 90% of Indonesia's energy needs are supplied from fossil fuels, especially oil and coal (Anindhita et al., 2015; Imaduddin et al., 2014; Yudiartono et al., 2018). The release of Government Regulation Number 79 of 2014 about National Energy Policy, Indonesia will still depend on energy sources from coal to reach 30% minimum in 2030 and 25% minimum in 2050. The fundamental policy is that coal has sufficient abundant reserves with lower usage levels (Reserve and Production ratio of coal is 500 years) while oil is only 16 years, and its price increases continually (Anindhita et al., 2015; Mardansyah, 2008; Yusuf, 2012). The data of the World Energy in the Statistical Review showed that the oil reserve and coal were 0.3 and 39,891 thousand million tons respectively in 2019 year. Whereas the production of oil and coal in 2019 year were 38.2 and 610 million tons respectively. Based on the data, the ratio of reserve and production of coal is 7 thousand times greater than oil. So coal is still the dominant primary energy source in Indonesia, especially to meet the industrial energy demand.

There was increasing the coal using in many industries. This is caused by the coal price is lower than the price of oil. Almost all textile industries in Java Island have switched to use the coal fuel (Haryadi & Suciyanti, 2018; Sulistyowati, 2013). The increased use of coal has caused the problem of FABA (fly ash and bottom ash) disposal to be more serious. The coal combustion will produce ± 20% of the total coal ash consisting of 20% fly ash and 80% bottom ash (Karo-karo & Sembiring, 2008). The electric steam power plant (PLTU) owned by PT. Semen Tonasa with 2 × 25 MW and 2 × 35 MW capacity produce 41.62 tons of bottom ash every day (Yunita, 2017). We can imagine how many tons of FABA if the coal using increase year by year. Therefore, we need the simple technological breakthroughs that can be done massively by all industries which using coal as a fuel.

The law number 32 of 2009 article 59, paragraph 1 states that FABA is categorized as hazardous and toxic waste (*Limbah Bahan Berbahaya dan Beracun* or LB3). Therefore, the FABA needs to be managed carefully because it harms to human health and the environment. The law number 32 of 2009 and the Government Regulations number 101 of 2014 about the Environmental Protection and Management also explained the hazardous and toxic waste management. These regulations state that everyone who produces LB3 is obliged to manage the LB3 that they produced. In other words, the LB3 management is the LB3 producer's responsibility. It's management responsibility can be transferred to the third party who has a business license of LB3 management if the producer of LB3 cannot manage by themselves. Therefore, this study has the primary concern of coal ash utilization regarding to minimize their storage and disposal. The volume increase of coal ash continuously will decrease the ash storage facilities (in cases of limited area for landfill expansion) and increase in handling, transporting, and costs (James et al., 2012). The study of bottom ash utilizing can be an alternative to overcome this problem. The bottom ash can be used as a fuel material into briquettes form (Marganingrum et al., 2020) which be reused by company itself. The specific objectives of this study was to evaluate the economic feasibility of bottom ash utilizing project as the material of briquettes fuel.

LITERATURE REVIEW

The coal ash increasing needs further study to find the properly technologies for ash processing and utilizing. However, research on bottom ash utilizing has not been done as much as fly ash (James et al., 2012). The current FABA utilizing is to civil engineering applications generally such as road construction, dykes, building materials, geopolymer applications, and in cement production (Estiaty et al., 2013; Jayaranjan et al., 2014; Prasandha et al., 2015; Santoso & Roy, 2003), while coal waste for energy sources or fuel is still very limited. This related to low heating value of coal waste due to the inadequate volatile matter content to burn again. Based on this, several previous studies do the mixing of bottom ash with biomass to increase the caloric value (Estiaty, et al., 2018; Slamet & Gunawan, 2016; Triantoro et al., 2019).

The Government Regulation No. 101 of 2014 states that the LB3 producer, including ash coal combustion, can utilize their LB3. This

LB3 can be reused, recycled, and recovered to convert other product that can be used as a substitute for raw materials, auxiliaries, and fuels for themselves under safe for human health and environment. Hold this regulation the study was conducted on the bottom ash utilizing as a fuel alternative (Marganingrum et al., 2020). That study was done in one of weaving and textile industry. This study was continued on a pilot scale to determine its economic feasibility. The question rising is would its benefits outweigh its costs? While waste disposal management activities were invisible in the short term, so often, it is undervalued. It was also defined as the external cost, including environmental and social costs (Jugović et al., 2018; Wang et al., 2015).

The textile industry in West Java is one of the sectors experiencing loss due to competitiveness and the rupiah's exchange rate (Kurniadi et al., 2017; Zultaqawa et al., 2019). In challenging economic conditions, many textile industries were burdened with the cost of coal waste disposal. One solution was utilizing waste become to be a valuable product for their purposes. It would reduce the cost of waste managing and providing a source of income for the company itself (Kamble et al., 2019). To avoid undesirable losses in waste using, an economic analysis is needed. This study aims to assess the financial feasibility for coal bottom ash or unburnt carbon utilizing in the briquette form to be substituted fuel in the textile industry. The assessment is applied to the pilot plant scale. The feasibility assessment could help this company in decision making to implement the pilot project or not.

Feasibility study can be done in many aspects such as market, technical, management, law and social, and then economic and financial. The financial aspects can be analyzed using the Cost Benefit Analysis (CBA) which is consists of Net Present Value (NPV), Net B/C Ratio, Internal Rate Return (IRR), and Payback Period (PP) (Pratiwi et al., 2020). This study also used the cost-benefit analysis (CBA) approach to assess financial feasibility on the pilot project of bottom ash and unburnt carbon utilizing. The CBA is to provide the information regarding the product applied by company owners. As like the other economic valuation methods, CBA is an economic tool used to compare the benefits against the costs of a given project or activity (Chadburn et al., 2013; Sososutiksno & Gasperz, 2017), can be used to assess the economic risk of a project (de Ruig et al., 2020), or determine the feasibility of a project or activity (Johnson, 2014). CBA was widely applied in various fields such as environment (Babalola, 2020; Makul, 2020; Špačková & Straub, 2015) , energy (Sidhu et al., 2018), health (Barstow et al., 2019; Botfield et al., 2020), disaster (Wild et al., 2019), water resources adaptation (de Ruig et al., 2020) etc.

Financial feasibility using Net B/C Ratio, payback period, and return on investment has be done on Poultry Chicken Farm (Elpawati et al., 2018). In this case, net B/C ratio was 0.15. If the B/C ratio is lower than one, the business is likely will experience a loss, so it is necessary to increase amount of production (Palupi et al., 2020). In the other case also found that the financial analysis results gave a Net B/C Ratio of 0, an IRR of 9.77 percent, and a return on investment of 20.3 years, which means that the project investment is not feasible (Pratiwi et al., 2020). NPV changes, Net B/C Ratio, IRR, and PP can occur because of certain changes. Therefore, we also need to do the sensitivity analysis to see eligibility business plan when things change to cost and benefit (Pratiwi et al., 2020). The sensitivity analysis will provide an overview of the extent decisions will be strong enough against with change in parameter influence. Sensitivity analysis done by changing parameters value which are then viewed how it affects the acceptability of an investment.

RESEARCH METHOD

Case Study Background

This study was done at one of the textile industries located in Bandung District, West Java-Indonesia, on the pilot plant scale. The industry has been experiencing a financial burden since the 1997 monetary crisis. However, they continue to run their business by complying with environmental regulations in their ash coal management. Some study activities are being carried out in collaboration with the Indonesian Institute of Sciences (LIPI) to utilize industrial waste. The aim was none other than toward a clean industry in addition to reducing the corporate expenses cost. In this case, we were trying to utilize bottom ash and unburnt carbon as substitution fuel in their boiler machine. Although still limited, studies using coal bottom ash were conducted (Syafrudin et al., 2015), and bottom ash briquetting was done to reduce the unburnt carbon (James et al., 2012).

The bottom ash utilizing becomes to be briquette was done by adding biomass purchased from outside parties. The function of biomass adding was to increase the burning level of bottom ash. A finding study by Kamble et al. (2019) shown co-gasification of coal and biomass has been emerging as potential clean fuel technology to achieve high thermodynamic efficiency with relatively low CO2 emission. This study used coal waste, so that provides certainly lower emission. The composition of the product was 60% weight of bottom ash and 40% weight of biomass. This formulation was based on previous study as an optimum formulation of briquette (Marganingrum et al., 2020). The briquetting process was done by adding the amylum as a binder of 2.5% product briquetting weight. Amylum was used in this study because it was easily available in the market at an affordable price.

This study assumes that the company purchases biomass continually from outside parties at the price of Rp 750/kg. The assumption was used in this study because the biomass that used in this study was still free for a trial. Whereas the biomass price from the outside party was Rp 750/kg. The biomass composition consisted of municipal solid waste (MSW) and Eichornia crassipes (Eceng Gondok), which had been fermented. MSW's utilization is nothing to worry about because the United States Environmental Protection Agency (US EPA) has declared MSW incineration as a cleaner source of energy (Azam et al., 2020). Moreover, this waste biomass will be burned in a boiler with a higher temperature. Thus, the mixture of bottom ash and waste biomass products will be one solution to overcome the significant barriers in biomass systems' high investment costs due to intense competition with fossil fuels (Malico et al., 2019).

This industry has three boiler machines, namely Omnical Boiler (fluidized bed), Bertrams Konus Oil Boiler (fluidized bed) and Actom John Thompson Boiler (chain grate). The average uses of coal in these boilers are 7 ton/day, 2.3 ton/day, and 18 ton/day, respectively. The coal waste produced from all three boilers is as much 3 ton/day. The disposal fee of coal waste is Rp 165/kg. The waste of coal combustion contained 150 kg/day of bottom ash.

Reusing of bottom ash as substitution fuel was only used in Omnical Boiler. The amount of coal substitution by briquettes is approximately 10% of coal used. We did the boiler observation for one month continuously. We produced ± 250 kg/day of briquette according to bottom ash availability and engine capacity for briquetting. We collected briquette production sample and raw material as well. The substitution processing was conducted for 8 hours from 08.00 am until 04.00 pm in Omnical Boiler (Figure 1).

Method

This study used the Cost-Benefit Analysis (CBA) approach for assessing of economic and financial feasibility of bottoms ash or unburnt carbon utilizing as substitution fuel in the textile industry. The CBA types were consisted of three types, namely ex-ante, in medias res, and ex-post. In this study, the kind of CBA that we applied was in media res due to the financial assessment was conducted during the life of a current project (Boardman et al., 2011; Brubakken, 2020).

The determinate of decision rule based on CBA was generally described in the following equation (Turner et al., 1994):

$$\sum_t (B_t - C_t)(1 + r)^{-t} > 0 \quad (1)$$

$$\sum_t (B_t - C_t \pm E_t)(1 + r)^{-t} > 0 \quad (2)$$

B_t is the benefit in year t, C_t is a cost in year t, E_t is the environmental or social cost in year t, r is the discount rate, and t is time preference.

CBA is comparison total present value between the benefit flow and the current cost flow based on the opportunity cost of capital invested (Elpawati et al., 2018). Besides implemented Present Net Value (NPV), three indicators of feasibility investments were applied (Sososutiksno & Gasperz, 2017), such as Net Benefit-Cost Ratio (Net B/C), Payback Period (PB) (Mandasari et al., 2016; Nurmalina & Riesti, 2010; Pasaribu & Sukandar, 2017) , and Return of Investment (ROI) (Masters et al., 2017).

Net Present Value (NPV)

Net Present Value (NPV) was the present value of the net profit gained from a project. NVP in this study was formulated as follows (Nurmalina & Riesti, 2010; Setiawan et al., 2019):

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t - K_t}{(1+r)^t}$$
$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t - K_t}{(1+r)^t} \quad (3)$$

B_t is benefit in the first year to t year, C_t is cost in the first year to t year, K_t capital used in the investment period, r is discount rate, and t is time preference. The feasibility economic based on NPV is as follow:

- NPV > 0 means a project already declared profitable and feasible implemented.
- NPV = 0 means the project is not profitable and is not loss or in the other words the project is able to return exactly equal social capital Opportunities Cost factor normal production.
- NPV < 0 means a project is not feasible implemented

Net Benefit Cost Ratio (Net B/C)

Net Benefit-Cost Ratio (Net B/C) is a numerical comparison between current values benefits divided by present value cost flow (Elpawati et al., 2018; Pratiwi et al., 2020). The number shows the magnitude of additional benefits on each an additional cost of one unit money. The project can be accepted and continued if Net B/C is one or more. Net B/C was formulated as follows:

$$Net\frac{B}{C} = \frac{\sum_{n=1}^{t} \frac{B_t}{(1+r)^t}}{\sum_{n=1}^{t} \frac{C_t}{(1+r)^t}} Net\frac{B}{C} = \frac{\sum_{n=1}^{t} \frac{B_t}{(1+r)^t}}{\sum_{n=1}^{t} \frac{C_t}{(1+r)^t}} \quad (4)$$

B_t is benefit in the first year to t year, C_t is cost in the first year to t year, r is discount rate, and t is time preference.

Payback Period (PB)

The payback period (PB) is the ratio between investment expenditures with the benefits in a certain time (Isamu et al., 2018) or the period of return of investment incurred through the net benefit obtained. This PB calculation already calculates the time value of money because the net benefit amount is obtained using the interest rate factor (Nurmalina & Riesti, 2010). Sometime to calculate the payback period also could ignore the time value of money (Mandasari et al., 2016).

The formula used to calculate PBP in this study is as follows (Mandasari et al., 2016; Nurmalina & Riesti, 2010):

$$PB = \frac{I}{A_t} PB = \frac{I}{A_t} \quad (5)$$

I indicate investment cost, and A_t is average net benefit every year.

Return of Investment (ROI)

ROI is a number that shows the ratio between net benefit and invested capital. A positive ROI indicates that the total investment cost can be returned and profit from the remaining investment costs. While negative ROI shows that the income earned cannot cover the total investment costs incurred. Thus, it can be said that a higher ROI will be better than a low ROI. ROI of 100% means the total investment has been returned. The ROI was formulated follows:

$$ROI = \frac{Net\frac{B}{C}}{I} ROI = \frac{Net\frac{B}{C}}{I} \quad (6)$$

I is total investment cost.

RESULTS AND DISCUSSION

Material Characteristic of Product Briquette and It's Air Emission

Table 1 shows the characteristic of raw material and product briquette in this study. The table shows average value of 17 samples analyzed. We can see that bottoms ash contained high fixed carbon and low volatile matter, whereas biomass contained low fixed carbon and high volatile matter.

The coal waste from textile industry most cannot be used directly and must improve the quality first (Suprapto, 2009) to be able to utilize the caloric value remind (Estiaty et al., 2018; Triantoro et al., 2019). While the biomass

Table 1. Characteristic Raw Material and Product Briquette

Parameters	Unit	Bottom Ash	Biomass	BCF Product	Coal
Proximate:					
Moisture	%, adb	4.36	11.74	7.39	7.90
Ash	%, adb	64.85	44.11	53.06	14.36
Volatile Matter	%, adb	5.12	36.61	18.29	37.05
Fixed Carbon	%, adb	25.67	5.14	21.26	39.20
Ultimate:					
Total Sulfur	%,adb	0.91	0.25	0.72	0.38
Carbon	%, adb	28.01	20.83	30.97	56.47
Hydrogen	%, adb	0.76	3.71	1.99	4.77
Nitrogen	%, adb	0.39	0.99	0.57	1.00
Oxygen	%, adb	5.08	27.71	15.92	21.52
Gross Calorific Value	cal/g,adb	1952.93	1895.53	2500.76	5341.50

Source: Analysis result (2020)

problems are handling and economic of utilizing. The handling biomass generally was quite tricky because of its low density (Triantoro et al., 2019). Besides low density, the biomass of MSW required handling and processing to be used economically. Based on this fact, this study's aims made both waste materials (bottom ash and MSW as biomass) were more useful, mixed of both materials could be completely burned, and not warm to environment and human health.

Regulation of the Minister of Environment Number 2 of 2008 concerning "Utilization of LB3" in article 7 stated that the utilization of LB3 as a fuel substitution must meet the following criteria, such as 1) calorie content equal to or greater than 2500 kcal/kg (cal/gram), 2) moisture equal to or less than 15% and 3) not contain halogenated compounds. Based on the study results, as shown in Table 1, the BCF product had fulfilled the first and second criteria. The third criterion was constrained by analysis equipment and become to be our concern for the next study.

This study emphasized to the waste materials utilizing to be valued economic goods by minimizing negative impacts on the environment and human health. This textile industry, where this study conducted is only had limited temporary sites of coal waste disposal. Therefore, they always send coal waste to third parties once every three days. These costs become a burden for the industry during the current economic downturn. The pilot project of bottom ash utilizing could help the company to carry out the disposal problem of coal waste. Then this results of cost-benefit analysis were needed for decision making by the company.

If we only used biomass or bottom ash as a single material, the caloric value was less, whereas moisture content was qualified. Coal bottom ash had a volatile matter, and fixed carbon was 5.12% (adb) and 36.61% (adb), whereas biomass had 25.12% (adb) and 5.14% (adb). Combining the two compositions material as BCF that causes the heating value was higher than the heating value of its raw material. Volatile matter content in the material served to accelerate the combustion. The utilization of coal bottom ash as fuel is to continue burning coal because the range of volatile matter can not burn the carbon residue (fixed carbon). Bottom ash combined with biomass adds volatile matter content to BCF so that the volatile matter and fixed carbon content are almost equal. Thus it is expected that the carbon residue in the bottom ash will burn out. The total ash combustion of BCF was a safe material for the environment because the ash characteristics were almost the same as soil. The reusing of bottom ash in this study can reduce the pollution environment and simultaneously reducing the use of resources. This was one strategy in clean production (Nugroho et al., 2019) besides clean production in the textile wastewater context (Ozturk et al., 2014).

During the trial burning test (TBT) using the briquette product substitution, we also conducted the air emission monitoring by collaborating with the Center for Textiles and Pulp of Bandung District.

a) Bottom Ash

b) Biomass

c) Amylum as the binder

Source: Documentation of study (2020)

Figure 1. The raw materials used in this study

Table 2 shows the result of air emission and ambient test from coal combustion with BCF product substitution. The substitution of BCF was only conducted in the Omnical boiler, so we compared the emission from its boiler stack with the current emission standard.

During the trial burning test (TBT) using the briquette product substitution, we also conducted the air emission monitoring by collaborating with the Center for Textiles and Pulp of Bandung District. The air emission monitoring was needed to know the impact of BCF substitution on air pollution and boiler performance. Table 2 shows the result of air emission and ambient test from coal combustion with BCF product substitution. The substitution of BCF was only conducted in the Omnical boiler, so we compared the emission from its boiler stack with the current emission standard.

The coal burning emission always contained CO_x, SO_x, NO_x and particulate. So these parameters become primary parameter to be watched. Based on the air emission monitoring (Table 2 and Table 3), the BCF briquette emissions of coal substitution meet the current emission standard. These data showed that BCF briquette did not given impact significantly to air pollution so it safe for environment. But we can not count the economic assesment of environment impact before and after of BCF substitution due to air pollution impact to human health needs a long data serries. This study was intended only for financial assessment however air emissions of BCF briquettes as a coal substitution must be ensured it was safe enough for environment.

Table 2. The Results of Air Emission Test with BCF Product Substitution

No	**Parameter**	**Unit**	**Boiler 1 Stack fueled coal and BCF**	**Standard***	**Method**
1	Particulate**)	mg/Nm³	70.9	230	SNI 7117.12-2005
2	Sulfur Dioxide (SO_2)	mg/Nm³	493.9	750	IK-Paskal.LU.MU-02
3	Nitrogen Dioxide (NO_2)**	mg/Nm³	370.3	825	IK-Paskal.LU.MU-01
4	Opacity	%	<20	20	SNI 7117.11-2005
5	Oxygen (O_2)	%	10.8	-	SNI 19-7117,10-2005
6	Flow Rate	m/s	6.5	-	SNI 7117.12-2005

Source: Analysis result (2020)

Note : *) The standard was based on Government Regulation Number 41 of 1999
****)** Measurements were made for 1 hour

Table 3. The Result of Ambient Air Test

No	Parameter	Unit	The Results of Test		Standard*	Method
			Front Area of Industry **	***Behind Area of Industry*** **		
1	TSP (Total Dust)	$\mu g/Nm^3$	<159.9	<159.9	230	*In House (Sensor Electro Chemical)*
2	Nitrogen Dioxide (NO_2)	$\mu g/Nm^3$	<37.6	<37.6	400	
3	Sulfur Dioxide (SO_2)	$\mu g/Nm^3$	<52.2	<52.2	900	
4	Carbon Monoxide (CO)	$\mu g/Nm^3$	2248	2664	30000	
5	Ozone (O_3)	$\mu g/Nm^3$	<39.3	45.83	235	
6	NH_3	ppm	0.64	0.46	-	
7	H_2S	ppm	<0.01	<0.01	-	

Source: Analysis result (2020)

Note : *) The standard was based on Government Regulation Number 41 of 1999

**) Measurements were made for 1 hour

Source: Documentation of Study (2020)

Figure 2. The Air Emission Monitoring

The ash content of fuel contributed to particulate emission (Pasymi, 2008). We can see Table 1, ash content of BCF is more than coal. This will increase the particulate emission. Even though the correlation between the number of biomass adding and particulate emissions increasing was not yet clear. But Table 2 showed that particulate emission of BCF was lower than emission standard. Morever there was reference stated that biomass can reduce the NOx content of coal combustion (Sutarto et al., 2020). The BCF substitution observation also did not disturb to the Omnical boiler performance. Based on BCF characteristic and its air emission showed that the pilot project was safe enough to technical and environment aspect and potentially to continue.

Cost Estimation

The capital cost prepared by company consisted of space to work and machines. The briquette making used two equipment, namely mixer machine and briquetting machine. The capacity of each machine is showed on Table 4. These machines become company investment and counted as fixed costs. The purchase of a mixer machine was 30 million rupiahs and a briquette machine was 40 million rupiahs. Other fix cost was the construction space of hangars where briquette production was carried out. The amount of costs incurred by the company for this amounted to 25 million rupiahs. Therefore, the total of fixed costs as company investment was 95 million rupiahs.

Other cost components were cost production as variable costs. Cost production consisted of power consumption, material purchasing used in the production of BCF, gas consumption, and employee salary. This study used the assumption that BCF production was constant every day due to bottom ash limitation availability in this industry. Production was conducted by maximizing of bottom ash availability, which was 150 kg per day. Table 5 shows the power consumption used during BCF production. The total power of mixer machine was 6 KWh and briquetting machine also 6 KWh. So the total power consumption was 12 KWh per day. The current tariff of power used by industry is Rp 1,115.00 per KWh.

Table 4. Characterization of Machine Usage

Equipment Type	Num. of Unit	Operational Time	Capacity	Capacity per-day (kg)
Mixer Machine	1	8	30 Kg/hours	240
Briquetting Machine	1	4	60 Kg/hours	240

Source: Analysis result (2020)

Table 5. Power Consumption

Equipment	Power	Number of Unit	Total Power	Usage Timing	Power Consumption
	(Watt)	(Unit)	(Watt)	(Jam)	(KWh)
Mixer Machine	750	1	750	8.0	6
Briquetting Machine	1,500	1	1,500	4.0	6
Total Power Consumption per day			2,250		12

Source: Analysis result (2020)

Table 6. Production Cost

Material	Unit	Number Per Day	Unit Price (Rp)	Total Price (Rp/day)	Total Price (Rp/month)	Price per Unit (Rp/Kg)
Bottom ash	kg	144	-	-	-	-
Biomass	kg	96	750	72,000	1,800,000	300
Binder	kg	6	7,600	45,600	1,140,000	190
Water	liter	64	10	640	16,000	3
Gas Consumption	kg	0.05	147,000	7,056	176,400	29
Salary	person	2	50,000	100,000	2,500,000	417
Power Consumption	kwh	12	1,115	13,380	334,500	56
Sum Cost Production				**238,676**	**5,966,900**	**994**

Source: Analysis result (2020)

Table 7. The Benefit per Month Obtained by Industry

Items	Benefit (Rp)
Benefit from cost of bottom ash disposal	540,000,-
Benefit from purchasing of coal substituted	6,850,000,-
Sum Benefit per Month	**7,390,000,-**

Source: Analysis result (2020)

The cost of purchasing material in briquettes production consisted of coal bottom ash, biomass, binder, and water. The other costs for BCF production were gas consumption and employee salaries. The detail of variable cost in production process can see in Table 6. The total cost of BCF production was Rp 5,966,900 per month or Rp 994 per kilogram unit product.

In addition, investment and cost production, the other costs were maintenance costs for machine and building. A machine maintenance cost was counted as each machine investment to total machines investment multiplied by the machine's depreciation cost. This cost was same every month. At the same time, the building maintenance cost was Rp 40,000 flats every month. So the total maintenance cost was Rp 625,000 flats every month.

Aggregate of Benefits

The company achieved the real profits from the disposal costs of coal bottom ash and the purchasing cost of number coal substituted by BCF briquettes. Table 7 shows the industry benefit gained during BCF briquettes using as substitution fuel in the industry itself. The company made total benefit of Rp 7,390,000 per month.

Table 8. The Calculation of Cost and Benefit of Briquette Product in the Industry (in Rp)

Year	BENEFIT Accumulation	COST Accumulation	OM Cost Accumulation	PV Benefit Accumulation	PV Cost Accumulation	Net Return Accumulation
1	81,290,000	165,077,500	70,077,500	73,900,000	150,070,455	11,212,500
2	169,970,000	242,207,500	147,207,500	154,518,182	220,188,636	22,762,500
3	258,650,000	319,337,500	224,337,500	235,136,364	290,306,818	34,312,500
4	347,330,000	396,467,500	301,467,500	315,754,545	360,425,000	45,862,500
5	436,010,000	473,597,500	378,597,500	396,372,727	430,543,182	57,412,500
6	524,690,000	550,727,500	455,727,500	476,990,909	500,661,364	68,962,500
7	613,370,000	627,857,500	532,857,500	557,609,091	570,779,545	80,512,500
8	702,050,000	704,987,500	609,987,500	638,227,273	640,897,727	92,062,500
9	790,730,000	782,117,500	687,117,500	718,845,455	711,015,909	103,612,500
10	879,410,000	859,247,500	764,247,500	799,463,636	781,134,091	115,162,500
11	968,090,000	936,377,500	841,377,500	880,081,818	851,252,273	126,712,500
12	1,056,770,000	1,013,507,500	918,507,500	960,700,000	921,370,455	138,262,500
13	1,145,450,000	1,090,637,500	995,637,500	1,041,318,182	991,488,636	149,812,500
14	1,234,130,000	1,167,767,500	1,072,767,500	1,121,936,364	1,061,606,818	161,362,500
15	1,322,810,000	1,244,897,500	1,149,897,500	1,202,554,545	1,131,725,000	172,912,500
16	1,411,490,000	1,322,027,500	1,227,027,500	1,283,172,727	1,201,843,182	184,462,500
17	1,500,170,000	1,399,157,500	1,304,157,500	1,363,790,909	1,271,961,364	196,012,500
18	1,588,850,000	1,476,287,500	1,381,287,500	1,444,409,091	1,342,079,545	207,562,500
19	1,677,530,000	1,553,417,500	1,458,417,500	1,525,027,273	1,412,197,727	219,112,500
20	1,766,210,000	1,630,547,500	1,535,547,500	1,605,645,455	1,482,315,909	230,662,500

Source: Analysis result (2020)

Table 9. The Calculation of Benefit Cost Ratio and Payback Period

Year	Net (B-C) Ratio	Payback Period	ROI
1	0.492	(1.25)	12%
2	0.702	(1.45)	24%
3	0.810	(1.72)	36%
4	0.876	(2.13)	48%
5	0.921	(2.78)	60%
6	0.953	(4.01)	73%
7	0.977	(7.21)	85%
8	0.996	(35.57)	97%
9	1.011	12.13	109%
10	1.023	5.18	121%
11	1.034	3.30	133%
12	1.043	2.42	146%
13	1.050	1.91	158%
14	1.057	1.57	170%
15	1.063	1.34	182%
16	1.068	1.17	194%
17	1.072	1.03	206%
18	1.076	0.93	218%
19	1.080	0.84	231%
20	1.083	0.77	243%

Source: Analysis result (2020)

Cost-Benefit Calculation

Table 8 and Table 9 show the calculation of Benefit-Cost analysis of BCF production. This calculation used the interest rate (r) assumption of 10%. The net benefit/cost ratio was calculated as present value ratio between benefit accumulation and cost accumulation. OM (operational and maintenance) Cost Accumulation is an accumulation cost without investment. Based on the economic assessment, the company got a payback period and net benefit of the project on the ninth year, precisely in fourth month of ninth year. In this time, net B/C ratio was more than one, and ROI was 109% meaningful; the company's investment was 1.09 times. Based on financial calculation, this pilot project had been giving benefits since the first year. It was indicated by the positive net B/C ratio; in fact, the profit value cannot return the company's investment for this project on the first year.

The company could achieve more beneficiary if the external (social) cost were included in this calculation. Environmental safety consideration is more important than just looking for profit if the company wants to contribute in a clean industry or clean production strategy. The investments in the waste sector often get impeded because of high costs. This can be helped by issuing rules to facilitate waste even though strict controls need to be carried out by the authorities**.**

CONCLUSION AND RECOMMENDATION

The financial calculation and also environmental consideration showed that the pilot project was feasible to continue. The air emission of BCF substitution meet the current standard regulation and the burning test did not disturb the boiler Omnical perform. The net B/C ratio of the pilot project was more than one after the ninth years. At that time, the ROI was 1.09 times. The company could buy back some machines that have been invested before the machine's life ends in the tenth year. The company has also achieved positive benefits since the first year namely reducing cost to buy coal and coal waste disposal.

The pilot project was recommended to applied at the others industry which using same boiler and generating the bottom ash. Thus hazardous waste problem of coal ash and burning emission can be reduced. This of course requires policy support from local and national government. The government supporting can make this same project more massive in throughout the coal user industries.

ACKNOWLEDGMENTS

The authors say thank you to the Finance Ministry of Republic Indonesia who giving funding this study through RISPRO LPDP schema program.

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