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GREEN TECHNOLOGY DEVELOPMENT IN COCONUT SHELL COMBUSTION PROCESS TO IMPROVE FARMERS' WELFARE AND REDUCE ENVIRONMENTAL POLLUTION

(Case Study of Indragiri Hilir Regency, Riau Province, Indonesia)

INDRA MUCHLIS ADNAN[1], KHAIRUL IHWAN[2], MUANNIF RIDWAN[3]*, HANITA DAUD[4], TRIYANA SYAHFITRI[5] and BAYU FAJAR SUSANTO[6]

[1]Faculty of Law, Islamic University of Indragiri, Tembilahan, Riau, Indonesia.
Email: indraunisi66@gmail.com

[2]Faculty Of Engineering and Computer Science, Islamic University of Indragiri, Tembilahan, Riau, Indonesia.
Email: ihwanp5@gmail.com

[3]Faculty Of Engineering and Computer Science, Islamic University of Indragiri, Tembilahan, Riau, Indonesia.
Corresponding Author's Email: anifr@ymail.com, anifdosen@gmail.com

[4]Faculty of Science and IT, Universiti Teknologi PETRONAS, 32610 Seri Iskandar, Perak, Malaysia.
Email: hanita_daud@utp.edu.my

[5]Faculty of Law, Islamic University of Indragiri, Tembilahan, Riau, Indonesia.
Email: syahfitritriyana512@gmail.com

[6]Faculty of Economic and Business, Islamic University of Indragiri, Tembilahan, Riau, Indonesia.
Email: bayufajar14@gmail.com

Abstract:

The community in Indragiri Hilir regency uses combustion to make coconut shell charcoal, which pollutes the environment around the production site and also results in low added value. Therefore, this study aimed to develop green technology for the combustion of coconut shells to improve the welfare of farmers and reduce environmental pollution. The results cover the technical aspects of the equipment used, which include a pyrolysis tube as a combustion chamber and a condensation tube for changing smoke to liquid. Based on the analysis carried out, a production capacity of 6,250 kg of coconut shell produces 2,500 l of liquid smoke, 1,875 kg charcoal, and 125 l of Tar with a BEP value of 5,353/l for coconut shell charcoal, a BCR of IDR 1.8, and a payback period of 4.03 months. Meanwhile, the environmental impact is positive because green technology can reduce air pollution caused by traditional shell combustion.

Keywords: Coconut Shell, Green Technology, Technical, Financial, Environmental.

1. INTRODUCTION

Indragiri Hilir (Inhil) Regency has the largest coconut plantation in Indonesia with production reaching 390,924.28 tons per year and a land area of 295,380.24 ha (dpmptsp.inhilkab.go.id, 2022). In general, coconut is processed into copra, and the process emits coir and shell waste, which are less environmentally friendly and contribute to greenhouse gas emissions. Traditionally, farmers burned coconut coir to avoid accumulation, but the residue from the combustion often causes fires on peat soils. Meanwhile, coconut shells are processed to become charcoal, which is also carried out by combustion.

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The productivity level in Indragiri Hilir Regency is equivalent to 390,924.28 tons of copra or 1,368,234,980 tons of coconut scale with the assumption that each has an average weight of 1 kg. The coconut fruit consists of 35% coir, 12% shell, 28% flesh, and 25% coconut water. Then, the amount of burned coir and shells account for 47% of the total coconut grains production (Prananta, 2004), therefore, 643,070,441 tons of these wastes have been burned to date. The utilization of coir and coconut shell waste is expected to reduce combustion by 643,070,441 tons with a target of 50% to improve the community's economy and reduce greenhouse gas emissions.

The biological function of coconut shells is to protect the core of the fruit and is located inside the coir with a thickness of 3–6 mm. They are categorized as hardwoods but have higher lignin and lower cellulose with a moisture content of about 6- 9%, which is calculated by dry weight and is mainly composed of lignin, cellulose, and hemicellulose.

Table 1.1. Coconut shell chemical composition

No	Components	Percentage
1	Cellulose	26.6%
2	Hemicellulose	27.7%
3	Lignin	29.4%
4	Ash	0.6%
5	Extractive components	4.2%
6	Uronic anhydrous	3.5%
7	Nitrogen	0.1%
8	Water	8.0%

Source: Suhardiyono in Prananta (2004).

The burning of coconut shells at high temperatures in a room that is not in contact with air will result in a series of decomposition processes, which produce charcoal, tar, gas, and distillate often referred to as liquid smoke. According to (Girard, 2004), smoke is a suspension of solid and liquid particles in a gas medium. (Darmadji, 1997) stated that liquid smoke is a solution mixture from the dispersion of wood in water made by condensing the smoke from the pyrolysis of wood. Furthermore, pyrolysis of 100 kg coconut shell for 4 hours can produce 40 l of liquid smoke, 30 kg of charcoal, and 2 l of tar. This process requires about 20 l of kerosene as fuel and according to a previous study, 1 kg of the shell consists of 4 coconuts (Setiadji, 2007).

2. METHODOLOGY

Procedure

The procedure is generally divided into several stages namely problem identification, literature study, data collection, technical feasibility analysis, financial, and environmental impact. Data collection was based on the level of coconut productivity in Indragiri Hilir Regency which is 390,924.28 tons of copra or 1,368,234,980 tons of coconut grain-scale with the assumption that each has an average weight of 1 kg (http://disbun.inhilkab.go.id). According to (Palunkun,

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2004), the potential waste from coconut fruit consists of 35% coir, 12% shell, 28% flesh, and 25% water. This study aims to develop green technology in utilizing coconut shell waste to improve the welfare of farmers and reduce environmental pollution due to the combustion process.

Data Processing

Data processing is carried out to analyze the technical, financial, and environmental impacts of efforts to develop green technology in the process of combustion to produce charcoal. This is aimed at improving the welfare of farmers and reducing the environmental pollution. Meanwhile, aspects of the feasibility measure include marketing, legal, environmental impact, technical, financial, and organizational management. However, this study focuses only on technical, financial, and environmental impact.

Technical Aspect

It involves determining the production capacity, the type of technology, the equipment and machinery used, as well as the location.

Financial Aspect

The financial aspects include:

1) Cost Analysis

This includes all sacrifices (inputs), including the funds used for production (output) within a certain period. The input consists of fixed and variable costs. The total cost is the sum of fixed with total variable costs, which can be formulated according to Sapoetra in Surya Cahyadi (2008), as follows:

$$TC = TFC + TVC$$

Description:

TC = Total cost (IDR),
TFC = Total fixed cost (IDR),
TVC = Total variable cost (IDR).

2) Revenue and Income Analysis

Revenue analysis aims to determine how much income is made from the establishment of a liquid smoke processing plant to calculate its profit margin. Revenue is the multiplication of the product obtained with the selling price, formulated as follows:

$$TR = Y \times V$$

Description:

TR = Total revenue (IDR),
Y = Yield achieved (liters of liquid smoke),
v = Production selling price per unit (IDR).

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Net income is the difference between total revenue and all costs which are formulated as follows:

$$Pd = TR - TC$$

Description:

Pd = Net Income (IDR),
TR = Total Revenue (IDR),
TC = Total Cost (IDR).

3) Break Even Point Analysis

BEP (Break-Even Point) Analysis determines the level of revenues required to cover all costs, both operating and financial. It is often defined as a condition where a business does not make a profit and suffer a loss. BEP can be formulated as follows:

$$BEP = \frac{TC}{Output}$$

Description :

BEP = Break even point,
TC = Total cost,
Output = production results

4) Payback Period Analysis

This analysis determines the number of years needed to cover the initial investment costs in the use of machines used in the construction of a liquid smoke processing plant. It is calculated as follows:

$$\text{Payback Period} = \frac{I}{TR - TC}$$

Description:

I = Initial investment (IDR),
TR = Total Revenue (IDR),
TC = Total Cost (IDR).

Enviromental Impact Aspect

Every activity to create change cannot be separated from the surrounding environment. Therefore, it is necessary to analyze the environmental impact of these activities.

3. RESULTS AND DISCUSSION

Green Coconut Shell Combustion Technology.

Green Technology is a concept that starts from the theories of designing an environmentally friendly and energy-efficient application system (Alan Hidayat, 2020). Concern for the environment is the starting point for the development of green technology in a broader scope,

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considering the fierce increase in the market competition for business people both nationally and internationally.

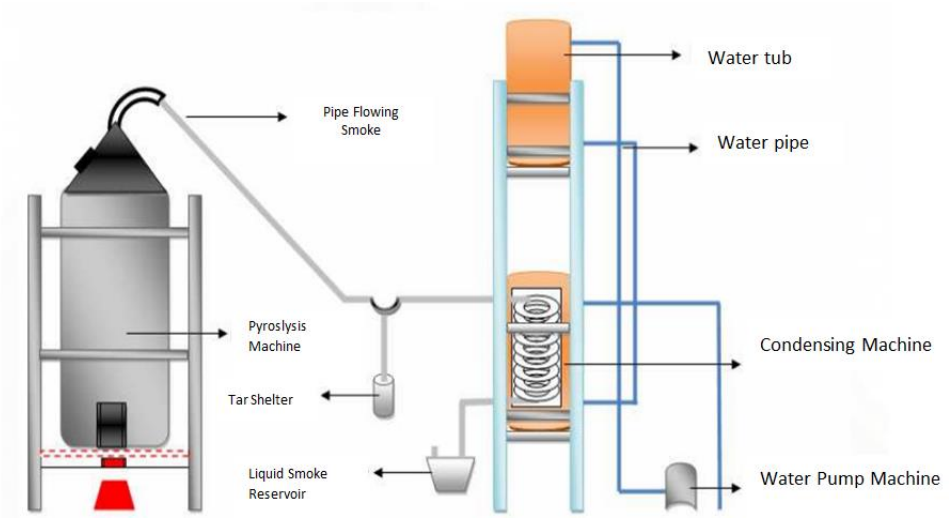
Technical Aspect

The technical aspects include the following components:

Pyrolysis

This is the process used for coconut shells combustion as shown in Figure 3.1 below. The output produced in this pyrolysis machine is in the form of charcoal and smoke mixed with tar. The tar-mixed smoke produced from this machine still requires further processing such as condensation or evaporation.

Figure 3.1. Green technology of coconut shells combustion (source: Khairul Ihwan, 2010)



Condensation

This process changes the physical form of smoke into a liquid, otherwise known as liquid smoke by evaporation.

Production capacity

The planned production capacity is 250 kg coconut shell/day or 6,250 kg/month. Assuming that there are 25 days of production in 1 month.

Worker

Two workers are needed to produce 250 kg of liquid smoke per day.

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Financial Aspect

Financial aspects analyze several things that are considered important in this study such as the amount of capital for equipment procurement, operational costs, and income. The surplus-value of these results is as follows:

Table 3.1. Green Tech Development Cost

Source of investment funds	
Owner's equity	IDR 59,000,000
Investment Fee	
a. Pyrolysis Machine Purchase	IDR 45,000,000
Total investment assets	**IDR 45,000,000**
Pre operating Cost in month 0	
a. Raw material cost	IDR 100,000
b. Marketing and distribution costs	
c. Energy (LPG)	IDR 25,000
Total Investment	**IDR 45,125,000**

Cost Analysis

Cost analysis used for the plan to build a liquid smoke factory is carried out within a certain period and it consists of fixed and variable costs. Fixed cost does not change even though there is an increase in production.

Table 3.2. Details of operational costs per month of the Greentech Coconut Shell Combustion

Fixed cost	**Month**
a. Shrinkage	IDR 250,000
b. Repair and maintenance	IDR 112,500
TFC	**IDR 362,500**
Variable cost	
a. Raw material cost	IDR 6,250,000
b. Labor wages	IDR 6,000,000
c. Electricity cost	IDR 100,000
d. Energy (LPG)	IDR 625,000
TVC	**IDR 12,975,000**
TC	**IDR 13,337,500**

Revenue Analysis

The use of Greentech in coconut shells combustion generates revenue from the sale of grade 3 liquid smoke, charcoal, and tar. The revenue (gross income) obtained depends on the selling price and the amount of production. The number of estimated monthly receipts is shown in Table 3.7

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Table 3.3: The number of monthly receipts

Receipt type	Total	Price	Revenue
Liquid smoke grade 3	2,500 liters	6,000	IDR15,000,000
Charcoal	1,875 Kilograms	5,000	IDR9,375,000
Tar	125 liters	1,000	IDR125,000
Total Revenue		**IDR 24,500,000**	

The income from the use of green coconut shell combustion technology is obtained from the difference between the amount of revenue and the total costs incurred in the production process. In this plan, the income earned is **IDR 11,162,500** per month

Feasibility Analysis

- **Break-Even Point (BEP) Analysis**

This analysis aims to determine the BEP value to be achieved, which is the state where the revenue (gross income) is equal to the total cost. The BEP depends on the total cost and revenue earned. Furthermore, this liquid smoke industry will break even when the product price is IDR 5,353 per liter with a production capacity of 6,250 kg of coconut shell.

- **Benefit-cost of Ratio (BCR) Analysis**

This is carried out to determine the comparison value between costs and revenues. The results showed a BCR value of IDR 1.8, indicating that every additional IDR 1 in production costs will increase income by IDR 1.8. Therefore, green technology can be applied to improve the welfare of coconut farmers in the Indragiri regency. Meanwhile, based on the benefit-cost ratio analysis, the comparison value is IDR 1:1.8.

- **Payback Period Analysis**

The payback period analysis using green technology is used to determine the number of years needed to cover the investment costs of procuring green technology tools for combustion coconut shells. Based on the payback period analysis, it can be estimated that the results achieved are 4,031 months, while the details of costs and income can be seen in Table 3.4 below:

Table 3.4: Payback period analysis calculation results

No.	Item	Value (IDR
1.	Investment (I)	IDR 45,000
2.	Total Cost (TC)	IDR 13,337,500
3.	Total Revenue (TR)	IDR 24,000
4.	Total Income (P)	IDR 11,162,500
5.	Payback Period (month)	4.031 months

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The payback period is obtained based on the comparison between the amount of investment and income received. Greater income results in a faster period (years) needed to cover the initial investment costs and vice versa. Based on the results of the calculations in Table 3.9, the payback period value is 0.8 years, indicating that it will take 8 months to cover the initial investment costs for the liquid smoke factory development plan.

Environmental Impact Analysis

The environmental impact arising from the use of green technology is positive, both physically (natural environment) and non-physical (social, cultural, and political). Physically, coconut shells are used as raw material for making charcoal by combustion and its process is detrimental to the environment, emitting a very thick smoke that disturbs its stability and causes respiratory problems, air pollution, as well as other disturbances. Furthermore, air pollution caused by standard shell combustion is no longer a problem due to the use of green technology.

Meanwhile, non-physically, green technology has a positive impact in realizing the development mission of Riau Province No. 4 of 2004 "The realization of an economy based on regional resource potential and empowerment of economic society" which is described as follows:

1. Provide education to the local community about the use of green technology in coconut shell combustion,
2. Increasing regional innovation in the field of coconut waste processing
3. Participate in running the economy by increasing the added value of local raw materials
4. Involve in realizing local government programs to improve the welfare of the local community.

Figure 3.6 Traditional/conventional combustion of coconut shells.

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4. CONCLUSION AND SUGGESTION

4.1 Conclusion

Based on the analysis of the Greentech development in improving the welfare of coconut farmers and reducing the impact of environmental pollution due to the traditional combustion process in Indragiri Hilir Regency, the following conclusions were made:

1. The development of Greentech in the coconut shell combustion process to improve the welfare of coconut farmers and reduce the impact of pollution due to the traditional combustion process (open combustion) in the Indragiri Hilir Regency is feasible based on the technical, financial, and environmental aspects.
2. The equipment used in the development of green tech is basic and easy to obtain, consisting of a pyrolysis and condensation tube as a combustion chamber and a place to change the smoke to liquid, respectively.
3. Based on the financial aspect analysis, a production capacity of 6,250 kg of coconut shells produces 2,500 l of liquid smoke, 1,875 kg of charcoal, and 125 l of tar with a BEP and BCR value of 5,353 per liter and IDR 1.8, respectively, as well as a payback period of 4.03 months
4. The environmental impacts analysis arising from the use of green technology on coconut shell combustion showed a positive result for both the physical (natural environment) and non-physical (social, cultural, and political). Physically, coconut shells are used as raw materials for making charcoal by combustion. Meanwhile, non-physically, green technology has a positive impact in realizing the development mission of Riau Province No. 4 of 2004 "The realization of an economy based on regional resource potential and empowerment of economic society" which is described as "The provision of education to the local community about the use of green technology in coconut shell combustion, increasing regional innovation in the field of processing coconut waste, participating in running the economy by increasing the added value of local raw materials, taking part in realizing local government programs to improve the welfare of the communities."

4.2 Suggestion

This study has several limitations, therefore, suggestions are needed and the results are expected to be useful for the community and policymakers in developing local resources in the Indragiri Hilir regency.

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