

Feasibility Analysis of Compact-Mobile Biomass Pallet Technology as Renewable Fuel for Small and Medium Industries

Sawarni Hasibuan^{a1}, Hendra Adiyatna^b, Imas Widowati^c, Jayakrishna Kandasamy^d

^a Industrial Engineering Program, Universitas Mercu Buana, Jakarta, Indonesia
¹E-mail: sawarni02@mercubuana.ac.id

^b Sekolah Tinggi Teknologi Bina Tunggal, Bekasi, West Java, Indonesia
E-mail: hendraadiyatna20097@gmail.com

^c Sekolah STT Wastu Kencana, Purwakarta, Indonesia
E-mail: imas@gmail.com

^d School of Mechanical Engineering, VIT University, Vellore, India
E-mail: mail2jaikrish@gmail.com

Abstract— Wood or biomass pallets as renewable energy are possible to use like B20 to meet small and medium industries (SMEs). This research aims to analyze the feasibility of the compact-mobile wooden pallet biomass production to meet the needs of a case study on Food SMEs. Specifically analyzed aspects of raw materials and supply chains, market and marketing, compact-mobile pallet technology, and financial feasibility. The data collected consists of primary and secondary data. Primary data is obtained through expert interviews related to recommendations, while secondary data is compiled from relevant company report results, production and consumption data, investment data, and operational costs. The compact-mobile wood pallet supply chain starts from raw materials, processing, transportation, and end-use. The compact-mobile wood pallet industry is designed to have 5 tons/hour with a defect rate of 5%. The capital cost requirement is projected to be IDR 30 billion. The BEP is at a minimum capacity of 2.82 tons of compact-mobile wood pellet per hour. Financially, the compact-mobile pallet industry deserves a WACC of 10.95%, NPV value of IDR 28.94 billion, IRR 21.82%, and 6-year PBP. The simulation results from the pallet's selling price at least IDR 1,038,145 per ton but the PBP increased to 11 years. The development of a wood pellet industry is related to the efforts of diversification and saving the use of fossil energy fuels; therefore, the form of infrastructure that must be prepared is not only physical needs.

Keywords— pallet compact-mobile; biomass; supply chain; NPV; IRR.

I. INTRODUCTION

Indonesia is a tropical country rich in biomass potential. According to ESDM, the potential for Indonesia's waste biomass is converted into enormous electrical energy, which is equivalent to 50 GWe and already utilized by 1,600 MW or new 3.25% [1]. As already known, biomass can be used as an energy source [1], [2]. The development of bioenergy through wood pellets production is very prospective, considering that potential wood pellets are used as fuel for both industrial and household [3], [4]. Wood pellets have been used as fuel that has been consumed widely on a global scale, the market potential in Indonesia as a tropical country is also increasing. Indonesia's timber pellet market will be increasingly glanced at by the world and can be one of the world's major exporters.

Indonesia's extraordinary potential is a glance at Korea, which means the wood pellet industry's growth should be accelerated. The greater the demand and lack of supply pushes the price of wood pellets to expensive, the more the industry grows to gain current momentum, i.e., when demand is huge while the supply is minimal [5]. The timber waste industry that originally became a problem today began to be seen as a potential raw material for this wood pellet industry [6].

It is supported by the news that the EU will require its member countries to drive 20% of electricity from renewable energy by the year 2020 [7]. Based on data from AEBIOM and Member State sector organizations in the *ihb.de* site, EU wood pellets' needs from year to year continue to increase. In the year 2013, the total needs of wood pellet European countries reached 16 million tons. The price of wood pellets ranged from USD 120 per metric ton in the European

market. The largest provider of wood pellets today in Siberia/Russia. Indonesia can be a potential supplier with government support.

Besides, the benefits of wood pellets can also be felt in various lines of local life. In the future, this renewable energy will be an essential staple of society; it is subject to small and large industries [8]. These wood pellets can be used for daily society as fuel for heating, a biomass stove, and everything related to heat. For an industrial scale, the wood pellet is a source of Indonesia's future energy. The application of wood pellets as a fuel for electric power plants as well as dryers is one of the roads for the breakdown of the electrical crisis in Indonesia. It is an advantage that has a high investment value that the wood pellets in Indonesia, an archipelago country, is the existence of widespread raw materials when viewed from the geographical position. The raw material in the form of wood is abundant in all corners of the country, even to the islands said 3T area (remote, outer, and lagging). The production process of wood pellets to be integrated is expected to be a positive energy availability solution [9].

Some of the issues examined in this study are as follows:

- how is the readiness for the application of compact mobile biomass pellet technology to be applied to the small-medium industry
- how is the financial worthiness and sensitivity of the application of compact mobile biomass pellet technology applied to the intermediate small sector of the infrastructure aspect.

Hence, this research aims to analyze the readiness to apply compact mobile biomass technology to the small-medium industry. This research is also subject to analyze the financial feasibility and sensitivity of the application of mobile compact biomass pellet technology to apply to the small intermediate industries of infrastructure aspects.

II. MATERIAL AND METHOD

A. Research Framework

A biomass pellet, especially a wood pellet (WP), is the current flagship fuel, especially in countries that have 4 seasons as fuel substitute coal (partially/wholly), heating, biomass stove, and drying on laundry services [10]. At the same time, domestic WP marketing is set with the model of a package with a stove or burner used in households (substitute LPG), food processing factories such as chickens, tofu, *Gudeg Yogya*, restaurants/stalls, tea dryers, tobacco, corn, fish, and fried entrepreneurs, etc. [11].

By utilizing the type of biomass palletization technology, the research has been developed today, it is expected to encourage energy optimization of biomass as renewable energy and environmentally friendly [1], [5], [8]. In this regard, preliminary studies are required to determine how much impact palletization technology and its products are in the small and medium industries. This study includes identifying technology implementation targets, identifying readiness of science resources, including human resources, infrastructure, funding, and readiness of the industrial infrastructure itself. This study is intended for all stakeholders to be downstream of the research of palletization technology to the industry capable of synergies

in their duties and responsibilities according to their competence and potential to achieve the agreed objectives and the timelines (timeline) measurable and transparent.

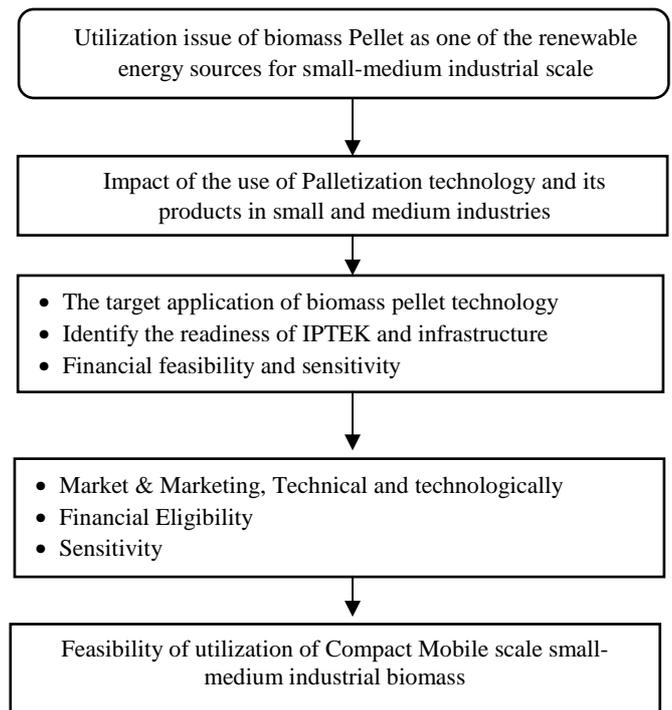


Fig. 1 Research framework

B. Data Collection

Data collection combines library studies, interviews, and field observations. The library study method is a method used to look for theories, concepts, and generalizations that can be a theoretical basis for the research done. Theoretical foundations are used so that research has a solid foundation and not just a deed of trial—an interview with experts representing the development stakeholders of mobile compact biomass technology. Data gathered from previous research in pallet production. The Data collected includes the potential for raw materials, market potential, technology availability, and the company's records or documents.

C. Data Analysis

This study applied the feasibility analysis of the utilization of the compact-mobile palette of palletization technology from the technical aspects-technology. The market-marketing, financial and sensitivity, and its impact on industrial scale Small and medium enterprises are also analyzed [12], [13]. Besides, this study applied the marketing portfolio analysis using Porter's strategy.

D. Stages of Research

The steps in this study are as follows:

- Identifying market potential and marketing
- The projection of the domestic and international markets is done by projection. Marketing strategy is done using the strategy method of competing Porter.
- Identify the alignment of palletization technology-the compact biomass-mobile.
- Calculating the financial feasibility and sensitivity of the compact-mobile biomass technology.

The financial feasibility of the compact-mobile biomass technology can be seen from four investment parameters: Net Present Value (NPV), Internal Rate Return (IRR), Net B/C, and Payback period (PP). NPV calculations are performed to determine the value of net benefits gained during the business period [14], [15]. The IRR calculation of a qualification can be known by comparing the IRR value with the opportunity cost of capital (CoC). The calculation of PP is used to see the period of the capital development of the compact-mobile biomass palletization technology.

E. Data Analysis

The analysis of the data used in this study includes (1) market analysis and marketing of products palletization biomass technology compact-mobile, (2) technology and basic design palletization biomass compact-mobile, (3) analysis of raw materials and supply chains, and (4) financial analysis (NPV, IRR, BEP) and sensitivity.

III. RESULT AND DISCUSSION

A. Local Market Potential

The bioenergy development of wood pellets is one of the best strategies considering that wood pellets can fuel both the industry and households. Considering that wood pellets have been used as fuel consumed widely globally, Indonesia's potential as a tropical country is increasing [5]. The timber pellet market in Indonesia can be one of the world's major exporters.

Indonesia's extraordinary potential is a glance at Korea, which means the wood pellet industry's growth should be accelerated. The greater the demand and lack of supply pushing the price of wood pellets increased and pushing more and more industries grew to gain current momentum, i.e., when demand is huge, whereas the supporter is minimal. The timber waste industry that originally became a problem today began to be seen as a potential raw material for this wood pellet industry's raw materials.

It is supported by the news that the EU will require its member countries to drive 20% of electricity from renewable energy by the year 2020. Based on AEBIOM and Member State sector organizations' data in the *ihb.de* site, EU wood pellets' needs from year to year continue to increase [16]. The price of wood pellets ranged from USD 120 per metric ton in the European market. The largest provider of wood pellets today in Siberia/Russia. Indonesia is potentially a potential supplier with government support.

Besides, the benefits of wood pellets can also be felt in various lines of local life. In the future, renewable energy can supply the energy needs of both small and large industries. For daily society, wood pellets can be used as fuel for heating, biomass stove, and all things related to heat. On industrial scale, the wood pellet is a source of Indonesia's future energy. The application of wood pellets as a fuel for electric power plants and dryers is one alternative to overcome the electricity crisis in Indonesia. Indonesia's advantage is that the raw material of wooden pallets is widespread if viewed from its geographical position. The production process of integrated wood pellets can be a positive solution for energy availability.

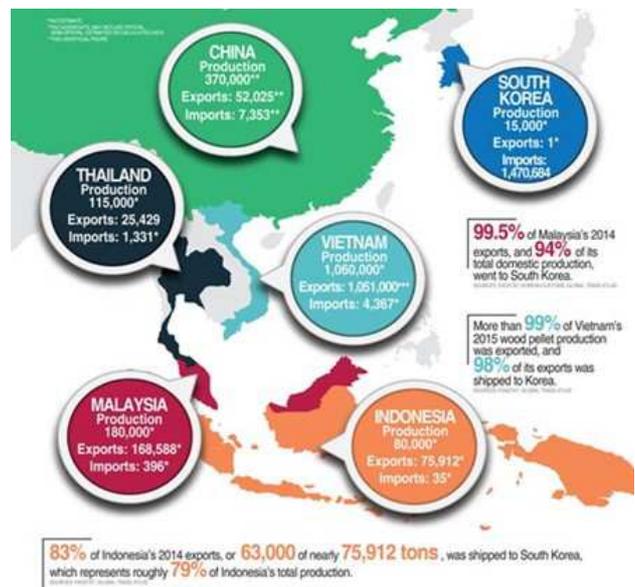


Fig. 2 Map of Wood Pellet producer in the ASEAN year 2015 (million tons) [17]

B. Marketing Strategy Portfolio

The competition of the wood pellet industry between companies becomes the main strength of competition. The higher level of competition results in higher industrial profits, but company profits can be decreased.

1) Influence of wood market competition pellet intensity:

- Industrial Growth: Increased industrial growth can cause competition between industries for the same raw materials and customers, leading to the market leader.
- Fixed Cost and Storage Cost: More and more wood pellets competitors cause price uncertainty for a particular grade. Besides, storage also becomes an obstacle because storage also provides a specific value in sales.
- Brand Identity: Brand identity can affect competition among the wood pellet industry because customers can recognize the quality of a good or bad wood pellet brand and become an important aspect considering consumers' voice is one of the essential holders in marketing.
- Competitor diversity: with so many cultural and historical differences, sales competition between wood pellet industries can be unstable and pressure one another.

2) *Substitute threat*: the threat of replacing wood pellets has become one of the obstacles in the face of increasing energy technology, alternative non-renewable nuclear energy, and renewable geothermal energy is one of the energy sources being considered in the future. But this does not affect the industry because, for the aspect of the plant being made, it will be far more expensive than wood pellet plants. Also, many countries want wood pellets rather than the two alternative energy threats.

3) *Buyer Strength*: The buyer's power impacts the competition of the wood pellet industry, because if there are only a few buyers, then the industry can be fully controlled by the buyer. The buyer will also occupy a strong position if

the buyer purchases in large quantities from the wood pellet industry. Conversely, buyers' strength will weaken if there are many buyers of wood pellets and information on the buying and selling prices of wood pellets in the industry is lacking.

4) *Seller Strength*: In industry, there is a need for raw materials, in this case, sawdust, and so on from suppliers. This position is almost the same between Buyers and the Wood Pellet Industry. Suppliers will have power if many industries want raw materials for wood pellet makers, and the industry has no choice because if it changes suppliers, there may be high additional costs. Conversely, suppliers will be weak if there are more competitive suppliers in selling standardized raw materials.

5) *Threats to new entrants*: Several threats must be passed for new entrants in the wood pellet business, from economies of scale (determining initial prices to attract customers), investment capital, distribution access, knowledge and access to technology used in the wood pellet industry, brand loyalty (whether customers loyal to a certain brand or not), and finally the government regulations regarding the wood pellet industry in general.

6) *Increasing the competitiveness of Indonesian wood pellets*: In the short term, it can happen if a country has good production management such as managing raw material sources, having skilled labor, supporting capital facilities, utilizing technology effectively and efficiently so that it can reduce the cost of producing wood pellets so that it can make pellets wood at low prices and competitive quality. Indonesia has a comparative advantage that is more dominant to play a role in the domestic market first. One example is the existence of a program from the Indonesia Climate Change Trust Fund (ICCTF) that utilizes red *calliandra* (*Calliandra calothyrsus*) as a raw material for the medium-sized wood pellet industry. This program supports government programs in increasing resilience to climate change [18]. Also, a medium-scale wood pellet factory can help the surrounding community increase income, provide jobs, and help areas that are not affordable by electricity.

Considering the efficiency of this wood pellet is higher than gas and fossil fuels, it is possible to use this wood pellet as renewable energy to substitute fossil fuels. It has been applied to bio-cellular fuels, where the palm oil content reaches 20% (B20) [19]. The positive impact is that the government will be able to save more foreign exchange from importing petroleum. The use of wood pellets is reliable enough to be used to meet the energy needs of (alternative) small and medium industries such as the food and soft drink industry, metal craftsmen, the wood industry, and the ceramic industry. Therefore, the development of the wood pellet industry on the small and medium scale is a prospective choice for developing the design capacity of wood pellet machines that are tailored to the needs of small and medium industries. For the utilization of wood pellets in large quantities, the pellet industry can be relied upon to meet the needs of steam and gas (gasification) power plants and is projected to meet the export market of wood pellets that are still wide open.

C. Analysis of Raw Materials and Supply Chains

Wood pellet is currently a flagship fuel, especially in countries with four seasons, such as Europe and subtropical countries. In the country, wood pellet is used as a fuel substitute for coal, mostly for heating, laundry dryers, and biomass stoves. Meanwhile, domestic wood pellets are used as a burner or stove for the food industry, such as fried, *gudeg*, drying furnace, and so forth that have been using LPG fuel. A comparison of the physical characteristics of wood pellets with coal can be seen in Table I.

The wood pellet has some excess compared with coal, ash content, pollution, waste, efficiency, handling, and carbon generated. The drawback is only on the value of the heat produced. With this condition, it can be said that the selection of wood pellets as a fuel source is more profitable both in terms of economical, practical, and more environmentally friendly.

TABLE I
CHARACTERISTICS OF PHYSICAL PROPERTIES OF WOOD PELLETS[20][21]

No.	Factor	Wood Pellet	Calories
1	Caloric Value	4000kcal/kg	5000-5500 kcal/kg
2	Ash Content	< 4%	20 to 40 %
3	Pollution/poisonous self-fluent smoke	No Smoke No Sulphur	Sulfur, Phosphorous
4	Moisture	8%(max)	20 to 20%
5	Efficiency of boiler	75%	75%
6	Wastages/losses	8-10%	15-20%
7	Labor usage	Single person	Require two persons
8	Boiler Efficiency	Normal flash deposit	High wear & tear
9	Handling	Easy packing	Tough material
10	Type of fuel	Carbon Neutral	Carbon positive

Broadly, the supply chain of wood pellets ranging from the procurement of raw materials, processing, transportation, and phase of use. Raw materials of wood pallet production can use the wood chip, sawdust, or biomass from sugarcane pulp or crop waste. The bagasse (sugar cane) has high energy and fuel quality. The highly-reliable bagasse pallet can have a high-calorie value of 3,400 – 4,200 kcal/kg, before being reconditioned with the calorie value only around 1,825 kcal/kg. Biomass from agricultural products such as corn stalks, wheat straw, rice straw, peanut bark, corn cob, cotton twigs, soy stems, weeds (weeds), twigs, foliage, sawdust, and other plant waste can be palletized. It makes it easy to store and distribute as well as attractive performance.

The red *calliandra* plant is a wood pallet (WP) best raw material compared to Chinese and Sengon [22]. *Calliandra* wood produces high calories when burned (4,600 kcal), so that many people use it for firewood. *Red calliandra* can be harvested one year, next to every six months, replanting ten years so suitable as a choice of energy plantation plants that can produce energy wood pellets equivalent to coal energy. Other types of plants that can be used as industrial plants for the raw materials of wood pellets that produce lignocellulose are:

- *Akor (Acacia auriculiformis)*
- *Acacia mangium*
- *Hybrid Accruasia (Acacia sp.)*

- *Eucalyptus pellita*
- *Calliandra calothyrsus*
- *Leucaena leucocyphalus*
- *Gliricydia maculata*
- *Acacia leucophloea*
- *Albizia procera*
- *Sesbania grandiflora*
- *Bamboo: Ater, Apus, Thorns/Ori, and Petung*

Wood industrial waste in the form of powder, debris, or twigs and bars are then processed through the process of cutting into small parts (chipping), processing (pelletizing), and drying and packing or packing). This process requires different investments and equipment from the timber industry. Investment can be in the form of chipper, screening, pelletizer, dryer, packer, and power generation devices and conveyors. Broadly the production of wood pellets followed the stage in Figure 3.

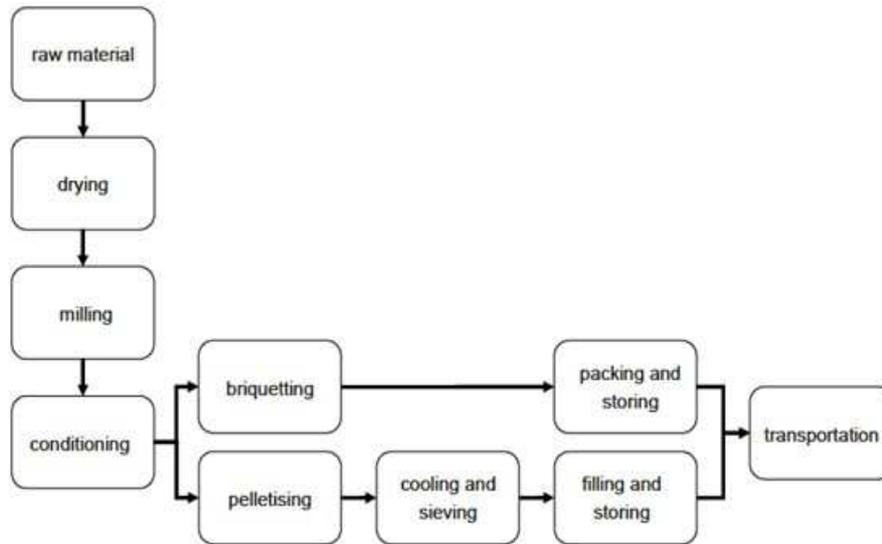


Fig. 3 Process of pellet production and briquette

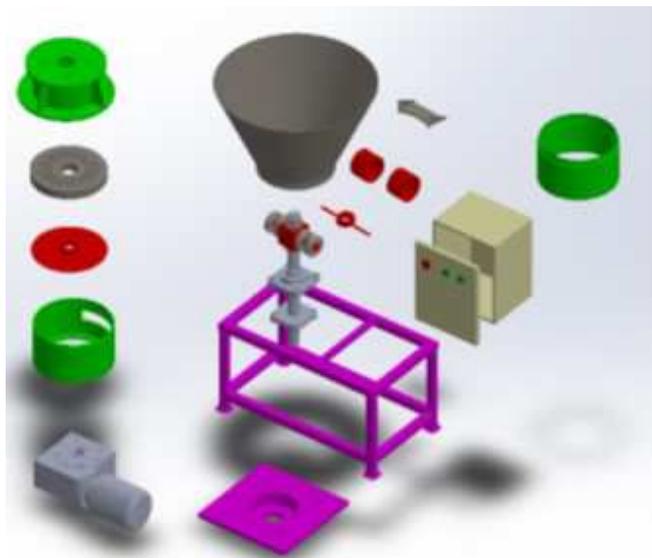


Fig. 4 Components of mini wood pellet machine

The transportation stage is the stage of sending wood pellets to users whose activities can be in the form of small and medium industrial centers. It includes the food and beverage industry, catering companies, hotels, and restaurants that need wood pellets as fuel for cooking, and stoves. In places where wood pellet users can be used as heating media for boilers or power generation units (gasifier) and other uses as fuel for stoves and stoves [23] that are used for quite a long time (4-5 hours). For this purpose, financial

services units need to be involved, technical consultants use machinery and equipment, and carry out maintenance.



Fig. 5 Use of wood pellets for fuel stoves and heating furnaces

D. Financial Analysis and Sensitivity

After reviewing the supply of raw materials, production technology, and market potential, the next is the economics review of wood pellet mills' development plan. Due to its business nature, which is profit-oriented, then the economy factor controls all other aspects. Therefore, the value of some assumptions initially is significant to be observed to achieve an agreement in the calculation scenario. The

assumptions used in the base-case scenario are summarized in Table II.

TABLE II
NPV, IRR, PAYBACK PERIOD

Selling Price (IDR/ton)	NPV (IDR)	IRR (%)	Payback Period (Year)
1,250,000	28,943,498,728.07	21.82	6
1,500,000	63,098,342,536.06	34.85	4
1,100,000	8,450,592,443.27	14.15	8
1,000,000	(5,211,345,079.93)	8.94	12

Total capital cost is IDR 30 billion with a portion of equity of 10% and a debt of 90%. With the company's cost of equity of 15% (company's required return rate) and 14% debt interest rate, and 25% corporate tax, it can be obtained weighted average cost of capital/WACC by 10.95%. The WACC value is then used as a discount rate calculation of NPV, IRR, and Payback Period (PBP).

With a one-day work period of 16 hours, the approximate output of 5 tons/hour using an output defect rate of 5% can produce good-rate wood pellet output of some 76 tons per day. Furthermore, assuming 25 working days in 1 month, then in 1 year there are 300 working days. It is estimated to be generated good-rate wood pellet output of 22,800 tons per year. If the assumption of the wood pellet selling price of IDR 1,250,000 per ton will result in IDR 28.5 billion sales per year.

Operating expenses consist of HR expenses amounting to IDR 275 million per month or IDR 3.3 billion per year and the amount of electrical power consumption is 650 kVA. It is based on working hours with a tariff of IDR 1,200/kWh amounted to IDR 312 million per month or IDR 3.74 billion per year. The price of raw materials, assuming 65% of yield, ratio of *Albacia* and *Calliandra* by 75:25. This state is based on the assumption of the cost of *Albacia* reaching IDR 235 per kg and *Calliandra* IDR 200 per kg, then the composite price of raw materials became amounting to IDR 226.25 per kg or IDR 1.74 million per work hours or IDR 8.35 billion per year. Depreciation obtained from the linear calculation of the total capital cost of IDR 30 billion divided the project life for 20 years to be IDR 1.5 billion per year.

At the selling price of a pellet of IDR 1.1 million per tons will decrease NPV, IRR and increase the time of payback period, if the selling price of pellet to IDR 1 million per tons will produce negative NPV. This is because the pellet's selling price is already under the price limit that produces NPV = 0.

According to simulated calculations, operating profit in the first year is projected to be IDR 11.6 billion. The cost of borrowing repayment per year from a portion of the debt of 90% of total project funding amounted to IDR 27 billion was IDR 2.7 billion (total debt divided into debt repayment for 10 years). Also, IDR 3.78 billion's interest expense is in the first year of a debt interest rate of 14% annually. Thus, the profit before tax in the first year is estimated at IDR 5.12 billion.

The corporate tax expense of 25% per year based on the tariff change of the agency in Law No. 36 the Year 2008 is the corporate tax expense of 25% per year based on the tariff change of the agency in Law No. 36 the Year 2008 is IDR

1.28 billion. Thus, the net profit in the first year amounted to the corporate tax expense of 25% per year based on the agency's tariff change in Law No. 36, the year 2008 is IDR 1.28 billion. Hence, the net profit in the first year amounted to IDR 3.84 billion. The net profit in the first year is 13.48%. Net profit margin in the 11th year increased to 30.53%, it is possible because the debt repayment finished in the 10th year. The net profit margin is projected to stabilize by 30.53% up to the project's 20th year.

On the assumptions used do not take into account escalation and subtraction over the 20-year project life. With a WACC match discount rate of 10.95% will be generated NPV in the 20th year/end of the project amounted to IDR 28.94 billion, IRR project of 21.82% and Payback Period for six years. The selling price limit of pellet where IRR = WACC and generates NPV = 0 is at IDR 1,038,145 per ton with a payback period of 11 years.

E. Analysis of Sensitivity

The results of simulated NPV project sensitivity calculations can be seen in Fig. 6, for the simulation results of the IRR project is presented in Fig. 7.

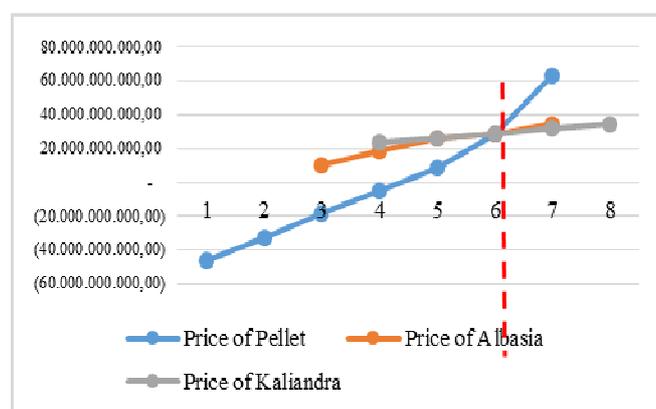


Fig. 6 Sensitivity analysis of NPV

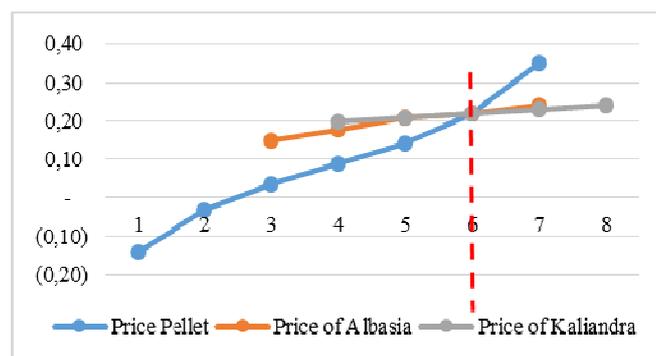


Fig. 7 Sensitivity analysis of IR

Finding out the minimum production capacity of wood pellets that indicate a business does not experience a loss is to calculate the break-even point of operational cash flows that include income and operational costs that must be budgeted, including variable costs and fixed cost. Variable cost consists of labor or HR costs and electricity costs. The fixed costs include labor or human resources, depreciation, and loan interest. Based on the cash flow data contained in Table II, the BEP can be calculated as in Table III.

TABLE III
BEP ANALYSIS

Variable	Cost	Unit
Electricity	3.744.000.000	IDR/Year
Material	8.353.846.154	IDR/Year
Sub Total	12.097.846.154	IDR/Year
Fixed Cost		
Depreciation	1.500.000.000	IDR/Year
Man Power	3.300.000.000	IDR/Year
Sub Total	4.800.000.000	IDR/Year
Pellet Price	1.250	IDR/kg
BEP/Year	13.518,28	ton
BEP/Day	45,06	ton
BEP/Hour	2,82	ton

Production capacity, which is the break-even point, is 2.82 tons per hour. If the company produces below 2.82 tons/hour, it will suffer losses.

IV. CONCLUSIONS

Broadly, the supply chain of wood pellets starts from the procurement of raw materials, processing, transportation, and use. Raw materials can be derived from the wood forest or biomass waste from oil palm plantations, rubber, sugarcane plantations, and wood waste in the form of debris or sawdust. The recommended source of raw materials is the cultivation of red *Calliandra*, which rapidly grows and quickly harvested.

The development of wood pellet making technology is related to the efforts of diversification and fossil fuel energy saving. Therefore, it is required to persevere the infrastructure and support the provision of incentives for restructuring the industrial machinery. It is also crucial to support energy-saving use. The other essential factor is incentives for waste treatment into energy sources that require sympathy. Besides, facilitating research and development activities in the field of renewable energy use in industrial sectors are also urgent in this issue.

The total capital cost of industrial wood pellet capacity 5 tons per hour amounting to IDR 30 billion. If the assumption defect rate output is 5%, then the output of good-rate wood pellets is 22,800 tons per year. If the assumed selling price of wood pellet amounting to IDR 1.25 million per ton and WACC of 10.95% then generated NPV value for 20 years of the IDR 28.94 billion project, IRR of 21.82%, and payback period for six years means that the project is considered Financial. The simulation results showed a minimum price limit of IDR 1,038,145 per ton, but the payback period increased to 11 years.

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