
Economic Analysis of Biomass as a Replacement for Conventional Coal by Considering Externalities

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ABSTRACT

The textile industries have begun to take proactive initiatives to deal with global warming issues. Several potential initiatives have been explored, however the financial implications for the industry and society it is still debatable. The present paper aims at evaluating economic analysis to replace coal to a more environmentally friendly energy source, i.e., biomass. A case study of textile company in West Java which aims to meet net zero fossil fuel by 2025 was taken as a studied case. The economic analysis was conducted using incremental analysis which is a proper technique to compare two or more mutually exclusive alternatives. Incremental analysis is a detail technique, properly used when two or more alternatives have insignificant differences, and the data available is cost. The externalities were included in the analysis, which is the main contribution of the paper. Data was collected from both on one year company demand and ministry of energy and mineral resources. The incremental analysis techniques employing present value and benefit-cost ratio resulted that, rice husk pellet is the potential alternative energy source to replace coal as energy source compared to sawdust, corncobs, and municipal waste as those four types are the only types that are intended for industrial activities.

Keywords:

coal; biomass; economic analysis; rice husk pellet; sawdust

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1. Introduction

According to government regulation number 79/2014, Indonesia aims to meet its national energy requirements of 400 MTOE by 2025 and 1,000 MTOE by 2050, with coal being the primary energy source. Indonesia's reliance on coal as its principal energy source has ramifications in the context of climate change and the rise in air pollution induced by the rise in global temperature. The GHG is projected to increase twice by 2030, from 168 million tonnes CO_{2e} in 2019 to 498 million tonnes CO_{2e} in 2030 ([Arinaldo and Adiatma, 2019](#)). Textile firms such as Adidas, H&M, Nike, and Puma, which have pledged to play an active part in lowering greenhouse gas emissions, have begun to pay attention to GHG issues, despite the fact that their commitments have not yet been fully realized. One of the textile industry's initiatives to reduce greenhouse gas emissions is to replace coal-based fuels with ecologically acceptable alternatives. Biomass is an eco-friendly alternative energy source generated from plants or animals, including their waste and by-products. Shifting from coal energy to biomass can be a strategy for lowering GHG emissions due to the numerous benefits of utilizing biomass, such as the renewable or infinite nature of biomass, high diversification of biomass fuel supplies, CO₂ neutrality so that it directly decreases GHG emissions, revitalization of the environment by creating jobs and new goods, biomass (and biofuels) that can be derived from the sea, low-quality soil, non-agricultural items, and even toxic waste. In reality, however, the textile industry faces obstacles in making this shift ([Vassilev et al., 2015](#); [Conca, 2015](#)).

Many industries have benefited from utilizing coal that it is difficult for them to switch to an alternative energy source. Coal's low price relative to other energy sources, for example, is one of the numerous factors that elevate it to the top position among energy sources. The nearly global availability of coal is an asset in and of itself, as transportation and storage are simplified and made easier ([Shwartz, 2019](#)). The usage of coal is viewed as both negative and positive, depending on the perspective of the judge, whether it is the public, industry leaders, the government, or the coal mining business. Therefore, it is necessary to do additional research to determine whether replacing coal energy sources with renewable energy is advantageous for all stakeholders. The transition from coal to biomass raises the question of whether biomass is equally profitable for both companies and society.

The aim of the paper is to examine economic profile of replacing coal to biomass as energy sources. A textile firm of fashion industry in West Java, Indonesia, was taken as a studied case. The firm has intended to replace coal with a more environmentally friendly source of energy, such as biomass, to achieve carbon neutrality by 2025. Economic analysis using incremental analysis of both present worth and benefit-cost ratio was conducted to identify the alternative energy sources that yields the greatest coal savings.

Assessing the economic viability of biomass has often involved economic analysis. In Surabaya, research examined the viability of using biomass from organic waste as a power source from an economic and technical standpoint. This study studied Biomass Power Plant with a positive NPV, and the operation of this Biomass Power Plant can reduce GHG emissions by 687,813.12 tCO₂/year ([Azmi et al., 2014](#)). In Aceh, Oil Palm Biomass Power Plant was studied to examine the viability of Oil Palm Biomass Power Plant using empty fruit bunches (EFB), shells, and fibers as the biomass. The study concentrates on technical issues by examining the electricity efficiency produced by biomass, which was equal to 79.82% ([Nazruddin, 2014](#)). In district of North Penajam Paser, East Kalimantan, research was conducted about the analysis of the potential and viability of renewable energy systems. Using the biomass type from palm oil waste, this research focuses on calculating the electricity potential that can be generated from palm oil waste and analyzing viability from an economic perspective (NPV, LCOW IRR, BCR, PBP). Another research focus on the viability of making chemicals from biomass and petroleum, with an emphasis on the chemical composition of each source. Considerations for the research's technological, economic, and environmental elements ([Fiorentino and Ripa, 2016](#)). Another research in Italy was conducted focusing on the environmental assessment of power plant. The approach aims to utilize life cycle assessment (LCA) to recognize and assess environmental effects associated with the generation of thermal energy in biomass power plants ([Paletto et al., 2019](#)). To evaluate the type of energy consumption that is most popular in Japan and to gather information about costs, labor, and energy production, a study was conducted on the assessment on the economic, environmental, and social aspects of using wood pellets as energy. Input-output analysis is another technique for conducting economic, social, and environmental studies ([Nischiguci and Tabta, 2016](#)). In the Philippines, research on testing the viability of producing biomass briquettes from a mixture of carbonized paper waste, sawdust, and rice husk. Interviews, discussion groups, and literature reviews were the methodologies employed in the socioeconomic underpinning of the study. The goal of the study is to determine the COGS and manpower needed to produce biomass briquettes ([Romallosa and Kraft, 2017](#)). A study on the evaluation of the environmental, social, and economic aspects of biomass production was done by Wichtmann et al. in 2011. The researchers gather information from numerous research findings using the literature study method. Classifying difficulties that frequently arise during the biomass production process follows the classification of final biomass products (such as ethanol from wheat, biodiesel from grains, and biogas from corn, among others) ([Wichtmann and Wichmann, 2011](#)). Research on the social impact of using biomass derived from pine in Australian forests resulted that employment, workplace health and safety, and a qualitative investigation of stakeholder issues are the impact indicators examined. For each indicator, coal and biomass are compared in this study ([Weldegiorgis and Franks, 2013](#)). The present paper contributes to the current body of knowledge by demonstrating the externalities involving social and environmental aspect to be included in the economic analysis.

2. Literature Review

This research is based on a case study of a textile industry seeking to replace its coal energy supply with a more environmentally friendly source. The biomass used in this study, which is limited to corncob, sawdust, municipal and hyacinth waste, and pelletized rice husk, represents the potential biomass in West Java. Below is the description of the potential biomass in West Java, carbon taxes, incremental analysis, and research perspective are explained in this part.

2.1 Biomass potential in West Java

Biomass is a biorenewable resource, all of which come from organic matter, including both living and dead plants, as well as from animals and their waste. There are various types of biomass, namely, industrial plantation forest, social forestry logging waste (about 20% -30% of all felled trees), land clearing, waste from wood and bunch processing, agroforestry waste and solid waste (Roni *et al.*, 2017). West Java has abundant farm and livestock products that can be utilized as biomass as shown in Table 1 (Ditjen EBTKE, 2021).

Table 1. Biomass production rates in West Java

Type of biomass		Potential total in West Java (ton/year)	Type of biomass		Potential total in West Java (ton/year)
Palm oil	Shell	8,773	Wood	Round wood waste	17,026
	Fiber	12,546		Plywood waste	9,761
	Empty Bunch	32,167		Sawdust waste	937,855
	Midrib	150,585	Waste	Waste	7,716,509
	Stem	41,148		Spay cut	3,712,095
Sugarcane	Bagasse	130,880	Livestock waste (biogas)	Dairy cows	1,117,858
	Sugar cane leaves	10,621		Buffalo	779,320
Coconut	Coconut shell	13,189	Goat	550,864	
	Coconut fiber	24,619	Sheep	5,043,954	
Rubber	Rubber wood waste	369,370	Pig	19,203	
Paddy	Husk	1,671,632	Free-range chicken	1,839,753	
	Straw	8,358,161	Hens	2,180,665	
Corn	Cob	1,068,696	Broiler chickens	53,292,321	
	Skin	1,068,696			
	Leaf	1,424,928			
	Stem	2,137,392			

Source: [Ditjen EBTKE \(2021\)](#)

To reduce the group this research focuses on several biomass types such as municipal waste briquette, rice husk pellet, corn cob and sawdust, additionally these four types of biomasses are the only type which are intended for industrial activities (Ditjen EBTKE, 2021) Municipal waste briquettes located in Saguling Reservoir or Citarum River produces 1,500 tons of waste per day, not only municipal waste the river grows water hyacinth massively that interferes the ecosystem as well as the fishermen (Damanik, 2017; Mutiah, 2020). Another biomass type that can be utilized in West Java is rice husk pellet, as West Java is one of the largest rice productions reaching 9.08 million tons of paddy or 5.3 million tons of rice. The heating value of rice husk itself reaches up to 2,000 kcal/kg (Bayu, 2020). Corn cob, another alternative choice, is a waste from corn where its production in West Java in one year is 1,816 million tons with corncobs produced at 20.87% of the total corn yield of around 363 thousand tons of corncobs. Corn cobs have energy of 3,500-4,500 kcal/kg (Solihat, 2021; Fitriani, 2017). The corncob biomass production process is more complicated than the others. This is due to the hardness of the corncobs, so that cutting technology is needed that is capable of cutting corncobs. The last alternative to be considered is wood pellet from HTE Perhutani that produces 11 million tons per year in 2025.

From the current selected biomass, some alternatives were eliminated in accordance to the biomass criteria selection (Kraiphanont, 2016).

- Operating locations: limited to 200 km.
- Feedstock origins: whether the raw materials for biomass come from local or imported.
- Biomass end-products: what products can be produced from the biomass raw material.
- Application: whether the supplier produces for residential or industrial purposes.
- Benefit & challenges: the advantages and challenges that exist beneath each biomass (economic and environmental aspects)

2.2 Carbon tax

The President of the Republic of Indonesia stipulates Presidential Regulation Number 98 of 2021 concerning Implementation of Carbon Economic Values. Carbon pricing or Carbon Economic Value (Nilai Ekonomi Karbon) is a comprehensive policy in preventing climate change. Carbon pricing instruments are divided into two instruments, namely trading instruments and non-trading instruments. For trading instruments consist of emission trading system (ETS) where the entity that emits more buys the permit that emits less and emission offset (crediting mechanism) where entities that carry out emission reduction activities can sell their carbon credits to entities that require carbon credits. A 2021 research from the Ministry of Finance of the Republic of Indonesia shows that while for non-trading instrument consist of carbon tax that are imposed on carbon content or carbon emitting activities and result based payment (RBP) where payment is given for emission reduction results. The birth carbon tax aims to change the behavior of economic actors to switch to low-carbon green economic activities, support emission reduction targets and encourage the development of carbon markets, technological innovation and investments that are more efficient, low-carbon and environmentally friendly with the principles of fair and affordable implementation. The tariff for carbon tax suspended to the emitter is Rp 30 per kilogram of carbon dioxide equivalent (CO₂e).

3. Methodology

This study is primarily divided into two sections: data collection and data analysis. The data collecting is done by literature study and interview from the expert (the ministry and direct field expert). The first section is to select the potential biomass in West Java according to the aforementioned criteria which the data which the data was acquired from the Ministry of Energy and Mineral Resources and the company's expert. The ministry's data is essential to receive the most recent and accurate information regarding biomass in a certain region (West Java). While the company's expert provides the company's data regarding the coal consumption, the green plan, technology and machine used that later needs to be adjusted with the calculation.

The data analysis section consists of several steps, the first step is to select the potential biomass with criteria. The second step is to analyze the cost for all energy alternatives (coal and selected biomasses) to find out which alternative yields the highest saving for replacing coal in the company. The government is planning to implement carbon tax regulation to the industries thoroughly. Therefore, two scenarios will be implemented in completing this step, the calculation without considering carbon tax and the scenario with considering carbon tax. This second step requires the coal consumption and maintenance cost data in the company as the raw data input which will be to be converted into the selected biomass consumption, based on each one's calorific values. From this step, the operational cost for each biomass will be obtained for two scenarios (without carbon tax and with carbon tax). To gather a more credible result, incremental analysis is employed in the third step.

Incremental analysis is defined as the examination of the differences between alternatives, means it is to decide whether or not differential costs are justified by differential benefits ([Thuesen and Fabrycky, 2001](#)). In comparing one alternative to another, it is necessary to determine the cash flow representing the differences between two or more cash flows. Then the decision whether to select particular alternative rests on the determination of the economic desirability of the additional increment of investment required (Present Worth – PW) by one alternative (A1) over the other (A2), in which the alternatives are ordered in ascending order.

$$\begin{aligned} PW(i)_{A2-A1} > 0: & \text{accept A2} \\ PW(i)_{A2-A1} \leq 0: & \text{reject A2 and accept A1} \end{aligned} \quad (1)$$

The incremental benefit-cost (BC) follows the equation below,

$$\begin{aligned} BC(i)_{A2-A1} > 1: & \text{accept A2} \\ BC(i)_{A2-A1} \leq 1: & \text{reject A2 and accept A1} \end{aligned} \quad (2)$$

According to [Thuesen and Fabrycky \(2001\)](#), all alternatives are sorted in ascending order based on their capital outlays (cost in the first year), then calculated according to the desired method. Select the initial "current best" alternative that has the smallest first year cost where most cases Do Nothing is conducted. The next step is to compare

the “current best” and the first challenger alternative (which will always be the higher cost at $t=0$ that has not been involved in previous calculation). Repeat the calculation/comparison of the challengers to the “current best”.

The incremental analysis involves incremental present worth analysis and incremental benefit-cost ratio analysis. Incremental analysis is used when there are two or more mutually exclusive alternatives to compare to seek the best alternative among all. The incremental present-worth analysis is used to obtain which alternative maximizes net present value and incremental benefit-cost ratio is to find out which option is the most economically desirable between two or more mutually exclusive alternatives. The incremental analysis is conducted based on the approach from [Thuesen and Fabrycky \(2001\)](#). This study will focus on the cost comparison, incremental present worth both with and without carbon tax, and incremental benefit-cost ratio.

There are four biomasses to compare in the early stage with the coal, by using criteria from [Kraiphanont et al.](#), thus from data from Table 2 shows that the biomasses that fulfil the criteria are rice husk pellet and sawdust.

Table 2. Comparison of biomass ([Ditjen EBTKE, 2021](#); [Shyamalee et al., 2015](#); [Nurhilal and Tarigan, 2017](#); [Awulu et al., 2018](#); [Zhang et al., 2012](#))

Classification	Coal	Saw Dust	Rice Husk Pellets	Corn cob	Organic Waste & Hyacinth Briquettes
Location	Stasiun Bandung Collector	Lengkong, Sukabumi	Subang	Wanaraja	Waduk Saguling
Prod.capacity (ton/yr)	NA	937,855	1,671,632	1,068,696	NA
Cal.Value (kcal/kg)	4,200	4,509.41	3873.5	3,227.78	3,100
Price (Rp/kg)	1,340.90	737-848	500-650	350	500
Rupiah per kcal	0.288476	0.15835	0.163	0.1084	0,1613
Kcal per rupiah	3.46649	6.1186	7.746	9.2222	5.6363
Bulk density (kg/m ³)	560 - 600	210	511	282.38	NA

The externalities from using coal were analyzed based on its component as shown in Table 3 are the negative impacts that will be quantified based on consultation with environmental experts which will be used as the benefit in the incremental benefit-cost ratio method.

Table 3. Externalities of the use of coal

Component	Description	Damages
Air quality	Changes in air pollution levels around the factory	Public respiratory health risks (ARI, Asthma, Pneumonia) chronic cough, cough with phlegm, and heart attacks
	Dust from employee vehicles and trucks	
	Total dust particulates (NO ₂ , SO ₂ , Benzene, Cd and Mn)	
Sound Pollution	Noise level around the factory	Risk of hearing damage, increased blood pressure, sensory disturbances, headache/pressure, and discomfort
Solid Waste	The type of solid waste that appears increases	Skin health risks, kidney, liver, tuberculosis, eye irritation
Water quality	Change in water level	Flood
	Water pollution from the dyeing process so that the water quality decreases	Risk of damage to aquatic ecosystems, decreased amount of oxygen, decreased soil fertility, comfort
	Quality of groundwater around the factory	Risk of skin disease (cholera), digestion, dysentery, liver infection
Ecosystem	Changes to the natural ecosystem affected by the factory	Ecosystem imbalance, decrease in plant & animal varieties, decrease in food quality
	The number of plants that change due to waste from burning coal	Decreased quality of food, decreased income of farmers
	Animals affected by factory activities	Decreased food quality, risk of death of livestock, decreased breeders' income

Component	Description	Damages
Public health	The level of solid waste managed around the factory	Improved waste management
	Sanitation level around the factory	diseases from sanitary hygiene
	The spread of lung disease due to dust and smoke from burning coal	Chronic stones and long-lasting phlegm require special treatment
Accident	Potential for vehicle accidents for employees and local residents	
	Potential fire from technical fault	

4. Results

The first step of this study is to select two biomasses as the studied case required, based on the biomass selection criteria and the results are sawdust and rice husk pellets which will be analyzed economically. Table 4 shows that none alternative has the same mass to each other. The number is adjusted based on the real/current calorific value needed in the company which is resulted from the coal combustion. The differences between each energy alternative is caused by the bulk density and calorific value of each one of them. The lower the density, the highest it requires to equalize the current coal energy, thus this may cause the more space needed to keep the biomass in the factory. With the differences of mass from each energy alternative this leads to the difference of cost to purchase the raw material of biomass. For example the price for coal is Rp 1,3340,900 per ton or around Rp 1,340.9 per kg, the price for rice husk pellet is around Rp 792.5/kg and for sawdust is Rp 575/kg. Beside purchasing cost, transportation cost is required to calculate since the purchasing cost for each alternative does not include the transportation fee. In this study the company uses a third party transportation mode to deliver their biomass needs. The transportation cost for each alternative is shown in Table 5. This economic calculation used an interest rate of 5.25% for 10 years and compounded monthly.

Table 4. Mass comparison energy used for each alternative in one year

Classification	Mass (kg)	Purchasing Cost
Coal	46,164,121	Rp61,859,922,140
Rice Husk Pellet	50,055,326	Rp28,781,812,885
Sawdust	42,996,603	Rp34,074,807,290

Table 5. Transportation cost

Rice Husk Pellet		Sawdust	
Travel time	Total Cost Monthly	Travel time	Total Cost Monthly
4h 50m	Rp 119,676,000.00	7h 40m	Rp 321,384,000

The calculation for carbon tax requires the total emission of CO₂ emitted from each energy alternative where the carbon emission for each energy alternative is obtained from the calculation of the usage of energy alternative in tozn with respective calorific value for each. The CO₂ per year emitted from combusting coal equal to 113,563 tons, rice husk pellets combustion equals to 26,128 tons and sawdust combustion equals to 511 tons. Comparison of carbon emissions from coal fuel, sawdust and rice husk pellets is shown in Table 6.

Table 6. Comparison of carbon emission and carbon tax

Alternative	Total Carbon Emission (ton)	Carbon Tax (per year)
Coal	113,563.74	Rp 3,406,913,532
Rice Husk pellet	26,128.89	Rp 783,866,417
Sawdust	511.418	Rp 15,342,561

This case study only provides cost, which means there is no real cash flow provided. Therefore, the cost comparison is conducted to find the energy alternative with the highest saving cost. However, for the incremental

analysis method, the data used is only cost which means the cash flow is always below zero, which means this method is used to reject the higher cost alternatives. The next step is to calculate the total saving cost from implementing biomass where the total costs are derived from both capital expenditure which involves machine investment and operational expenditure which involves raw material purchasing, transportation rate and maintenance cost. Both in calculation with and without considering carbon tax, biomass alternatives still manage to save billion rupiah to the company compared to using coal as energy supply. This is because the carbon tax itself from each energy alternative differs as showed in Table 6, the carbon tax from coal combustion reaches Rp 3,406,913,532 in a year which is the highest among all the energy alternatives, while rice husk pellet reaches Rp 783,866,417 and sawdust which is the lowest among all the energy alternative reached carbon tax Rp 15,342,561 in a year. Sawdust has the lowest carbon tax because it emits the lowest carbon to the air since it is combusted perfectly and has a low emission factor. The cost comparison between coal to each biomass is shown in Table 7 which states that rice husk pellet has the higher saving than sawdust to replace coal.

Table 7. Cost comparison for all alternatives

Alternatives without Carbon Tax	Differences	Alternatives with Carbon Tax	Differences
Coal - Sawdust	Rp21,364,903,519	Coal - Sawdust	Rp24,757,701,894
Coal - Rice Husk Pellets	Rp29,078,393,924	Coal - Rice Husk Pellets	Rp31,701,441,039

Incremental present worth is calculated by using the data provided which is only cost, therefore the number will always be below zero. Thus, this method is to reject the alternative with higher costs. From the Table 7, both scenario (without and with carbo tax) shows that each step rejects the challenger which means the final decision is to accept rice husk pellets as the best option among all alternatives.

Table 8. Incremental present worth analysis

Classification	Alternative	Incremental Present Worth	Decision
Without carbon tax	Sawdust - Rice Husk Pellet	-Rp 53,927,604,668	Reject Sawdust
	Coal - Rice Husk Pellet	-Rp 116,472,473,934	Reject Coal
With carbon tax	Sawdust - Rice Husk Pellet	-Rp 59,905,516,024	Reject Sawdust
	Coal - Rice Husk Pellet	-Rp 225,819,847,713	Reject Coal

In this paper all the data provided is merely cost, therefore to calculate using this incremental benefit-cost analysis method, the differences of the carbon tax for each biomass and coal, presented in Table 6, and the differences of the monetized externalities are assumed as the benefits for each biomass respectively. Therefore, the benefit of coal is supposed to be zero, because both the difference of carbon tax of coal and itself as well as the difference of the monetized externalities equal to zero. Meanwhile all the cost corresponding to each alternative without carbon tax included is assumed as the cost for each energy alternative. The annual monetized externalities shown in Table 9 will be annualized with interest rate of 5.25% for 10 years period compounded for 12 months, which result the benefits for each biomass from prevention cost equals to Rp 25,288,017 and from failure cost equals to Rp 110,152,886. Those benefits are applied equally as the components of benefits for sawdust and rice husk pellets.

Table 9. Monetized externalities

Component	Description	Damages	Prevention Cost	Failure Cost
Air quality	Total dust particulates (NO ₂ , SO, Benzene, Cd and Mn)	Public respiratory health risks (ARI, Asthma, Pneumonia) chronic cough, cough with phlegm, and heart attacks	Rp 25,000,000	Rp 50,000,000
Sound Pollution	Noise level around the factory	Risk of hearing damage, increased blood pressure, sensory disturbances,	Rp 10,000,000	Rp 15,000,000

Component	Description	Damages	Prevention Cost	Failure Cost
		headache/pressure, and discomfort		
Solid Waste	The type of solid waste that appears increases	Skin health risks, kidney, liver, tuberculosis, eye irritation	Rp 100,000,000	Rp 75,000,000
Water quality	Change in water level	Flood	Rp 50,000,000	Rp 30,000,000
	Quality of groundwater around the factory	Risk of skin disease (cholera), digestion, dysentery, liver infection, risk of damage to aquatic ecosystems, decreased amount of oxygen, decreased soil fertility, comfort	Rp 25,000,000	Rp 75,000,000
Ecosystem	Changes to the natural ecosystem affected by the factory	Ecosystem imbalance, decrease in plant & animal varieties, decrease in food quality	Rp 10,000,000	Rp -
	The number of plants that change due to waste from burning coal	Decreased quality of food, decreased income of farmers	Rp -	Rp -
	Animals affected by factory activities	Decreased food quality, risk of death of livestock, decreased breeders' income	Rp -	Rp 50,000,000
Public health	The level of solid waste managed around the factory	Improved waste management	Rp 25,000,000	Rp -
	Sanitation level around the factory	diseases from sanitary hygiene	Rp -	Rp 10,000,000
	The spread of lung disease due to dust and smoke from burning coal	Chronic stones and long-lasting phlegm require special treatment	Rp -	Rp 80,000,000
Accident	Potential for vehicle accidents for employees and local residents		Rp -	Rp 50,000,000
	Potential fire from technical fault		Rp -	Rp 800,000,000

0 clearly stated that all the ratios do not show more than 1, this is caused by the lack of data for real benefits from the company. The benefits showed are all below cost which clearly result in below 1 ratio. However, findings show a consistent result with incremental present worth which is to accept rice husk pellet as the best option among all alternatives.

Table 10. Incremental benefit-cost ratio

Alternative	Incremental Benefits	Incremental Costs	Incremental BC Ratio	Decision
Sawdust - Rice Husk Pellet	Rp5,977,911,356	Rp77,134,904,053	0.0775	Reject Sawdust
Coal - Rice Husk Pellet	Rp36,623,570,886	Rp290,783,939,239	0.1259	Reject Coal

From the incremental benefit-cost ratio, the benefits and costs are assumed as the cash flow in this calculation with the same method from the previous incremental present worth analysis. The first stage of incremental Present Worth analysis result rice husk pellet as the "current best" which will be the next defender with coal as the challenger. The calculation in 0 shows that the incremental of the cash flows is still negative, this is because the benefits are all assumed from the difference of carbon tax and difference of monetized externalities – not real benefits – yet the cost used is the real cost.

The next step is to calculate the incremental present worth between coal as challenger and rice husk pellet as the defender to find the next “current best”. The final result of incremental present worth analysis using BC cash flows result a consistent decision which is rice husk pellet as the best energy alternative.

Table 11. Incremental present worth analysis with BC cash flows

Alternative	Incremental Present Worth	Decision
Sawdust - Rice Husk Pellet	-Rp 55,157,427,556	Reject Sawdust
Coal - Rice Husk Pellet	-Rp 225,819,847,713	Reject Coal

5. Discussion

Based on the analysis, present worth incremental analysis and incremental benefit-cost analysis have a consistent result for the best energy alternative option is rice husk pellet. In cost analysis, the savings from using rice husk pellet amount to Rp 29,078,393,924 when carbon tax is not considered, and Rp 31,701,441,039 when carbon tax is taken into account. This shows that the carbon price on coal is far higher than the carbon tax on rice husk pellets in terms of its overall cost contribution. Rice husk pellets still have the lowest overall operational costs even though sawdust has the lowest carbon price of all the alternatives. The main reason why rice husk pellet has the lowest total cost is because of its low purchase price. The other reason is also from the supplier location for rice husk, which is in Subang, is relatively closer to Bandung, where the factory is located, compared sawdust.

In the incremental present worth technique, the output is always ricing husk pellet, with a negative present value of Rp 225,819,847,500 when carbon tax is ignored. While for the incremental present worth method where carbon tax is taken into account, the result is rice husk pellet with the present worth equals to negative Rp 116,472,473,934. The negative value is due to the fact that only cost data is provided; no cash flow – especially revenue – is provided in this study. However, by properly implementing this method, rice husk pellets are ultimately chosen as the best energy alternative because from the first stage to the second, rice husk pellets’ incremental present value has been negative, meaning the choice is to accept the defender rather than the challenger (in the first stage sawdust is the challenger and in the second stage coal is the challenger). Therefore, to obtain a more credible and desirable result, it is essential to include revenue or benefit in the calculation. Keep in mind that the cost in this study is obtained from the consumption of coal, therefore there is no direct income related to the use of coal.

In incremental benefit cost ratio, the result is still consistently rice husk pellet with the ratio equals to 0.077 and 0.13. The reason the ratios in both stages do not show a more than 1 B/C ratio is because there is no revenue data used in this study, thus the benefit in the calculation is assumed from the differences between carbon tax of coal and carbon tax of each biomass as well as the difference monetized coal externalities of coal and each biomass. This indicates that coal’s benefit equals to zero, because the difference between carbon tax of coal and coal’s itself equals to zero, as well as the monetized coal externalities to its externalities equal to zero. Therefore, it is essential to state a clear benefit for each alternative in calculating incremental-benefit cost ratio for future studies.

The same case with the incremental present-worth analysis where the analysis uses cash flows from benefit cost method, the result still shows consistently rice husk pellet as the best alternative with present worth equals to negative Rp 55,157,427,556. The negative number is caused by the assumed benefits against real costs which means there might be a mistake in monetizing coal’s externalities that leads to a relatively low number of benefits compared to the total cost.

6. Conclusion

The potential biomass to be implemented in a textile firm in West Java are justified based on economic analysis considering externalities. The present study suggests considering rice husk pellet as the new energy source to replace coal. After examining the comparison between coal and biomass qualitatively (classification and externalities), the findings show that all the methods both cost comparisons and incremental analysis, which includes incremental present worth analysis and incremental benefit-cost analysis, give a consistent result to reject coal and sawdust but accept rice husk pellet as the best energy alternative as the new energy replacement source for the company. However, due to a lack of data gathered from the company the number for incremental analysis does not show a desired number, a positive result for present worth and more than 1 for benefit-cost ratio. This might be because the

coal consumption does not directly generate revenue, so there is not a real cash flow to include in the calculation. Future research should consider investigating the revenue or benefits respective to each alternative to obtain a more accurate analysis.

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