Development of wood pellets processing industry for renewable energy

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Abstract. Wood pellets are environmentally friendly fuel with zero carbon emissions that have been recognized by the United Nations. This study aims to provide data and information to the development of wood pellets as a renewable energy. The study was carried out in Ciamis Regencies in 2017. These locations have a lot of potential for sawn timber and plywood industries, and wood pellet trading activities. The study employed descriptive analysis coupled with economic and financial analyses. The study shows that the wood pellet industry development needs to focus on the improvement and management of the value and supply chains. There are 5 stages in development wood pellet industries, comprising: 1) observation and identification, 2) regional planning and developing supporting infrastructure, 3) technology planning, building production and training facilities, 4) pelleting, and 5) designing institution for production and marketing. A potential source of raw material for the processing of wood pellets are feasible to be developed in Ciamis in terms of social, economic, environmental and policy aspects. The potential market for wood pellets in West Java are tempe and tofu industries, textile industries, farm and food industries. All of these illustrate the good prospect for developing wood pellets for the renewable energy business.

1. Introduction
The development of energy from wood, especially wood pellets, as an important alternative development in the exploitation of forests and forest products. The economic benefits of the cultivation of energy-producing plants, the supply/utilization of wood waste and the processing of wood pellets can create jobs and increase income for the community and the population around the forest. Therefore Wood Energy Plantations Forest (Hutan Tanaman Energi HTE) is potential and renewable energy sources to be developed [1]. Based on Presidential decree No. 5 of 2006 concerning the National Energy Policy (KEN) aiming at directing efforts in realizing the security of domestic energy supply, the Ministry of Environment and Forestry (KLHK) commits to develop Renewable Energy (ET) sourced from forest biomass that will contribute about 5% to the national energy mix in 2025, where the national target is 23%, and 10% to the energy mix in 2050, where the national target is 31% [2]. The primary energy mix at that time was still showing a very high dependence on petroleum, the government has subsequently issued Law No. 30 of 2007 concerning Energy. The law has prioritized the use of energy for community needs and increasing economic activity in energy-producing regions [3].
The amount of income from the cultivation of wood species producing energy, supply/utilization of wood waste and its processing are analyzed based on the feasibility of exploitation. To understand the feasibility of the cultivation of energy-producing plants and wood pellet processing, it is necessary to develop a wood pellet processing industry based on the results of research conducted both within the scope of the Forestry Research and Development Agency and other institutions that have been done. Analysis of the development is carried out starting from the upstream level, that is the cultivation of wood species producing energy, wood pellet processing technology both from cultivated energy wood and from the wood waste up to the analysis of the handling of processed wood pellet products. Some aspects of development that need to be analyzed based on the results of research that has been done previously include aspects of cultivation, technology, economics, and the environment. In the application of wood pellet industry development, assumptions are needed as a limitation in the analysis based on the current conditions and library search results.

Ciamis Regency has the opportunity to develop the wood pellet industry because the potential of Community Forest is big covering about 27,420.16 ha with 10,968,064 stands owned by the community. Besides that, there are already 387 sawmill and pallet wood processing industries available in the sawmill industry which have a relatively large market share so that the waste produced by the wood industry is relatively abundant.

Wood waste that has not been utilized properly in the value chain to increase the income of the processing group or wood industry [4]. The local government does not yet have a strategy and scenario of developing the community wood industry to synergize existing large-scale industries with the potential of the small scale industry, such as the foster father's model scenario, core plasma, etc. Local governments do not yet have institutions and master plans for productive lands to support the development of the wood processing industry and public furniture. Based on the existing potential in the study area, the development opportunities are utilizing sub-standard timber, wood chips, sawn wood waste, harvesting waste and community forest stands of Calliandra wood species.

Developing wood pellet product is advantageous since it is: (a) an environmentally friendly fuel with 0% carbon emissions, which has been recognized by the UN (United Nations), (b) used in power plants to reduce CO2 gas emissions, (c) a source of energy with a relatively high cost, but environmentally friendly that can be utilized continuously for future generations, and (d) suitable for the forestry sector [5], [6]. However, some problems may arise, including: (1) the development of wood pellets as alternative energy in several regions still faces obstacles even though in terms of the manufacturing process it has ease and the product market is quite perspective, (2) the delay in the development of wood pellets is due to problems in the lack of raw materials supply, social, economic, and market aspects.

The problem of raw material supply, social, economic and market aspects in the development of wood pellets need to be studied further. After these aspects are known, then the investment criteria can be calculated (NPV, BCR, IRR, and sensitivity) to analyze the feasibility of developing a wood pellet processing industry, using some assumptions.

This study aims to provide data and information to the development efforts of wood pellets as renewable energy. The specific objectives of the study are to: (1) Providing information on development scenarios through improving the wood pellet processing industry value chain, (2) Identifying action plans in the development of utilization of energy wood for wood pellets, (3) Providing information on potential sources of raw materials for pellet wood development efforts, (4) Analyzing the financial and economic business of wood pellet production, and (5) Conducting inventory of markets and marketing systems in the business of developing wood pellet.

The output expected from the results of this study is information and policy recommendations for Wood Energy Plantation Forest (HTE) for the development of forest-based biomass energy from wood pellets as Renewable Energy (RE) based on forest biomass. So that the problems of raw material, social, economic and market supply in the development of wood pellets need to be studied further.
2. Methodology

2.1. Logical Framework

The logical framework for wood pellet development schemes as a source of forest biomass energy, in general, starting from the forest to markets is presented in Figure 1 below:

![Wood Pellet Development Schemes as Source of Forest Biomass Energy](image)

Figure 1. Wood Pellet Development Schemes as Source of Forest Biomass Energy

Wood pellet development schemes as a source of forest biomass energy, in general, starting from the forest to the market. The schemes of wood pellet development that occur in the field are determined by each species of wood or energy wood species group and wood waste used for each location. Every stage in the wood pellet process was analyzed, starting from cultivation to marketing.

2.2. Research Hypothesis

The development of the utilization and management of wood waste is assumed to be still not optimal (distortive), causing high economic costs and less optimal distribution of incentives for stakeholders and wood processing industry businesses. Optimal management will increase the feasibility of wood pellet development from the aspects of silvicultural engineering, processing technology, institutions, business feasibility, marketing, trade, and environmental sustainability.

2.3. Data Collection

Data were collected from several actors including (1) sawn timber and plywood processing industry (collectors, traders, processors/industries); (2) agencies and institutions involved in waste and energy wood; (3) farmers and collectors of wood processing industry waste; (4) communities/farmers who cultivate energy wood; and (5) communities whose depend on energy wood cultivation activities. The locations for this study were selected based on the potential resources, the existence of processing/industry of sawn timber and plywood, and wood pellet trading activities carried out by many stakeholders in the area. Thus, Ciamis Districts of West Java Province were selected. Data began to be collected in April 2016 and July 2017, in the form of primary data and secondary data. Wood pellet processing was tested from the equipment available at the Forest Product Research Center and Development (P3HH) and The Indonesian Institute of Sciences (LIPI) and then its technical, economic, and environmental aspects were analyzed. The technical aspects include the potential
supply of wood as raw materials from community forests, the process of making Wood Pellet Tests using sawdust as raw materials and tools used, including the type of wood pellet making machine brought and prepared by a team from the Forest Products Research and Development Center. Economic aspects include the positive impact of the development of wood pellet management including employment and income. Environmental aspects include the impact of crop cultivation and wood waste treatment to improve environmental functions to increase carbon sequestration in the context of reducing Greenhouse Gases emissions.

2.4. Data Analysis
Data obtained from the field were then tabulated and analyzed descriptively to determine the scenario and action plan for developing wood pellets. The economic and financial analysis of wood pellets was conducted to see the feasibility of wood pellet development from cultivation to pellet wood products. The results of this analysis were used to plan the development of the wood pellet industry. Finally, a descriptive analysis was carried out to formulate recommendations on strategies for developing waste processing and the results of energy wood cultivation for wood pellets.

3. Result and Discussion
3.1. Development Scenario
The value chain and supply chain of wood pellets from upstream to downstream starts from the stages of cultivation, harvesting, processing, and marketing[7,8]. The development of wood pellets is intended to obtain optimal added value with the improvement and management of the value chain and supply chain of wood pellets, mainly from raw materials sourced from energy wood[9]. While the management of wood pellets from wood waste raw materials can go directly to the processing stage. Improvement and management of value chains, the supply chain for optimizing the added value of energy wood and wood waste for each stage of the value chain and supply chain are as follows[10]:

a. Cultivation
The value chain and wood pellet supply chain begin with a focus on cultivation activities. Improvement and management of the value chain and supply chain to optimize the value-added of energy wood and wood waste at the stage of forest cultivation, through:
1) Regulating and maintaining energy forest areas and sustainable community forests;
2) Standardizing the silvicultural methods and maintaining the sustainability of forests;
3) Governing the sustainable use of HTE;
4) Designing road facilities to support the connectivity, accessibility, and transportation of wood from the forest environment to the processing area;
5) Increasing capacity in forest management and administration systems.

b. Harvesting
The second stage of development is HTE harvesting. Improvement and management of the value chain and supply chain to optimize the value-added of energy wood and wood waste at the harvesting stage of the wood energy plantation forest (HTE) include:
1) Community institutions for managing sustainable harvesting of forest products;
2) Standardization of cutting cycle and harvest quality;
3) Standardization of logging and cutting methods;
4) Increased skills and community competency in logging, cutting, transportation, etc.;
5) Safe drying and warehouse facilities;
6) Increased skills and community competence (capacity building) in understanding wood quality, methods of drying, storing, transporting, etc.;
7) Capacity building in the logging administration system.
c. Processing

The development of the 3rd stage is the processing of energy wood and wood waste. Improvement and management of the value chain and supply chain to optimize the value-added of energy wood and wood waste at the stage of processing energy wood and wood waste, include:

1) Wood pellet processing industry planning area;
2) Preparation of feasibility studies and business plans and regional prospectuses;
3) Increased wood processing capacity into value-added products;
4) Procurement of standardized drying and processing equipment (with CSR schemes, private investment or bank loans);
5) Standardization of product quality and provision of QC Labs.;
6) Increased skills and competencies in production management and quality management;
7) Product quality certification , etc.

d. Marketing

The last stage of development is the marketing of wood pellets. Improvement and management of the value chain and supply chain to optimize the value-added of energy wood and wood waste at the marketing stage of wood pellets, include:

1) Establishment/strengthening of institutional capacity (cooperative) to mobilize wood pellet processing community groups.
2) Partnership with wood pellet users (tofu, tempe, livestock, textile industries, etc.)
3) Making prospectus of the industrial estate and its products as Ciamis featured products (prospectus books, multi-media, websites, etc.)
4) Participation in various renewable energy exhibitions (forest energy biomass) and wood pellet processed products both domestically and abroad (if possible)

3.2. Action Plan

a. Stages Activities

There are 5 stages of development activities that need to be carried out until the formation of production and marketing of wood pellets, namely: (1) observation and identification, (2) regional planning and supporting superstructure, (3) technology planning, production and training facilities, (4) pilot plant for wood and wood waste (Pelletizing), and (5) design of production and marketing institutions.

b. Road Map for the Development of Small Scale Wood Pellet Processing Industry in Ciamis Districts

Based on the above action plan, it is necessary to make a road map for the development of community-scale wood pellet management industry in Ciamis Regency as shown in the following figure.
Figure 2. Stage of Establishment of Wood Pellet Industrial Development Institutions

The picture above defines the stages of institutional formation in the development of the wood pellet industry comprising:

(1) Observation and identification which includes the potential of raw materials, wood pellet production, market potential (Ciamis, Bandung, Cirebon, and surrounding areas), technological needs, human resource capacity building needs, and industrial area needs.

(2) Forest area planning and infrastructure (upstream sector).

(3) Technology planning, production facilities, and training that can be carried out in conjunction with forest area planning and infrastructure.

(4) A pilot project of wood processing pellet processing pilot unit.

(5) Institutional development of the wood pellet processing industry.

(6) Promotion and investment.

Figure 2 shows that the results of observations and identification of the institutional formation stage of the wood pellet industry development obtained data that the potential of energy wood raw materials in Ciamis Regency amounted to 1,316,644 tons and when produced into wood pellets it would be obtained at 842,652 tons. With this basis, it is necessary to know the potential of markets in Ciamis, Bandung, Cirebon and surrounding areas. To produce wood pellets, it is necessary to determine the technological requirements. After that the need to increase the capacity of human resources (HR). While the availability of industrial estates in Ciamis Regency is available for 5 hectares and even then it is spread in several districts. Finally, there is a need for local government regulations proposed to the Regional Representative Council (DPRD).
The next stage is regional planning and superstructure that can be carried out by the Regional Planning and Development Agency (Bappeda), while technology planning, production facilities, and training can be carried out by the Research, Development and Innovation Agency (BLI) and LIPI.

The next stage of the pilot project is a wood pellet processing pilot unit that can be built in the Banjarsari sub-district of Ciamis Regency. The last stage is institutional development, namely the production and marketing institutions that can be implemented by the Community Forest Farmers Association (APHR) and the Indonesian Community Timber Industry Association (AIKRI). After the development stage is carried out, promotion and investment can be carried out by the local government.

For the success of the action plan, funding schemes need to be accompanied by, among others, BLI, Investors (Banks or private financial institutions) and/or local government. Besides, the action plan needs monitoring and evaluation that can be carried out by the scope of the BLI (Research and Development Center for Socio-Economic, Policy and Climate Change (P3SEKPI), Forest Product Research and Development Center (P3HH), and Forest Research and Development Center (P3H)) and the local government.

The institutional design activities are carried out by (1) preparing the institution of the development center for the wood pellet processing industry in the industrial zone of Ciamis Regency, which functions to manage HTE of Calliandra species and community forest, cutting, processing and marketing, (2) preparing the system and regulatory managing the area, (3) preparing information systems and investment policies in the industrial estate, and (4) preparing the wood pellet product and manufacturing prospectus in the industrial zone of Ciamis Regency.

3.3. Potential Sources of Raw Materials for Regional Pellet Business Development

The opportunity to develop the wood pellet processing industry is very big considering the raw materials from the cultivation of energy crops, Ciamis Regency forest product waste is very large both from wood industry waste and from the community forest.

3.3.1. Species for HTE

The wood species developed and feasible as raw materials for wood pellets with calorific values between 4500 cal/gram to 5000 cal/gram in Ciamis Regency are:

1. Calliandra (Calyandra calothyrsus)
2. Lamtoro Gung (Leucaena leucophala)
3. Gamal (Glirisedia sepium)
4. Turi (Sesbania glandiflora)
5. Akor (Acacia auriculiformis)
6. Sengon/Albazia (Paraserianthes falcataria)

The total available plants are generally calliandra and sengon (Albazia) with a potential of 1,096,806 m³, Density 0.65 and tree volume of 0.2 m³ so that it is obtained 712,924 tons per year.

3.3.2. Utilization of Forestry Waste (logging and industry)

The result of a rough calculation of the amount of logging waste from the forest area shows that the ratio between the amount of waste and the amount of Calliandra roundwood production and community forest is around 2.5, which means the percentage of logging waste is around 40% of roundwood production. So the potential of logging waste = 285,170 tons and the potential of industrial waste = 387 x 8 m³ /day x 30 days x 10 months = 928800 m³ /year or (603,720 tons /year), so the total available raw materials come from the waste of 1,601,814 tons per year.

3.4. Socio-Economic Aspects

The management of wood pellets from the aspect of cultivation of raw material supply and processing, both large and small scale, can have an impact on the condition of the community and the surrounding
environment. The positive impact of the development of wood pellet management especially in Ciamis Regency:

1) Utilization of wood waste (waste exploitation and wood processing industry).
2) Increased income of farmers cultivating plants.
3) Creation/absorption of labor for cultivation, a supply of raw materials, manpower for the processing which will ultimately improve the welfare of the community.
4) Increasing the capacity of natural and human resources.
5) Creation of community institutions in the management of cultivation, a supply of raw materials and processing.
6) The adoption of innovations in the form of cultivation and knowledge of farmers about the types of plants as raw materials for wood pellets (sengon, Calliandra, etc.).
7) Wood pellet management is also one of the strategies in the action plan in mitigating climate change.
8) Broadly managed wood pellets can have a positive impact on increasing local economic activity for upstream and downstream entrepreneurs and the surrounding population.

3.4.1. Developing Wood Energy Plantation Forest (Hutan Tanaman Energi/HTE): Case study of Calliandra

(1) Analysis of Costs for Energy Plantation Forest of Calliandra

The cost component of Energy Plantation Forest cultivation business activities refers to the results of interviews with wood farmer groups of community forest in the development of energy plantation forest in the Cijenjing District, Ciamis Regency in a standalone pattern. The cost of building HTE consists of land preparation costs, seed supply, planting, maintenance, and harvesting[11]. Some assumptions used in the analysis of the costs of cultivating wood energy include:

a) Land area for cultivation of energy wood species of Calliandra: 30 hectares;
b) Procurement of facilities and infrastructure: work huts, procurement of equipment and facilities to support the cultivation;
c) Duration of analysis: one rotation of HTE cultivation (the species of Calliandra) for 4 years;
d) Plant spacing (1.5 x 2) m or 3,666 stems per hectare without any intercropping;
e) The selling price of energy wood remains is of 19 USD/m3 at the planting site;
f) Land used for cultivation in their own land, (no land rental fee);
g) The inflation factor that affects the value of income and expenditure is considered the same so the price of the components of expenditure and income = constant prices;
h) The interest rate used is the effective average interest rate currently in effect, which is 12%/year.

Based on the results of the calculation, it was obtained that the energy of the independent pattern of wood energy species of Calliandra per hectare was 1.231,48 USD.

(2) Feasibility of Energy Plantation Forest Businesses

The cost component of energy wood cultivation business activities refers to the results of interviews with community forest wood farmer groups in the development of energy wood plants in Cijeunjing District, Ciamis Regency in the independent pattern.

The costs of developing community forests producing energy wood can be classified based on the details of the activities of the development of community forests including the costs of land preparation, seeding, planting, maintenance, and harvesting. Based on the calculation of field data, the total cost of cultivating energy wood in community forest plantation (HTR) with an independent pattern of Calliandra species per hectare is of 1.030,56 USD with the production of 120 m3, planting distance of 1.5 x 2 m and the number of trees 4,000 stems are planted. The selling price of energy wood is 19 USD per m3 so that the total income with a success rate of 75% is 2.222,22 USD. The area of land used for the energy wood cultivation of Calliandra is of 30 ha, concession rotation crop for 4 years, the land used for the cultivation of Calliandra cultivation is land owned by farmer groups, the
effective interest rate of 12% per year, rupiah exchange rate is of Rp13,500 per USD and the inflation factor is considered to be the same.

Based on these data, financial analysis can be done by calculating investment criteria, namely Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit-Cost Ratio (BCR) values. The results of the feasibility analysis of the energy timber plantation business using IRR, NVP and BCR parameters obtained an NPV value is of 794.52 or NPV > 0, BCR is 2.01 and IRR is of 29% (greater than the effective interest rate) therefore the development of wood energy cultivation business for raw material of wood pellets is feasible and very attractive for investors with independent patterns.

(3) Feasibility of Wood Pellet Processing Industry Business
In calculating wood pellet production costs, the species of raw material is Calliandra wood with an industrial capacity of 10 tons/hour (1 day = 10 hours, 1 year = 300 days equivalent to 30,000 tons per year) and the assumption of raw material prices of Rp 250,000/m³ (equivalent to 19 USD/m³), the amount of wood pellet production costs with yield is of 68% (1 ton wood pellet = 1,247 tons of wood) (not included drying and screening), which amounted to 71.5 USD per ton. After analyzing and calculating economic feasibility, NPV > 0, BCR > 1 is obtained and the IRR value is greater than the effective interest rate so that the development of wood pellet industry in Ciamis Regency is feasible to be developed and has bright prospects in terms of various aspects as market, environment, policy, social, technology, and business feasibility.

3.4.2. The Trade of Wood Pellet
The alternatives of marketing channels of wood pellet products are as follows:
(1) A zero-level channel where producers sell directly to end consumers.
(2) A one-level channel contains one sales intermediary, such as a retailer.
(3) A two-level channel contains two intermediaries. In the consumer goods market, they are generally wholesalers and retailers.
(4) A three-level channel containing three intermediaries, for example, local traders, wholesalers, and retailers.

The distribution flow of wood pellet trade as presented in the following figure:

![Wood Pellet Trade Distribution Flow Diagram](image)

Remark: IUPHHK is Permit for Utilization of Timber Forest Products

Figure 3. Wood Pellet Trade Distribution Flow
Based on the picture above it can be seen that the source of wood pellet raw materials can come from IUPHHK (outside Java)/Perhutani (Java), farmers (the result of energy wood cultivation or logging waste) and from industry (wood processing industry waste) that can be supplied to wood collectors or traders or can go directly to the wood pellet processing industry if there is a large volume of shipments due to transportation considerations[12].

As for the market potential of wood pellets in Ciamis Regency and the West Java region, especially Bandung, Tasikmalaya, Garut and Cirebon, they are tofu, tempe industry, textile industry, livestock cultivation, and food industry.

4. Conclusion And Policy Recommendation

4.1. Conclusion
a. The scenario of the wood pellet industry development is focused on the improvement and management of the value chain and supply chain for the optimization of value-added wood energy and wood waste starting from cultivation to marketing.
b. Wood pellet industry development activities begin with observation and identification of wood pellet marketing.
c. The development of the wood pellet industry as a pilot unit for forest village communities is required the intensity of assistance, monitoring and funding schemes from investors or other financial institutions or research institutions.
d. Wood pellet processing is very feasible to be developed in Ciamis Regency considering the source of raw materials derived from energy wood cultivation, logging waste and wood processing industry waste is quite available.
e. The development of the wood pellet industry in Ciamis Regency has bright prospects in terms of various aspects as market, environment, policy, social, technology, and business feasibility.
f. The potential market of the wood pellet in Ciamis Regency and West Java, especially Bandung, Tasikmalaya, Garut and Cirebon are industries of tempe, tofu, textile, livestock, and food.

4.2. Recommendations
a. The development of wood pellets for renewable energy businesses requires support in a shared vision of central and regional policies.
b. The competitiveness of the energy plantations forest (HTE) business has the opportunity to be increased as a source of forest biomass energy both for export and domestic.
c. Policy for developing the wood pellet industry is needed in Ciamis Regency and is supported by all relevant parties under the coordination of the Ministry of Environment and Forestry.

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