In addition to various infrastructures that strongly support industrial activities, KEK Sei Mangkei also provides several incentives that will facilitate investors doing business in the region, namely tax holyday incentives, tax allowances, and other incentives. Some forms of tax incentives or incentives to encourage the development of the SEI Mankei SEZ and investment in this region include**:**

Tax Holyday:

- 20 - 100% Income Tax reduction for 10 - 25 years for an investment of more than Rp 1 Trillion.
- 20 - 100% Income Tax reduction for 5 - 15 years for an investment of more than Rp 500 Billion.

Tax Allowance:

- Reduction of net income by 30% for 6 years;
- Accelerated depreciation and amortization;
- Income tax of 10%
- Compensation for losses of 5-10 years

Other incentives:

- Article 22 Income Tax Import is not collected
- PPN and PPnBM are free of charge
- Exemption from import duties
- Suspension of import duties
- Ease of immigration licensing
- Ease of land licensing
- Ease of employment licensing
- Goods traffic facilities
- Ease of investment licensing (3 hours) including: Investment permits, Company Deed and Legalization, NPWP, Company Registration Certificate (TDP), Foreign Workers Use Plan (RPTKA), Permit to Hire Foreign Workers (IMTA), Importer's Importer Identification Numbers (API-P) Customs Identification Number (NIK), and Certificate of Land Map Information Certificate (if needed).

5.2.2 Second location: Gunung Tua

Gunung Tua is the capital of North Padang Lawas Regency (Paluta). This area was chosen as a prospective factory construction site because of its strategic position, located in the middle of various production forest areas which will become suppliers of raw materials for wood pellets. The wood pellet factory in Gunung Tua will become the raw material estuary from the southern part of North Sumatra Province.

Most of the Gunung Tua land is flat like a stretch, some of the contours of the road are straight and bumpy. Gunung Tua is an important cross town in North Sumatra, because Gunung Tua is included in the central crossing of Sumatra. North Padang Lawas Regency is bordered by Labuhanbatu Regency, South Tapanuli Regency, Riau Province, and Padang Lawas Regency (Figure 12).

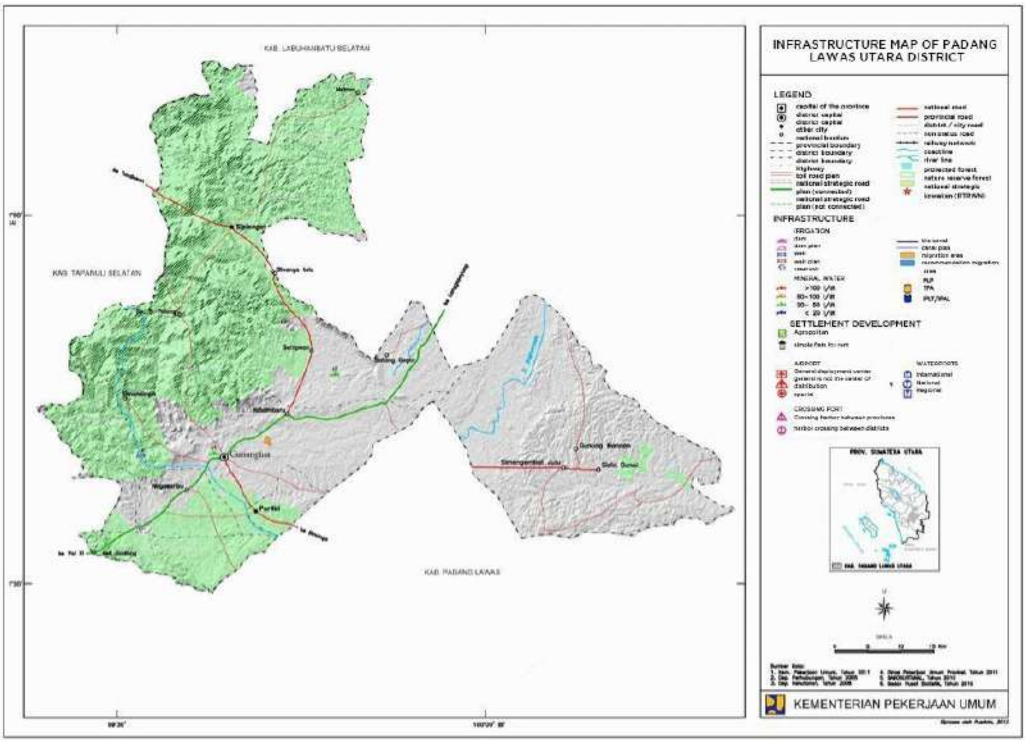


Figure 12. Map of North Padang Lawas regency

The population in this district is around 200 thousand people and will continue to grow. In language, Padang Lawas comes from the word Padang means flat land, while Lawas means broad. Padang Lawas means large flat land. The language of the local community uses Angkola, whose intonation is softer than the Toba Batak language and is similar to the language of Mandailing - South Tapanuli. Most people in this region are engaged in agriculture and plantations with the main commodity being oil palm.

5.3 Analysis of Raw Material Availability

One of the important things in the analysis of the supply chain system for the development of the wood pellet industry is the identification of the source of raw materials and the availability of raw material supply for wood pellets. Both of these are very important because the availability of sufficient raw material sources will support the sustainability of wood pellet production. Conversely, if the availability of raw material sources is not sufficient in the long run, it will result in the cessation of production activities. Termination of production will harm all parties, both the processing industry and the manager of the plantation as a supplier of raw materials.

In this regard, matters analyzed in this study include**:**

a. Desired wood biomass properties;
b. The main types of energy trees to be developed;

c. The nature of growth, growth and increment;
d. Suitable land and available around industrial sites;
e. Potential supply of raw materials;
f. Type development strategies to ensure sustainable supply; and
g. Delivery system of raw materials and wood pellet products.

5.3.1 Desired wood biomass quality

The use of woody biomass as fuel provides more advantages when compared to fossil fuel sources. These benefits include**:**

a. Abundant availability

   Renewable energy fuels are relatively abundant and are widely available in Indonesia. Supporting a tropical climate with high frequency of sunlight and a rich variety of tree species make Indonesia's forests a biomass factory all the time. This is an opportunity to develop woody biomass as an energy source on a wider scale.

b. Environmentally friendly

   Emissions of carbon dioxide (CO_2) remaining from the process of burning wood pellets are 90% less than burning fossil fuels. In addition, the combustion of biomass energy also contains less sulfur and heavy metals. This condition is one of the practices of environmentally friendly energy utilization.

Under these conditions, fuel produced from woody biomass is expected to have the following characteristics**:**

a. Has a high heating value;
b. Has sufficient water content to allow burning;
c. Has a high yield; and
d. Has a fast ignition rate and stable combustion.

The quality of raw materials for the needs of wood pellet production is influenced by the quality of the wood. In this case, the quality of wood as an energy source is influenced by several things, namely as follows**:**

a. Tree species

   Hardwood (*broad leaf wood*) and softwood (*coniferous wood*) have different potential as energy sources. The heating value of softwood tends to be higher than that of hardwood (Baker, 1983). However, these combustion heat values are slightly related to wood species and only vary by 5-8% (Prawirohatmodjo, 2004). Trees that grow fast and have many branches tend to have higher energy.

   Considering the nature of its growth, biomass-producing trees should have (a) rapid (incremental) growth with heavy branching; (b) high specific gravity (BJ); (c) easy to grow in various growing conditions; (d) sprouts quickly after prunning and (e) the wood produced has a high heat value. Based on these characteristics, there are

3 (three) types that are prospective for development as energy plantations, namely Kaliandra (*Calliandra callothyrsus*), Gamal (*Gliricidea sepium*), and Lamtoro (*Leucaena leucocephala*).

b. Silviculture System

Various studies show that the calorific value of wood can be increased by applying an appropriate silvicultural system. Some forest cultivation techniques that can be applied include**:**

a) The pattern of monoculture planting, namely the pattern of development of forest stands with certain or pure species with trees specifically intended as an energy source. In addition to the species mentioned, *Acacia vilosa*, A. *auriculiformis*, A. *mangium*, A. *oraria*, *Eucalyptus urophylla*, E. *alba*, E. *deglupta*, *Albizzia procera*, melina (*Gmelina arborea*), saga (*Adenanthera* spp.) also can be developed. In addition, it can also be used as hedges such as angsana/sono kembang (*Pterocarpus indicus*), secang (*Caesalpinia sappon*), Chinese petai (*Leucaena glauca*). Fences are able to grow from trees and are generally of small diameter so that they are not suitable for carpentry wood but have potential as energy wood.

b) To get a stand with many branches, the spacing must be adjusted as optimal as possible. Usually used a spacing of 1 x 2 m.

Furthermore, suggested maintenance patterns include**:**

a) The trubus model (branches are trimmed and left only the important part of the tree, the base of the main trunk).
b) Aimed at protecting against diseases, pests and fires that can interfere with the growth of biomass energy sources.
c) Thinning is done if needed with low intensity.
d) The development of the wood pellet business model uses the concept of partnership with the community, so that planting patterns with optimal land use such as agroforestry systems are recommended. This mixing system can mainly be done at the beginning of land clearing and or planting energy wood as a firebreak, garden boundaries or between plantation crops. For example planting gamal between coffee plants as shade. Kaliandra also has massive flowers that support honey bee cultivation.

c. Plant Age (Rotation)

The age of the plant at the time of harvest determines the quality of the wood harvested, especially for high-heat wood production. There is a trade-off whether harvesting is done when a tree that is old enough and has chemically undergone a stage of cell wall hardening (lignification) or is done at a young age even though the heat is lower but with a shorter period. But now fast-growing species have also been identified as having a high heat content. Some practices of planting Kaliandra as energy wood in Indonesia show that harvesting stems can begin at the age of 2 years after planting, even faster with rotation of planting (clear-cutting and replanting) at the age of 7 - 8 years.

d. Forest Ecology

Tree growth is influenced by climate, weather, rainfall, places to grow, soil fertility and intensity of sunlight. Therefore the ecology of the forest affects the quality of the raw material for wood pellets itself, which is the biomass of plant growth. The altitude that affects the temperature and humidity of the air visibly also distinguishes the growth performance of a species. Species that grow endemic to coastal areas generally show lower growth performance when planted on land in the mountains, and vice versa.

e. Tree Part

There is an effect of different parts of plants or trees on the quality of wood as an energy source. As an illustration, wood in the roots and stems have different heat content. This is influenced by the basic properties of wood such as the anatomy, physics, and chemistry of different wood in one tree. Meanwhile, according to Prayitno (2007), one of the factors that need to be considered in the use of wood as an energy material is a large growth speed with dense branching properties.

5.3.2 The main energy tree species to develop

In accordance with its objectives, the development of energy forests is expected to produce biomass with high productivity, normal growth, and economic cycles. Planted species must have characteristics (a) that can adapt to various soil and climate conditions; (b) grows fast (high increment) and can compete with weeds; (c) fast growing after pruning; (e) wood has a high calorific value and (f) has other economic value. Among fast-growing tree species, Kaliandra, Lamtoro and Gamal meet the above characteristics. Although not an endemic species, this species is able to adapt to various conditions in Indonesia. However, species do not withstand poorly drained soils and flood regularly. As a fast-growing and intolerant species, these trees do not grow well in plants with moderate to high intensity. Nevertheless, Gamal is able to grow in acidic and unproductive soil conditions.

In the highlands especially in Lake Toba, Kaliandra (*Caliandra callothyrsus*) originating from Central America can grow well to an altitude of 1,400 m above sea level with high rainfall until a long dry season up to 6 months. At its origin in Mexico and Central America Kaliandra grows to a height of 1860 m above sea level, especially in areas with rainfall ranging from 1000 - 4,000 mm with a dry season lasting for 2 - 4 months. This species can also grow at a minimum temperature of 18 - 22 ^{o}C, in contrast to Lantoro and Gamal which require warmer conditions. Therefore Kaliandra is preferably planted in a higher place. The last two species require temperatures of 25 - 30 ^{o}C for optimal growth.

In addition to growing fast, these species also have high heat content. Kaliandra has a volume growth (increment) of stands of 50 - 90 m^3/ha/year with an average heating value of 4,700 kcal/kg. In addition, Lamtoro increment is 20 - 60 m^3/ha/year and an average heating value of 4,197 kcal/kg. Meanwhile, the average Gamal tree increment is 32 m^3/ha/year with an average heating value of 4,168 kcal/kg. Biomass production for each type of wood is as follows**:**

a. Kaliandra (*Calliandra callothyrsus*)**:** 0.6 x (50-90 m^3/ha/year) = 30 - 54 Tons/ha/year
b. Gamal (*Gliricidea sepium*)**:** 0.7 x (32 m^3/ha/yr) = 23 Tons/ha/year
c. Lamtoro (*Leucaena leucocephala*)**:** 0.6 x (20-60 m^3/ha/year) = 12 - 36 Tons/ha/year
In detail the heating value, specific gravity and other characteristics are in Table 13.

Table 13. Calorific value, specific gravity, moisture content, bonded carbon and ash content of the tree species to develop.

No.	Type	Caloric Value (kkal/kg)	Specific Gravity	Moisture (%)	Bonded Carbon	Ash Content (%)
1.	Kaliandra	4.600 - 4.720	0,55 – 0,7	40	16,53 -16,70	0,25 - 0,47
2.	Gamal	4.900	0,74	12,51	18,12 - 24,00	0,88 - 2,97
3.	Lamtoro	4.464 - 4.679	0,60 – 0,75	30 - 50	15,32 - 20,32	0,95 - 2,08

5.3.3 Land suitability

Considering the physiology of Kaliandra, Lamtoro and Gamal they are fast-growing species that are vulnerable to shade, the area of energy timber plantation development with clear cut systems at the end of the cycle is prioritized for production forest areas, especially on critical land or open areas contained in production KPH Forest Management Production. Planting in open and critical areas, aside from being directed as a rehabilitation program, also reduces land clearing costs.

If the development of energy forests is prioritized in the area of production forests, available land is 1,421,905 ha or 46.53% of the total forest area in North Sumatra. Based on their functions, these forests consist of 641,769 ha of limited production forest, 704,452 ha of permanent production forest, and 75,684 ha of production forest can be converted. Furthermore, if energy forests are to be built on degraded land, 1,254,134.46 ha of degraded land will be available for biomass production. This area covers 17.27% of the total 7,262,037 ha of land available in North Sumatra. The critical area is spread over two watershed management areas, namely 943,633.38 ha in BPDASHL Asahan Barumun and the remaining 310.501.08 ha in BPDASHL Wampu Ular. Potential land for planting will be broader if it also includes 1,465,550 ha of potentially critical land and 2,133,820 ha of degraded land.

Based on overlaying of land cover maps, maps of production forest areas and maps of critical land, as well as the requirements for growing areas of energy wood species, we obtain maps of potential land availability for the development of energy forest plantations in North Sumatra (Figure 13 and Table 5.4). Considering the plan to develop wood pellet industry in two strategic locations, namely in the Sei Mangkei SEZ and Gunung Tua, the production forest area was identified at a radius of 100 km around it as shown in Table 5.4. The raw material for the factory in Sei Mangkei will cover an area of 73,910 ha from the Pematangsiantar, Asahan and Labuhanbatu Utara KPHs, while the

Gunung Tua wood pellet mill will be supplied from 195.365.5 ha of production forests from the North Padanglawas KPH, Padang Sidempuan and Sipirok.

The availability of land for the development of energy forest plantations to supply the wood pellet industry at two locations namely Sei Mangke SEZ and Gunung Tua is shown in Tabel 14.

Table 14. Suitability of land for energy wood crops to supply two industries

No.	KPH	Production forest			Limited production forest			Grand Total	
		Potential	Real	Total	Potential	Real	Total	Real	Total
1	2	3	4	5	6	7	8	9	10
1	KPH Wilayah II Pematang Siantar	55,858.1	16,686.1	72,585.7	10,328.6	475.6	11,510.8	84,096.5	17,161.7
	UNIT IX – KPHL	3,957.5	84.7	4,042.2	14.9	-	64.9	4,107.1	84.7
	UNIT VI – KPHP	35,257.6	9,241.8	44,499.4	-	-	-	44,499.4	9,241.8
	UNIT X – KPHL	-	-	-	1,082.6	11.8	1,751	1,751	11.8
	UNIT XII – KPHP	16,643	7,359.6	24,044.1	9,231.1	463.8	9,694.9	33,739	7,823.4
	Total ammount	111,716.2	33,372.2	145,171.4	20,657.2	951.2	23,021.6	168,193	**34,323.4**
2	KPH Wilayah III Kisaran	38,688.3	2,206.7	43,096.4	366.5	38.1	404.6	43,501	2,244.8
	UNIT III – KPHP	18,741.5	324.8	19,160.7	-	-	-	19,160.7	324.8
	UNIT VII – KPHL	12,303.6	1,346.6	14,573.1	-	-	-	14,573.1	1,346.6
	UNIT XIII – KPHL	7,643.2	535.3	9,362.6	366.5	38.1	404.6	9,767.2	573.4
	UNIT XXI – KPHP	14,261.6	5,310.9	19,572.5	627.1	2,154.6	2,781.7	22,354.2	7,465.5
	Total ammount	91,638.2	9,724.3	105,765.3	1,360.1	2,230.8	3,590.9	109,356.2	**11,955.1**
3	KPH Wilayah V Aek Kanopan (Labuhan Batu Utara)				40,692.2	27,631.6	68,366.5	68,366.5	27,631.6
	UNIT XXII – KPHL		-	-	23,275.4	23,105.8	46,423.9	46,423.9	23,105.8
	UNIT XXIII – KPHL		-	-	17,416.8	4,525.8	21,942.6	21,942.6	4,525.8
	Total ammount	-	-	-	40,692.2	27,631.6	68,366.5	68,366.5	**27,631.6**
4	KPH Wilayah VI Sipirok (Tapsel)	10,823.1	6,259.6	17,688.3	28,581.9	16,271.1	44,902.4	62,590.7	22,530.7
	UNIT XXVI – KPHL	10,823.1	6,259.6	17,688.3	28,581.9	16,271.1	44,902.4	62,590.7	22,530.7
	Total ammount	21,646.2	12,519.2	35,376.6	57,163.8	32,542.2	89,804.8	125,181.4	**45,061.4**
5	KPH Wilayah VII Gunung Tua (Paluta)	128,486.4	55,851.8	185,292.2	29,671.6	13,090.7	42,800	228,092.2	68,942.5
	UNIT XI – KPHP	12,128.8	15,032.9	27,161.7	1,574.5	1,781.9	3,356.4	30,518.1	16,814.8
	UNIT XXXI – KPHP	116,357.6	40,818.9	158,130.5	28,097.1	11,308.8	39,443.6	197,574.1	52,127.7
	Total ammount	256,972.8	111,703.6	370,584.4	59,343.2	26,181.4	85,600	456,184.4	**137,885**
6	KPH Wilayah X Padang Sidempuan	18,829	4,095.1	23,661.1	39,195	8,324	49,592.3	73,253.4	12,419.1
	UNIT XXVIII – KPHP	18,829	4,095.1	23,661.1	39,195	8,324	49,592.3	73,253.4	12,419.1
	Total ammount	**18,829**	**4,095.1**	**23,661.1**	**39,195**	**8,324**	**49,592.3**	**73,253.4**	**12,419.1**
	Grand Total	500,802.4	171,414.4	680,558.8	218,411.5	97,861.2	319,976.1	1,000,535	269,275.6
	Alocation to Sei Mangke factory	203,354.4	43,096.5	250,936.7	62,709.5	30,813.6	94,979	345,915.7	73,910.1
	Allocation to Gunung Tua factory	297,448	128,317.9	429,622.1	155,702	67,047.6	224,997.1	654,619.2	195,365.5

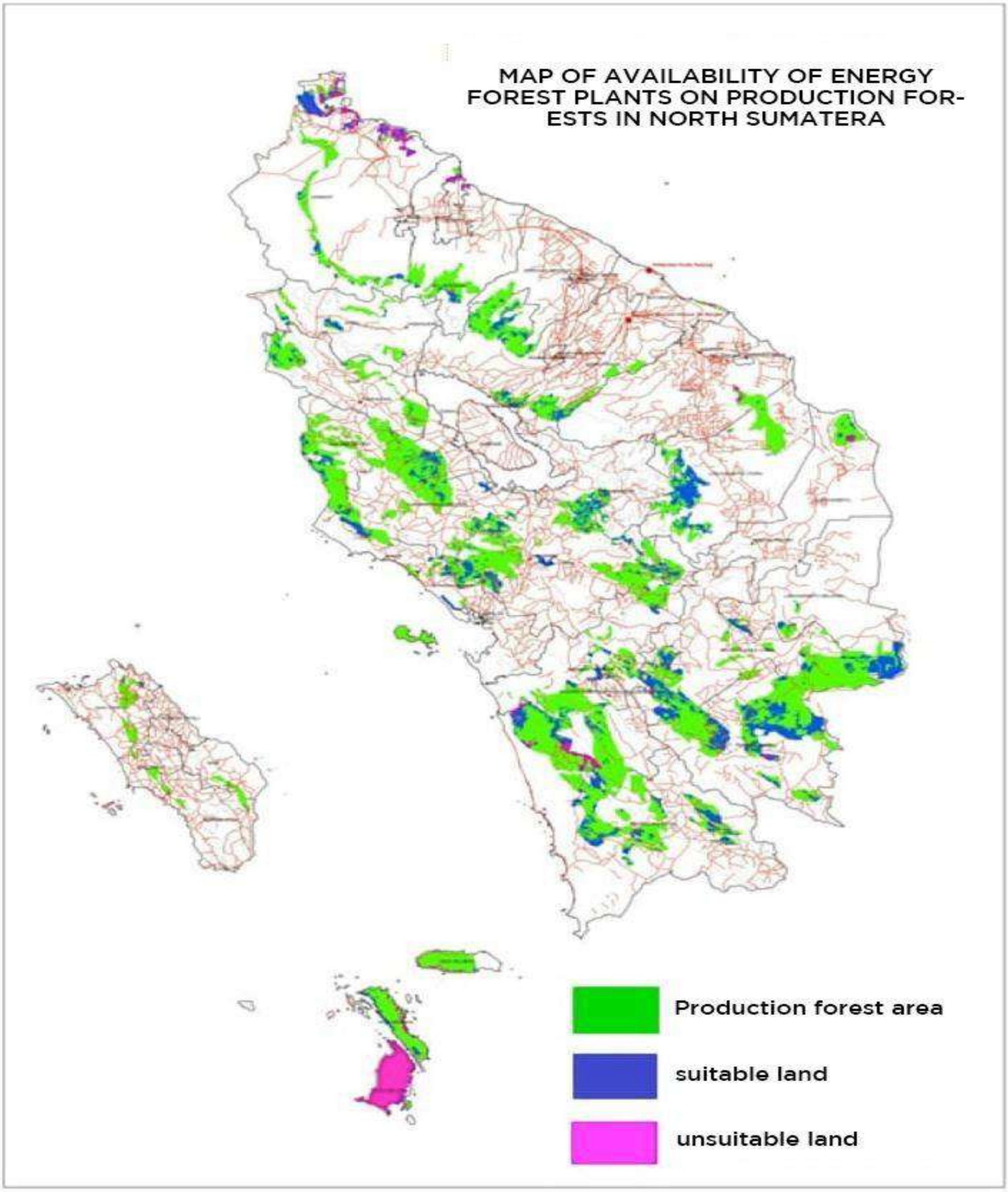


Figure 13. Availability of Land suitable for the Development of Plantation Energy Forest

5.3.4 Sei Mangkei SEZ

Wood raw materials for wood pellet mills in Sei Mangkei SEZ will be supplied from three KPHs, namely KPH Region II Pematang Siantar covering an area of 34,323.4 ha, Region III KPH in the range of 11,955.1 ha and North Labuhanbatu KPH covering an area of 27,631.6 ha. Thus, the potential area suitable for energy crops is 73,910.1 ha. If the energy crop cycle is set for 10 years, then every year an area of 7,391 ha can be planted.

Biomass production for each type of wood is as follows:

a. Kaliandra: (30-54 Tons/ha/year) x 7,391 ha = 221,730 - 332,595 Tons/year
b. Lamtoro: (12-36 Tons/ha/year) x 7,391 ha = 88,692 - 266,076 Tons/year
c. Gamal: 23 Tons/ha/year x 7,391 ha = 169,993 Tons/year

Gunung Tua

The wood raw material for the wood pellet factory in Gunung Tua, will be supplied from three KPHs, namely KPH Region VI Sipirok covering 45,061.4 ha, KPH Region VII Gunung Tua, covering 137,885 ha, and KPH Region X Padang Sidempuan, covering 12,419.1 ha. Thus, the potential area suitable for energy crops is 195,365 ha. If the energy crop cycles for 10 years, then every year it can be planted covering an area of 19,536 ha.

Biomass production for each type of wood is as follows:

a. Kaliandra: (30-54 Tons/ha/year) x 19,536 ha = 586,080 - 879,120 Tons/year
b. Lamtoro: (12-36 Tons/ha/year) x 19,536 ha = 234,432 - 703,296 Tons/year
c. Gamal: 23 Tons/ha/year x 19,536 ha = 449,328 Tons/year

5.3.5 Energy forest development strategies

The potential supply of raw materials for wood pellets in North Sumatra is very high, both for factories in the SEI Mangkei SEZ and in Gunung Tua, as described in points 5.3.3 and 5.3.4 above. However, the agricultural activities of the community around and within the forest area are also very high, especially in the production forest area. In some areas, some production forest areas, especially in areas with good accessibility have been 'controlled' by community members by planting oil palm. So it is not easy to get areas that are completely empty and ready to be planted with energy trees.

The concept of partnership with the community was developed to guarantee supply. In this case optimal land use such as agroforestry systems is recommended especially at the beginning of land clearing and/or planting energy wood as firebreaks, garden boundaries or between plantation crops. For example planting gamal between coffee plants as shade.

Alternative Raw Material Sources

Utilization of agricultural waste as raw material for wood pellets, is one of the strategies in ensuring the procurement of sustainable raw materials, and in sufficient quantities. Alternative sources of raw materials for biomass energy can be obtained from agricultural processing waste in the form of palm shells, rice husks, coconut shells, and sugarcane bagasse. North Sumatra has the potential to produce around 11 Million Tons of fresh fruit bunches (FFB). From the processing of crude palm oil (CPO), it produces waste in the form of empty bunches of 2.6 Million Tons, fiber of 1.3 Million Tons, and shells of 701,000 Tons. Furthermore, if this waste is treated there is an energy potential of 3,599,078 kcal (empty bunches), 3,599,078 kcal (fiber), and 2,769,420 kcal (shells).

Biomass energy sources from alternative raw materials by district in North Sumatra are listed in Table 15.

Table 15. Alternative biomass energy sources by regency in North Sumatra

No.	Regency	Rice Husk		Coconut Shell		Palm Shells		Sugarcane Bagasse	
		A (ha)	B (Ton)	A (ha)	B (Ton)	A (ha)	B (Ton)	A (ha)	B (Ton)
1.	D. Serdang	153.609	714.661	4.355	3.695	33.856	486.195	849	144.409
2.	Karo	20.966	13.194	-	-	-	-	-	-
3.	Simalungun	22,844	9.989	-	-	11.041	19.312	-	-
4.	P. Bharat	5.213	31.755	77	159	1.304	5.216	-	-
5.	Asahan	71.099	65.356	44.649	5.089	85.440	70.422	-	-
6.	T. Balai	253	1.062	3.233	2.743	-	-	-	-
7.	L. Batu	73.157	47.693	342	287.418	178.750	69.468	-	-
8.	Tapsel	103.961	89.761	5.875	253	5.817	2.303	-	-
9.	Taput	65,649	74.817	-	-	-	-	-	-
10.	Humbahas	19.247	87.634	182	88	376	1.220	-	-
11.	Langkat	58.788	61.717	6.242	4.729	1.145	382	-	96,000
	Total	594.856	1.135.983	64.955	304.174	317.736	654.518	849	240,409

Notes: A = Plant Area (ha), B = Production (Ton/year)

Based on Table 15, alternative raw material needs at the factory in Sei Mangkei have the potential to be supplied from Simalungun and Asahan, in the form of 89,734 Tons/year of palm shells, about 75,345 Tons/year of rice husks, and 5,089 Tons/year of coconut shells. Whereas the most potential agricultural waste for factories in Gunung Tua is coconut shells, which is around 287,671 Tons/year, followed by rice husks (137,454 Tons/year), and palm shells (71,771 Tons/year), which are supplied from Labuhan Batu area and South Tapanuli areas.

Cooperation

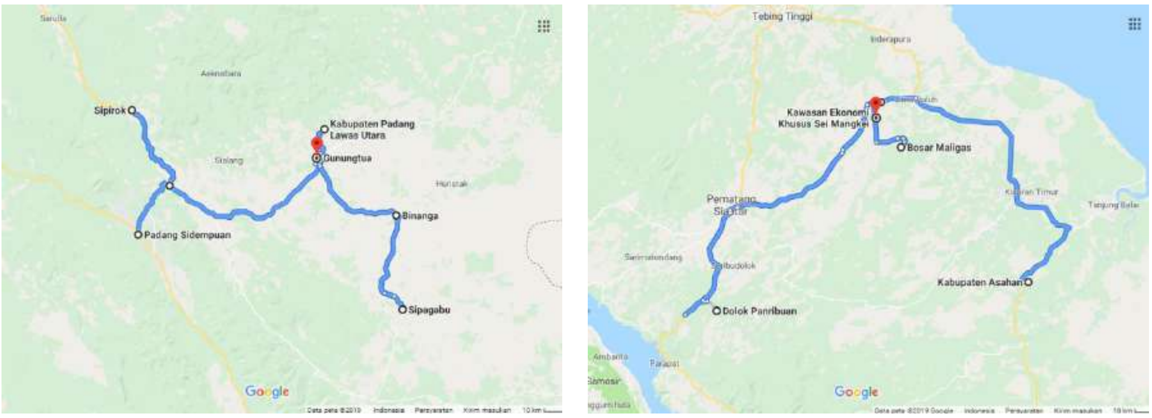
Another strategy that can be applied to maintain a sustainable supply of raw materials, is establishing cooperation with the communities around the factory. This collaboration can be carried out upstream, in the form of planting, or downstream in the form of wood chip processing. Communities plant energy crops on their land, where seeds and assistance are provided by the factory, then the wood (logs or shale) is bought by the factory at an agreed price. Community involvement in the wood pellet business is accommodated by official institutions that are accountable and transparent, such as Non-Governmental Organizations (NGOs), cooperatives, or Regional Government Owned Enterprises (BUMD).

5.3.6 Raw material delivery process

The wood pellet processing plant will be built in a radius of 50 - 80 km from the source of raw materials. Some of the production forest areas identified can be a source of raw material supply, including the Simalungun KPH and the Asahan KPH for industries in the Sei Mangke SEZ and the Padang Lawas Utara KPH, Binanga in Padanglawas, and the Sidempuan and Sipirok KPH in South Tapanuli for the industry at Gunung Tua. Delivery can be done using medium trucks with a capacity of 7 - 25 Tons. The route from the forest area to each industrial location is shown in Figure 14. The distance and length of travel to the wood pellet processing industry to be built are shown in Table 16.

Table 16.Hauling distance and and duration to the wood pellet plant site

No.	Industry Location	Raw Material Supply	Distance (km)	Time
1.	KEK Sei Mangke	Dolok Panribuan	81.2	2 hrs 10 min
		Bosar Maligas	18.8	43 min
		Asahan	82.5	2 hrs
2.	Gunungtua	Padang sidempuan	62.8	1 hr 43 min
		Sipirok	70.3	1 hr 52 min
3.	Binanga (Padanglawas)		25,8	46 min
4.	Padang lawas utara		11,9	25 min



(a) (b)

Figure 14. Route of Delivery of Raw Materials from Forest Areas to Industry. (a) Industrial location in Sei Mangke (left). (b) Industrial Location in Gunung Tua (right)

The road network in North Sumatra (Figure 15) is generally of good quality, so it will facilitate the process of sending raw materials from the forest area to the factory site. Since 2013 until 2017 the road conditions are very good, with the division of the region namely the East Coast Region, West Coast Region, Highlands Region, and the Nias Islands Region has improved, with the largest high-quality road conditions in the East Coast Region around 88.03 percent and lowest in the West Coast Region at 79.65 percent. The length of the provincial road network with good road conditions every year has seen improvement from 2013 with a road length of 69.60 km up to 2017 reaching 84.31 km.

Adequate transportation facilities greatly affect the smooth transportation of raw materials, and reduce production costs. Based on the data in Table 16 above, the longest distance from the raw material location is 82.5 km. If the price of wood in the forest is Rp

300,000/Ton, the average transportation cost is Rp 100,000/Ton, then the estimated price of wood in the factory is Rp. 400,000/ton (air-dried).

Figure 15. Map of the National Road Network in North Sumatra

5.4 Analysis of Technical and Operational Aspects

The purpose of this analysis is to examine and determine whether technically and technologically the choice of a wood pellet development plan can be carried out properly or improperly, both at the time of project development and routine operations. On the other hand, on a locational basis, this analysis must also pay attention to and refer to the spatial patterns established in the RTRW / RDTR and the results of the primary survey.

The analysis will include the determination of production strategies and production planning, the process of selecting technology for production, determining the optimal production capacity, location and layout of wood pellets, operational plans in terms of production quantities, plans to control raw material inventories, and product quality control. The technical aspect is an aspect relating to the project development process technically and its operation after the project is completed. Based on this analysis also can be known the initial design of investment cost estimation including the exploitation costs.

5.4.1 Development of technology and quality of wood pellets produced

In the 1970s, the energy crisis had spurred efforts to find a replacement for fossil fuels. Wood pellet from forest biomass is one of the main choices to replace fossil fuels. The wood pellet machine was originally used to make animal feed pellets. Technological developments, this tool can process wood raw materials with high hardness and density. In the late 1970s, the first wood pellet mill was built in Sweden. At that time the quality of wood pellets produced was still low, with ash content ranging from 2.5% to 17%.

The first wood pellet patent was registered in 1976 in the United States. At that time, wood pellets were made of bark and sawdust, and were first used for small scale local applications. Until the 1980s, world interest in producing wood pellets was still low, despite the huge source of wood processing residues. In North America, the wood pellet fuel industry began in the 1980s, with the adoption of wood pellet stoves for housing. The pellet stove provides a new and convenient way to warm up in housing in the winter. The consumption of wood pellet stoves increased rapidly in the 1990s and peaked in 1994, then increased with the advent of gas stoves.

In 1984, a new wood pellet mill was established in Vargada, Sweden, and in 1987, the Volvo Group pellet mill, made from the first dry wood, was built with a production capacity of 3,000 Tons/year. This commercial wood pellet mill has the longest history in Sweden, which is still used today.

The quality of wood pellets produced is increasingly high, in line with consumer demands, especially those relating to environmental safety. Since the Austrian standard (ÖNORM M1735) was published in 1990, several EU members have developed their own national pellet standards, such as DINplus (Germany), NF (France), Gold Pellets (Italy), etc. As the world's largest pellet market, the European Commission has set the EU standard (CEN TC335-EN 14961) for solid fuels, which is based on Austrian standards (ÖNORM M1735). While in Indonesia, it refers to the Indonesian National Standard (SNI) number 8021-2014.

5.4.2 Production capacity

Based on the results of the analysis described in section 5.3.4 above, the recommended wood pellet mill capacity based on the effective area that can be provided is 5,000 Tons per month or an engine capacity of 10 Tons per hour (21 hours per day; 25 days per month). In the initial stages, the construction of the wood pellet factory could be run with a capacity of 2,000 Tons per month and the engine capacity was 5 Tons per hour. Raw material requirements for the initial stage are 3,140 Tons/month (37,680 Tons/year). In the next stage, the factory's capacity can be increased to 5,000 Tons per month so that raw material needs reach 7,850 Tons/month. This can be achieved if the area of energy plantations increases, and public confidence in the energy wood business increases.

5.4.3 Production processes and machines used

Wood pellet production process is a stage that can consume more energy when compared to the stages of land transportation and sea transportation. The wood pellet production include 3 main stages namely, drying, grinding (grinding), and densification (pelleting). The process or stage of wood pellet production which has the largest energy consumption is the drying stage. At this stage heat energy is needed for drying raw materials.

In Indonesia, wood pellet factories generally use boilers with diesel fuel for drying. The greatest energy requirements compared to other stages, making this process also requires the highest operational costs compared to other processes. More attention to the drying process needs to be given related to energy needs. The wood pellet factory should have been integrated with the wood pellet powered power plant itself. This needs to be done, because in power plants 75% of the energy from biomass will be converted to heat energy, the remaining 25% will be electrical energy.

In general, the wood pellet production process is presented in Figure 16.

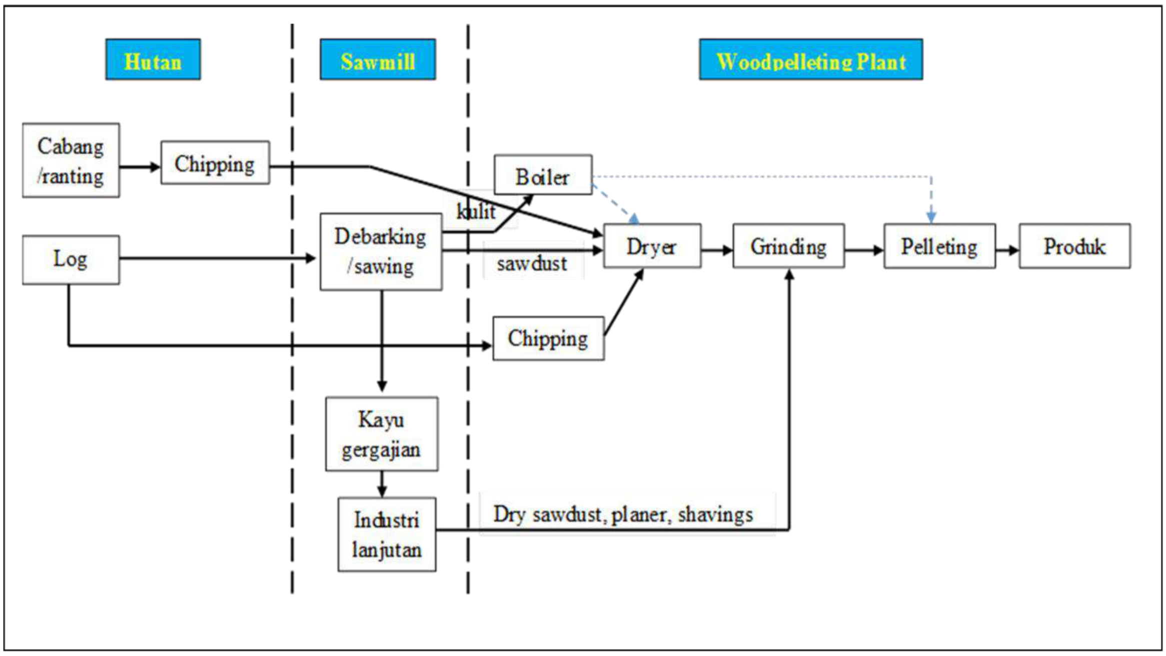


Figure 16. Wood pellet production process

Chipping

The initial stage of the wood pellet production process is to convert logs or logs into chips measuring 1-2 cm, using a wood chipper machine (Figure 17), this is done to obtain the size that is desired in the processing process. Chippers can be placed at a woodpellet factory site, or at a location close to sources of raw materials. Placing chipper in a location close to raw materials (forests) will reduce the cost of transportation of raw materials from the forest to woodpellet mills, because the raw materials transported become denser and relatively drier.

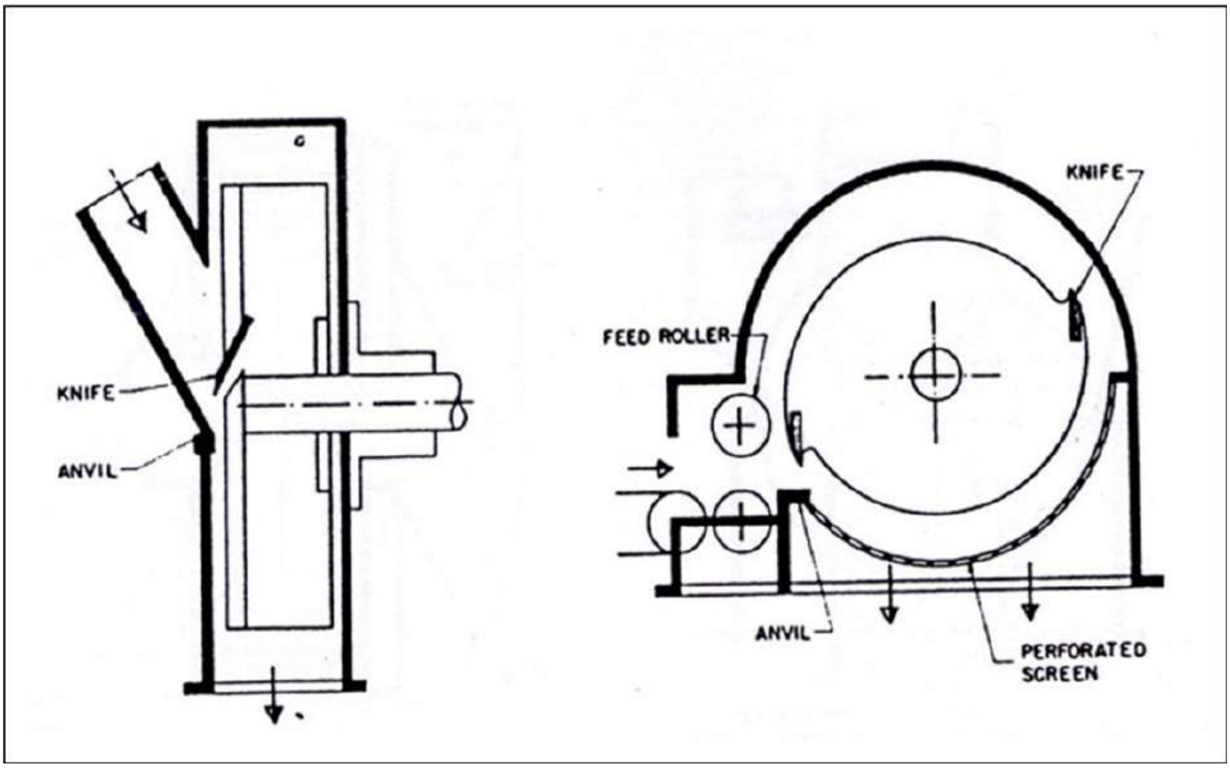


Figure 17. Schematic of the wood-chipper drum

Drying

There are two mechanisms for the presence of water in wood (wood cells): as free water in the cell cavity (lumen) and water bound in cell walls (cellwalls). What is meant by free water is water that is contained in a cell cavity, where this water is easily in and out. While bound water is water that is contained in cell walls, where the water is rather slow in and out.

The variables that influence the wood drying process are: initial water content, dryer temperature, heat carrier media, air circulation, air temperature, air humidity, dryer (machine), drying technique and duration of the drying. The wood drying process will run faster if the temperature is higher, the humidity is lower and the speed of air circulation around the wood surface is faster.

Lighter wood generally dries faster than heavier wood, because porosity of lighter wood is higher than heavier wood. Timber harvested directly from forests usually has a high moisture content, especially if harvested during the rainy season. Chip material with high water content will require high energy when crushing / hammer milling is carried out, compared to dry chips. Therefore, it is necessary to dry the chips, up to a maximum moisture content of 12%.

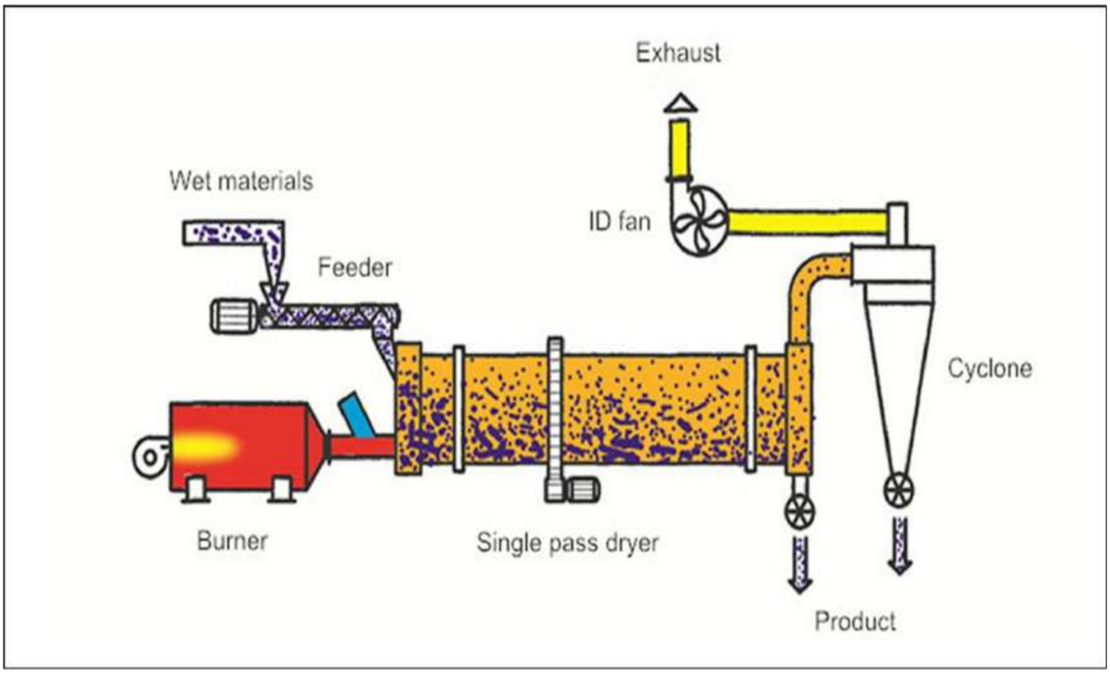


Figure 18. Schematic of the chips drying machine

Screening

Screening is carried out on raw materials to avoid the entry of hazardous materials and can damage equipment, such as metals, stones, plastics, and so on. An example of a screening tool is in Figure 19.

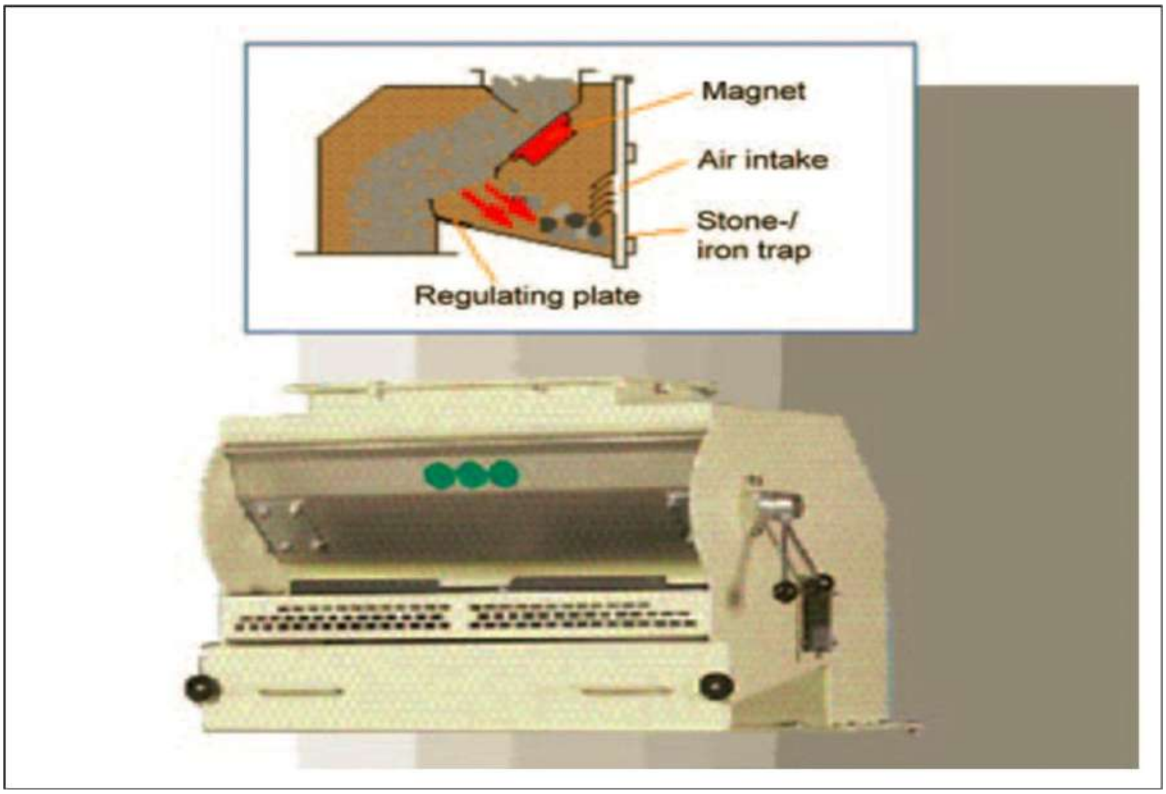


Figure 19. Screener

Hammer-milling/Crushing

Wood that has been processed in a chipper machine, dried, and filtered, is then crushed using a crusher (Figure 20), in order to obtain the desired powder size.

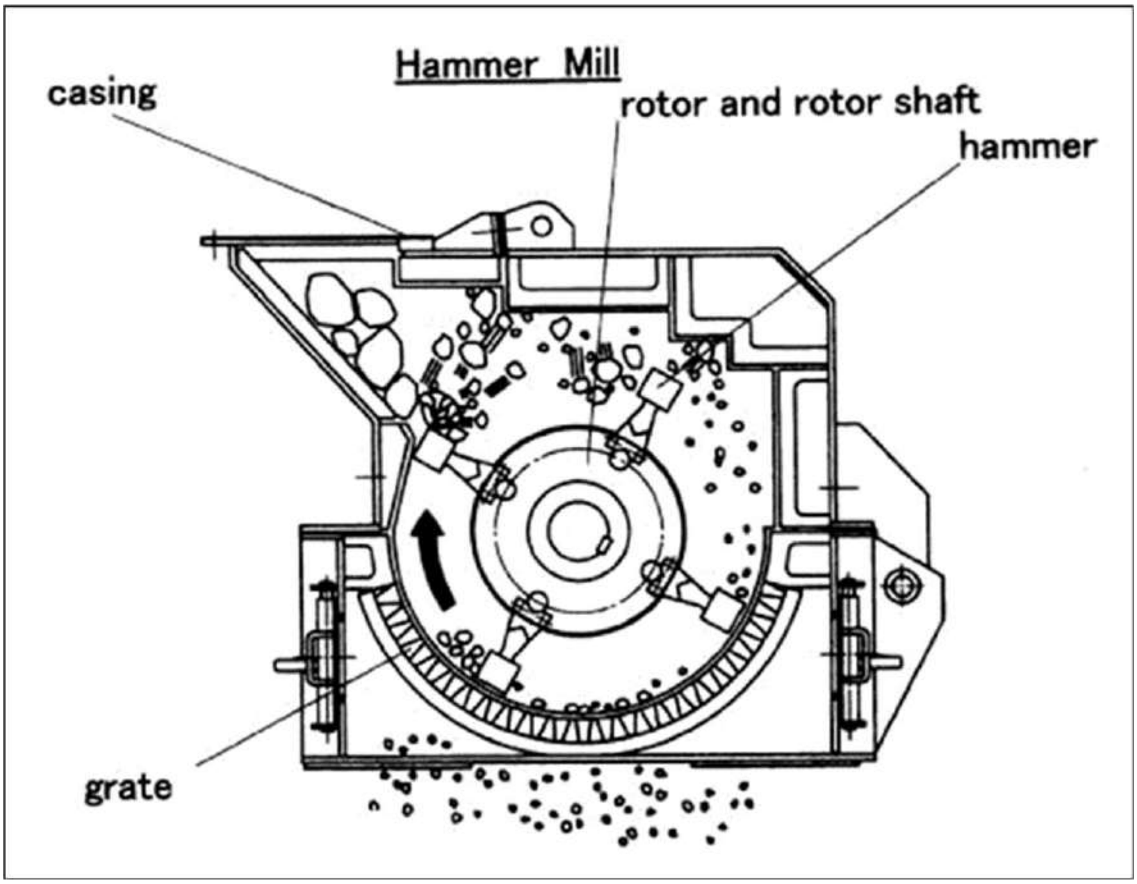


Figure 20. Wood crusher

Crushing process is carried out to uniform the size of sawdust into a certain size to be processed on a pellet machine. Mixing sawdust with additional ingredients, such as adhesives and other materials, is also carried out at this stage in the machine.

Pellet pressing

The quality and quantity of wood pellet products is mainly determined by the pelletizer tool. The quality of this tool itself is determined by the ability of wood pellet production according to specifications or international standards. The more wood pellet products produced or the longer life (life span) of the pelletizer, it indicates a good quality tool. The working principle of the pelletizer is the compression or pressing of the raw material by the roller into the mold (die) to form a wood pellet. High friction or friction on the roller & die against raw materials causes the temperature to heat so that the metal wears out quickly. The greater the friction, the wood pellet product is denser or harder but the metal material on the pelletizer also wears out faster. The quality of the metal as a die and roller material, as well as the design of the tool have a major role in the performance and life of the pelletizer.

Some ingredients commonly used in pelletizers include**:**

a. Carbon steel alloy: strongest die, cheap price but not corrosion resistant, rough die surface so that friction and compression is greater so that the resulting wood pellet is harder.
b. Stainless steel alloy: more corrosion resistant but more expensive, because the surface of the die is smoother, it takes a longer depth of die to produce hard wood pellets.
c. High chrome alloy: highest corrosion resistance, easier start up, because the die is smoother so the die depth is longer for hard wood pellet results, the most expensive price.
d. Optimization of the performance of the pelletiser: carpet is a thin layer of pressed material, which tastes at the top of the die surface. When the raw material enters the pelletizer it will be pushed by a roller and form a carpet. The more material put into the pelletizer the more carpet will be added. This carpet is then pressed into the die hole and produces pellets. So for material that can form a pellet, initially it should be able to form a carpet.

Setting between the roller and die with a certain distance which is commonly called a roller gap is important to produce the desired pellet quality. Characteristics of raw materials in the form of density and adhesion ability are other parameters that need to be considered. Roller gap can be set at a certain distance so that the performance of the pelletizer will be optimal, as shown in Figure 21. Generally a 1 mm gap is the optimum condition, but gap variations can be tried for the specific conditions of certain raw materials.

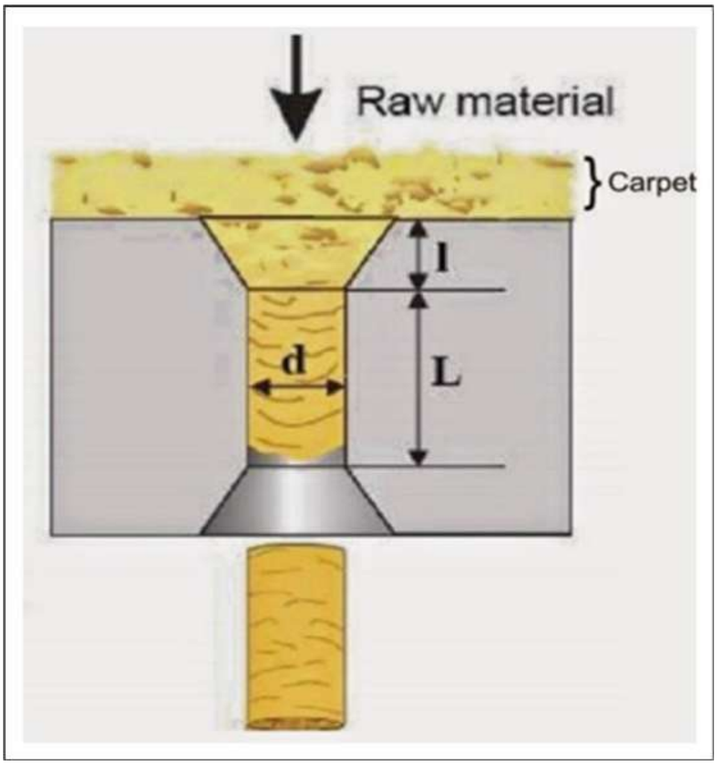


Figure 21. Roller gap

Most press machines require pre-heated sawdust to a temperature of around 120-130˚C. This process is carried out using dry steam, when the raw material is fed into the press.

There are two types of pellet press machines, namely flat die pellet mill and ring die pellet mill. Flat die pellet mill is usually used in factories with a maximum capacity of 500 kg / hour, while for large capacities a ring die pellet mill is usually used, as can be seen in Figure 22. below.

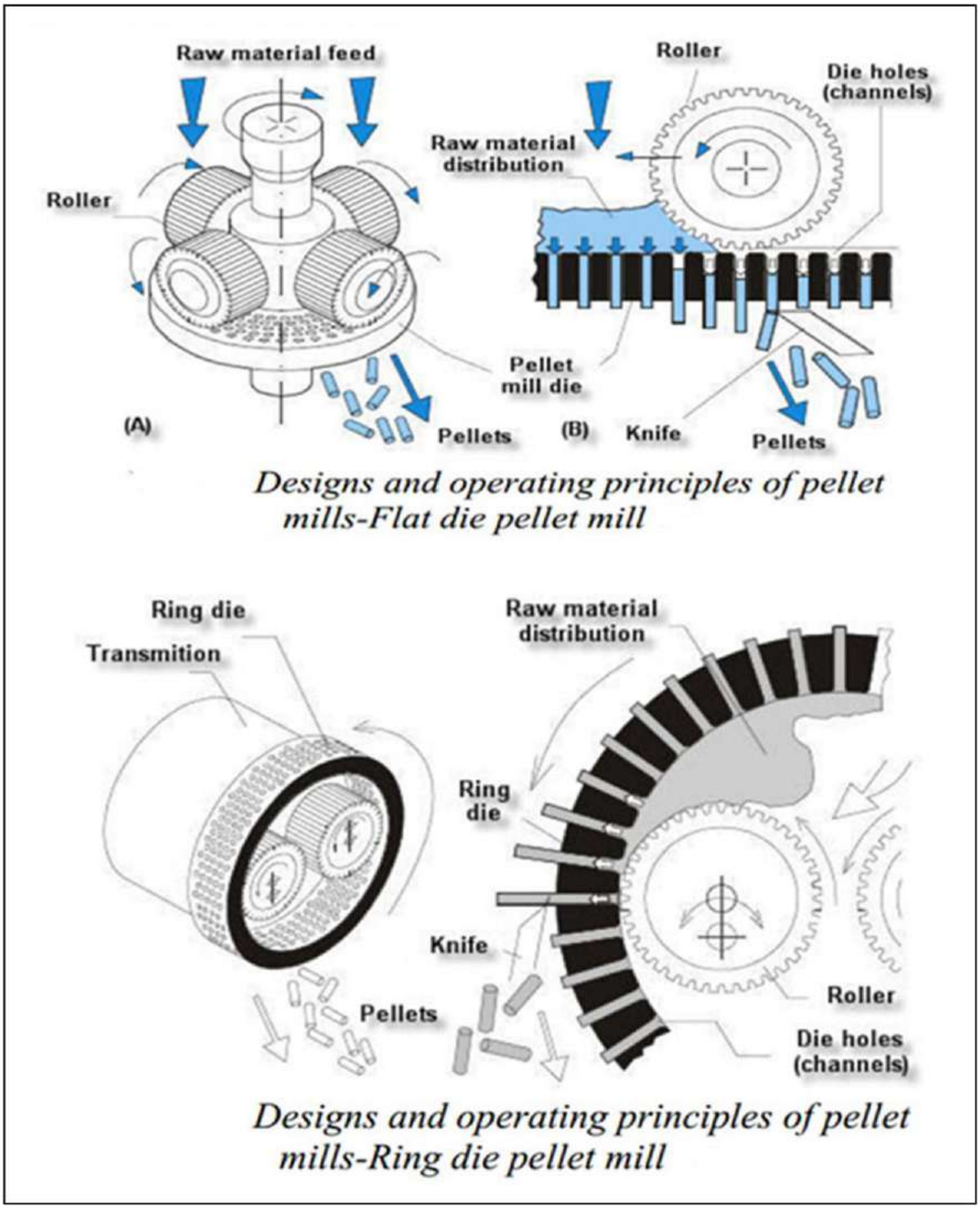


Figure 22. Wood pellet press machine

Flat die pellet mills are high operational costs (fast wear tools and more maintenance), and the price of tools is relatively cheap. While Ring dies are usually low operational costs, tools do not wear out quickly, have little maintenance, are widely used for the production of medium to large capacity wood pellets (>500 kg/hour), and the price of tools is more expensive.

Furthermore, important factors affecting the quality of the pellets produced are the wood dust moisture content and die temperature. Too high or too low water content in the wood pelleting process will cause the process to fail. To get good quality pellets, the moisture content of sawdust is around 12% and the average temperature of the die is 125 ^{o}C. Canada requires maintaining a temperature of 85 ^{o}C for a minimum die temperature. The higher the temperature the better the quality of the pellet. The acceptable wood pellet mill efficiency is 130 - 200 kWh/Ton, without drying system.

If the water content is too high (too wet) it will cause very high pressure (compression) on the die. This makes the temperature increase and produce steam in large quantities. High pressure will make the motor work too heavy and also potentially make the die clogged (blocked). This condition also affects the bearings on the roller. The resulting pellet will also be soft, easily broken, and clogged. Even though the compression is high but adequate temperature makes lignin out as an adhesive is not reached. Due to the high water content, the pellets will expand and emit water vapor, as a result the pellet surface is not smooth and cylindrical in shape as it should be.

When raw materials are too dry; because wood raw material has low density and lack of moisture content (too dry), the roller is not able to do adequate compression in the die. The lack of pressure also results in a lack of heat and lignin is unable to come out as an adhesive on the pellet. Because the raw material cannot produce enough friction and pressure, the material will slide freely inside the die and consequently the pellet is not formed. Pellets are not formed when using raw materials that are too dry.

Cooling

When the wood pellet comes out of the pelletizer, the temperature is very hot, soft and gives off steam. Before the pellet can be stored and used, the conditions must be cool and dry. The easiest way to cool wood pellets is to lay them out in a room so they cool themselves at room temperature.

Counter flow cooler (Figure 23) is a type of wood pellet cooler that is common in the industry today with directional cooling air and wood pellet products in the opposite direction. Gradual cooling will improve quality, reduce cracks on the surface and "fine". Wood pellets come out of the cooler with a moisture content of about 8% with temperatures ranging from + 5-10^{o}C from room temperature. Almost all coolers are equipped with screens to filter out "fine / powder" from wood pellets. "Fine/Powder" is then returned to the pelletizer to be used as raw material again.

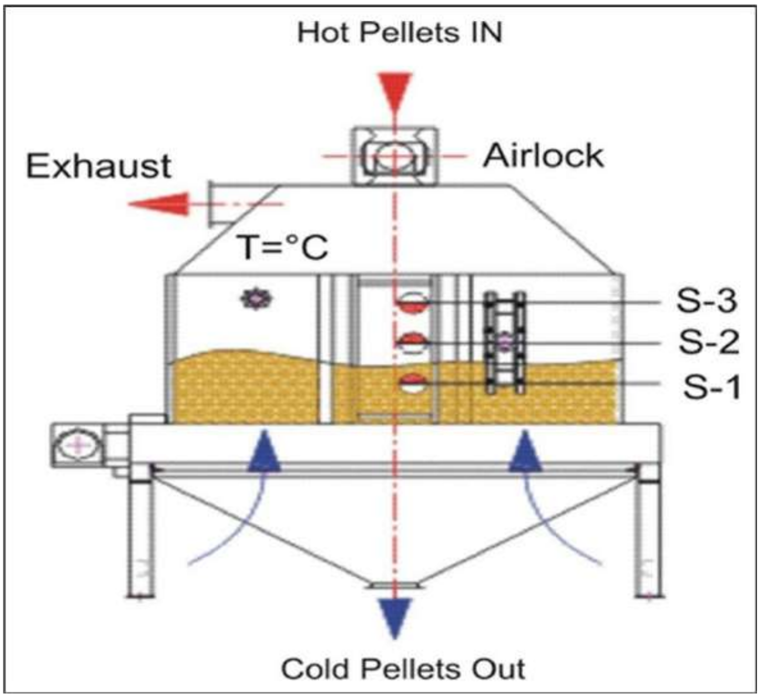


Figure 23. Counter flow cooler

Packaging

Before packaging, the pellet should be filtered first, to separate crushed or fine pellets. Crushed pellets are returned to the pelletizer machine, or as boiler / dryer fuel. If the soft pellets are not too damaged, they can be sold to the local market.

It is recommended to pack wood pellets with large sizes, so that if you do not use a packing machine, for example, directly from the cooler, it is not a problem, because the amount is small. Jumbo bag packaging with a capacity of 1 ton or 500 kg can be applied (Figure 24). Generally, small capacity wood pellet mills in Indonesia are packaged directly from the cooler.

Figure 24. Wood pellet packaging

Layout

Factory Layout is defined as the layout / arrangement of facilities, machinery and plant equipment owned by the company. The purpose of layout planning is to get the most optimal layout of production facilities available within the company. With this optimal layout arrangement, it is expected that the implementation of the production process can run efficiently and smoothly.

Wood pellet making machines are arranged in Product Layout or Line Layout patterns (Figure 25). In this type of layout machines and plant equipment are arranged according to the order in which the production process is required.

Some of the advantages of Product Layout are**:**

a. Machine facilities can be operated quickly
b. Determination of routing and scheduling is easy
c. Ingredients are quickly processed
d. Does not require many employees because the facilities are automatic

The weaknesses of the Product Layout are as follows:

a. One facility depends on other facilities so that the damage to one machine can stop the entire production process.
b. If the facility you want to add needs a series of other facilities so that investment is expensive
c. Requires careful process planning and careful process monitoring.

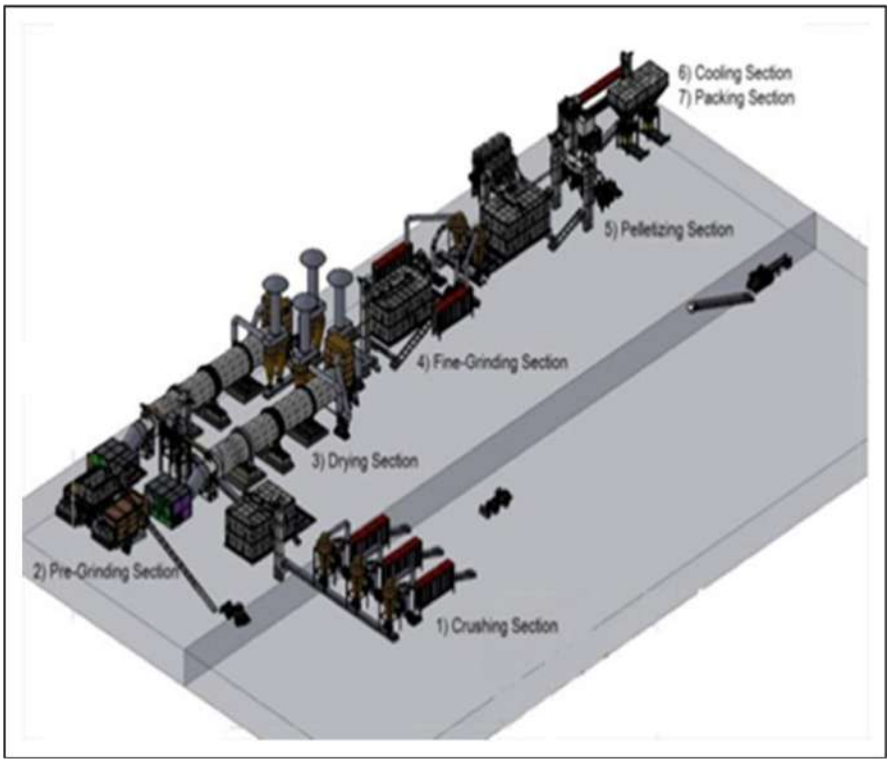


Figure 25. Lay out of Wood Pellet Mill Capacity of 10 Tons/hour (Yulong, 2019)

5.5 Analysis of Human Resource (HR) Aspect

This HR aspect analysis also includes an analysis of labor resources that aims to find out whether in the construction and implementation of wood pellet operations is estimated to be feasible or not seen from the availability of labor.

The number of HR personnel needed to manage this business is described in Table 17.

Table 17. Number of personnel involved

No.	Position Detail	Total (person)
1.	Director	1
2.	Factory Manager	1
3.	Sales & Marketing	1
4.	**Factory Plant Operation**	
	- Raw Material Staff	3
	- Quality Control Staff	2
	- Maintenance Staff	2
	- Production Staff	10
5.	**Accounting and Finance**	
	- Cashier	1
	- Purchasing	1
	- Cost Accounting	1
6.	**Administration & HRD**	
	- Payroll administation staff	1
	- Recepsionist	1
	- Janitor	1
	- Office Boy	1
	- Driver	1
	- Security	4
Grand Total		**32**

Job description and qualifications

Job description describes the duties and responsibilities of each section according to the hierarchy of the organizational structure formed. To hold certain positions also requires qualifications from the management personnel so that the capabilities of the management personnel involved are known. Job descriptions and qualifications of each section can be described as follows**:**

HR planning

So that the implementation of this wood pellet mill can run smoothly, we need human resources who understand this business, have high qualifications, are reliable and of high quality especially for key positions. For this reason, there are a number of things to consider in HR planning, namely:

a. Labor Selection (Recruitment Process)

The human resources (HR) who will be involved in this business plan will be obtained by recruiting experienced people, especially for key people at every level of their position. The recruitment and procurement of this workforce will be carried out in stages as needed. In addition, in order to assist government programs in reducing unemployment, the selection of human resources will be prioritized by the surrounding community first.

b. Training

Training is very important in a company, especially to run a new business where in the company there are very few competent people. Training is a company need in order to:

1) Increase the ability of competition.
2) Increase efficiency.
3) Increase productivity.

Training that will be provided to workers is as follows:

1) Training/production process training.
2) Training regarding the operation and maintenance of the system.
3) Training on services to customers (customer services).
4) Training on financial and human resource management.

HR development is carried out to improve the company's HR capabilities to be able to cope with any changes that occur due to the rapid development of technology and information. HR development can be done by providing career paths and education or further training.

5.6 Analysis of Financial Aspect

The analysis is divided into several sections. First is the assumptions section, which is a number of assumptions used in the calculation of financial feasibility indicators. These assumptions are built based on data and practices that have occurred to approach the real situation. Next, the financial feasibility indicator analysis section presents the results of the calculation of several feasibility indicators for a project plan, followed by a sensitivity analysis section. In the sensitivity analysis, several important variables are assumed to change and how they affect the feasibility of the project. Finally, the investment needs section presents the needs and allocation of funds.

5.6.1 Assumptions

Some of the assumptions used in financial analysis are as follows**:**

1. The conversion factor from raw materials to pellets is 99%,
2. The life span of machines and buildings is 10 years. In reality, it is possible that the machine can still be used after 10 years or still have a salvage value, but in this calculation, the salvage value of the machine is considered zero. The lifetime of this machine will be used as a time horizon of analysis,
3. Production capacity is 10 Tons per hour with an average utilization rate of 100%. This is done to facilitate the calculation. As for the possibility of engine usage below its maximum capacity will be captured in the sensitivity analysis,
4. Working time is 7 (seven) hours per shift, 3 (three) shifts per day, 25 days per month, and 12 months per year,
5. The price of raw materials on the spot is assumed to be constant at Rp 600,000 per Ton throughout the life of the project,
6. The price of pellets at the factory is assumed to be constant at Rp 1,500,000 per ton for the factory in Sei Mangkei and Rp 1,450,000 per Ton for the factory in Gunung Tua throughout the life of the project. This figure was obtained from data from interviews with business operators in other locations. The difference is due to the consideration of the shorter hauling distance from Sei Mangkei to the port, so that buyers are willing to pay a higher price,
7. The price of pellet making machine is Rp 22,810,900,000,
8. The real interest rate is 7.50% per year. This is based on the general interest rates on loans reduced by the inflation rate.

Since all prices, both input and output prices, are assumed to be constant at 2019 prices throughout the life of the project, the relative prices of all types of goods and services involved in this project are fixed. Thus, the prices used are basically real prices that are free of inflation.

5.6.2 Procedure

Net Present Value (NPV) is the difference between the current investment value and future net cash receipts. NPV can be obtained by the formula:

$$\boldsymbol{NPV} = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t}$$

explanation:

B_t **:** benefits gained in year t
C_t **:** costs incurred in year t
I **:** applicable interest rates (discounts)
n **:** the economic life of the project
Q **:** Current project year

If a project has an NPV value> 0, then the project is considered profitable to run.

Internal Rate of Return (IRR) is an indicator of the level of efficiency of an investment. A project/investment can be done if the rate of return (rate of return) is greater than the rate of return if investing elsewhere. IRR is calculated according to the formula:

$$\boldsymbol{IRR} = i_1 + \frac{NPV_1}{NPV_1 - NPV_2}\,(i_2 - i_1)$$

explanation:

i_1 : Interest rates that cause a positive NPV
i_2 : Interest rates that cause negative NPV
NPV_1 : NPV (+)
NPV_2 : NPV (-)

Benefit Cost Ratio (BCR) is the result of a comparison between the revenue to be obtained, and expenses in the company's time period, taking into account the applicable interest rate. BCR can be obtained using the following formula:

$$BCR = \frac{\sum_{t=0}^{n} \frac{B_t}{(1-i)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1+i)^t}}$$

explanation:

B_t **:** profit in year t
C_t **:** costs incurred in year t
i **:** interest rate (discount)
n **:** the economic life of the project
Q **:** Current project year

If the BCR value is ≥ 1, then a project can be profitable and implemented.

Payback period is the time period of return of investment that has been issued through profits obtained from a project that has been made.

Return period formula if cash flow per year amounts are different**:**

$$\text{Payback period} = \frac{n + (a - b)}{(c - b)} \times 1 \text{ year}$$

explanation:

n = The last year where the amount of cash flow still could not cover the initial investment.
a = Initial investment amount.
b = cumulative amount of cash flows in n^{th} year
c = cumulative amount of cash flows in n + 1 year

The return period formula if cash flows per year is the same amount**:**

$$\text{Payback period} = \frac{\text{(initial investment)}}{\text{(cash flow)}} \times 1 \text{ year}$$

Sensitivity analysis is carried out to determine the effects that mey occur when there are changes in conditions, such as a decrease in selling prices, and an increase in production costs/raw materials. Sensitivity analysis is done by calculating the IRR, NPV, B/C ratio, and payback period for several possible change scenarios.

5.6.3 Analysis of Financial Feasibility Indicators

If all of the above assumptions are fulfilled, the construction of the pellet plant at both sites is financially feasible. NPV with a real discount rate of 7.50% is IDR 81,684.2 Million. The IRR and BC-ratio values are 32.78% and 1.21, respectively (Table 18). Thus, this project is feasible to run with a 2.9 year payback period.

Table 18. Indicators of Financial Feasibility of the Pellet Mill

Indicator	Unit	Sei Mangkei	GunungTua
NPV	Million IDR	81,684.2	60,863.00
IRR	%	32.78	26.68
BCR	-	1.21	1.17
Payback period	Year	2.90	3.4

Although not as good as the planned plant in Sei Mangkei, the construction of a pellet plant in Gunung Tua is also still financially feasible. With a real discount rate of 7.50%, the financial indicators are as follows: NPV IDR 60,863.0 Million, IRR 26.68%, and BCR 1.17%. The payback period is also slightly longer, at 3.4 years (Table 18).

At the feasibility level according to the assumptions made, the COGS (HPP) is Rp 1,081,640 per Ton, with the main component being the raw material cost of Rp 666,057 per Ton pellet, and the electricity cost of Rp 265,015 per Ton pellet. Raw materials need to get more attention because the quality of raw materials, especially water content, is very influential on the effective price of these raw materials. The effect of the increase in water content in the raw material is the same as the effect of the increase in the price of the raw material. In addition, the cost of transporting effective raw materials has also increased. Keep in mind that COGS (HPP) is calculated based on the cost of producing pellets, which only form part of the total cost.

5.6.4 Sensitivity Analysis

IRR and NPV values are more sensitive to changes in pellet prices than to changes in raw material prices. This is of course understandable considering the unit price of pellets is much higher than the unit price of raw materials. Thus, with the same percentage change, the change in nominal value at the pellet price will be greater than the change in the nominal value at the price of raw materials.

Based on experience, the price of pellets in the international market is quite volatile. Pellet price fluctuations are determined one of them by the season in the purchaser's country, considering that pellet purchaser countries generally have four seasons. Pellet prices are generally higher in winter and lower in summer. Another factor that influences the world price of pellets is the price of coal, where if there is a decline in coal prices, the price of wood pellets also goes down.

Another change that deserves attention for later anticipated is the level of engine usage, given the chances of realizing this event are very high. From various experiences from various types of industries, the level of machine utilization below 100% is very common. Some of the main causes of the level of engine usage that is less than the maximum capacity are damage, engine age, and lack of raw materials. The decrease in the number of output purchases may also force management to reduce production by reducing machine working hours, but the production process itself actually does not experience any obstacles. The maximum level of use of the machine referred to in this sensitivity analysis is the non-use of engine capacity caused by factors outside management's control.

Changes in Pellet Prices and Raw Materials

If the price of pellets goes down by 10% together with the price of raw materials which increases by 10%, the establishment of a pellet factory in Sei Mangkei becomes unfeasible; IRR went down to 4.35% and NPV to IDR -8,657.2 Million (Table 19). If only one of the factors changes to 10% in a direction that is less favorable for investment, then the establishment of a pellet mill in Sei Mangkei is still feasible.

Table 19. Sensitivity analysis due to changes in raw material prices and pellet prices in Sei Mangkei

Change Prices on Raw Materials	**Change Pellet Price**				
	(-)10%	(-)5%	0%	+5%	+10%
	IRR				
+10%	4.35	15.06	24.63	33.81	42.94
+5%	9.32	19.38	28.72	37.85	47.02
0%	13.92	23.57	32.78	41.90	51.14
-5%	18.29	27.68	36.82	45.97	55.31
-10%	22.51	31.75	40.86	50.08	59.53
	NPV (mill IDR)				
+10%	-8,657.20	22,618.00	67,799.40	99,118.90	116,560.20
+5%	5,216.80	36,497.70	69,829.70	101,318.50	130,453.80
0%	19,090.80	50,377.40	81,684.20	113,008.30	144,347.50
-5%	32,964.70	64,257.00	95,569.00	126,897.80	158,241.10
-10%	46,838.70	78,136.70	109,453.80	140,787.20	172,134.80

A decline in the price of pellets by 10% coupled with an increase in raw material prices by 5% will make the construction of a pellet plant in Gunung Tua unfeasible. These changes will make the NPV value negative (Rp -13,488.2 Million) and the IRR value smaller (2.50%) than the discount rate used (Table 20). The contributing factor is the longer hauling distance to the product shipping port, thereby increasing transportation costs or reducing the effective price of the pellet.

Table 20. Sensitivity analysis due to changes in raw material prices and pellet prices in Gunung Tua.

Change Prices on Raw Materials	Change Pellet Price				
	(-)10%	(-)5%	(-)10%	+5%	(-)10%
	IRR				
+10%	-3.37	8.50	18.33	27.42	36.26
+5%	2.50	13.16	22.56	31.49	40.30
0%	7.63	17.56	26.68	35.53	46.34
-5%	12.34	21.81	30.76	39.53	48.45
-10%	16.79	25.95	34.80	43.63	52.59
	NPV (mill IDR)				
+10%	-27,358.5	2,859.8	33,100.1	63,359.4	93,635.0
+5%	-13,488.2	16,735.9	46,981.5	77,245.6	107,525.6
0%	382.0	30,612.0	60,863.0	91,131.8	121,416.2
-5%	14,252.2	44,488.2	74,744.4	105,018.1	135,306.8
-10%	28,122.5	58,364.3	88,625.8	118,904.3	149,197.4

Changes in pellet prices and machine utilization rates

The level of machine utilization up to the maximum capacity is very rare. With a new engine, utility levels close to their maximum capacity could be achieved. But it would be wise if the possibility of machine operation below its maximum capacity is calculated as a risk that needs to be managed. Considering the longer haulage to the shipping port that affects the selling price at the factory, the pellet plant in Gunung Tua is more vulnerable to a decrease in the level of machine utilization compared to the pellet plant in Sei Mangkei.

The combination of reducing the price of pellets and decreasing the level of machine utilization needs to be given major attention. A decrease in pellet prices by 10% and a decrease in machine utilization by 5% or conversely a decline in pellet prices by 5% and a decrease in machine utilization by 10% will make investment unfeasible for both locations; IRR values became less than 7.50% and NVP became negative (Table 21). In the case of the Gunung Tua factory, the decline in the level of engine utilization is more than 10% with other factors in accordance with the assumptions, the factory construction is not feasible.

Decreasing the level of use of the machine will extend the payback period with a longer time in line with the low level of use of the engine. As shown in Table 21, the extension of the payback period due to a 5% decrease in tool usage is shorter than the extension of the payback period due to a decrease in the use of 5% tool. For example, in the case of the Sei Mangkei factory when the price of pellets did not change, a decrease in the engine usage rate from 100% to 95% would extend the payback period by 0.8 years, but an increase in the payback period by 1.5 years if the level of machine usage drops from 95% to 90%.

Table 21. Sensitivity due to changes in machine prices and utilities

Pellet Price Change	Sei Mankei Machine Utilization				Gunung Tua Machine Utilization		
	0%	5%	(-)10%		0%	5%	(-)10%
	IRR						
-10%	13.92	4.15	-8.29		7.63	-3.11	-20.66
-5%	23.57	14.42	4.20		17.56	8.16	-3.11
0%	32.78	23.57	13.92		26.68	17.56	7.63
+5%	41.90	32.32	22.64		35.33	26.24	16.62
+10%	51.14	40.99	30.95		46.34	34.65	24.89
	NPV (mill IDR)						
-10%	19,090.8	-9.0	-37.2		382.0	-26.8	-54.0
-5%	50,377.4	20.7	9.0		30,612.0	1.9	-26.8
0%	81,684.2	50.4	19.1		60,863.0	30.6	0.4
+5%	113,008.3	80.1	47.2		91,131.8	59.3	27.6
+10%	144,347.5	109.9	75.4		121,416.2	88.1	54.8
	Payback Period (year)						
-10%	5.2	-	-		6.8	-	-
-5%	3.7	5.2	-		4.5	6.6	-
+0%	2.9	3.7	5.2		3.4	4.5	6.8
+5%	2.3	2.9	3.8		2.7	3.4	4.7
+10%	1.9	2.4	3.0		2.2	2.7	3.6

5.6.5. Needed investment

In order for the project to be realized, funding of Rp 65 Billion is needed. The allocation is Rp 36,267 Billion as capital cost, Rp 26,717 Billion as operational cost, and the reminder as reserves. The biggest capital cost was the purchase of machinery amounting to Rp 22,999 Billion, followed by the building of Rp 9,681 Billion, and heavy equipment of Rp 2,765 Billion. Whereas the biggest component of operational cost is production cost, which reaches Rp 24,648 Billion; the rest is for marketing and general and administrative cost. Table 22 details the main capital cost components**:**

Table 22. Investment Needs for the Development of the Wood Pellet Industry

No.	Component	Investment (Rp)
1	Building	6,234,375,000
	Factory (2500 m^2)	2,493,750,000
	Warehouse (1000 m^2)	952,875,000
	Office (300 m^2)	-
2	Pellet Machine	22,999,462,200
3	Vehicles and Heavy Equipment	2,765,000,000

The main heavy equipment needed is a forklift with a total of 17-18 units at a price of Rp 150,000,000 per unit. The vehicle needed is a Viar Karya 150 RMDT type vehicle with a carrying capacity of 0.39 Tons.

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

1. Government policies, specifically the Minister of Energy and Mineral Resources Regulation No. 50/2017 concerning the utilization of renewable energy sources for the supply of electric power, as well as the Minister of Energy and Mineral Resources No. 55/2019, concerning the amount of principal costs for the provision of power plants of PT. PLN, has not yet sided with private investors engaged in the development of renewable energy. This is indicated by the purchase price of electricity by PLN is still too low and the existence of a scheme of all assets transferred to PLN after the contract ends. Thus, the construction of PLTBm in North Sumatra is still not fully profitable under existing government policies.
2. World demand for wood pellets continues to increase by 13% per year, while production rates are only 11% per year, mainly from European Union countries, followed by Asia and Oceania, and North America. The highest pellet demand rate occurs in Asia and Oceania, which is 40% per year, especially demand for Japan and South Korea.
3. Until now, the domestic wood pellet market is still not encouraging. This is caused by the low selling price. Government policy support, especially those directly related to energy use, is not enough.
4. Based on the distribution of raw materials and the availability of land for industrial development, accessibility to ports and road transportation facilities, as well as other infrastructure support, wood pellet processing plants in North Sumatra should be built in two potential locations, namely (a) in Sei Mangkei Special Economic Zones (SEZ) in Simalungun Regency, and (b) around the town of Gunung Tua in North Padanglawas Regency. Sei Mangke SEZ is considered to be very potential because it has several advantages starting with its location in the plantation area far from the settlement, not far from the Port of Kuala Tanjung and including the existence of sources of raw materials, namely the area of energy plantations in Simalungun Regency and abundant water sources from the river Bah Bolon. While the Gunung Tua plant is planned to accommodate raw materials coming from the southern part of North Sumatra.
5. Some suitable of energy wood species to be planted in critical and suitable land areas as raw material for wood pellets are Kaliandra (*Caliandra callothyrsus*), Gamal (*Gliricidea sepium*), and Lamtoro (*Leucaena leucocephala*). These species

were chosen because they have characteristics; can adapt to various soil and climate conditions; grow fast (high increment) and can compete with reeds; fast growing after prunning; and has a high heating value. Of these three species, Kaliandra is considered more potential due to higher adaptability and greater growth or volume increment (30 - 54 Tons/ha/year).

6. Wood raw materials for wood pellet mills in Sei Mangkei SEZ will be supplied from three KPHs, namely KPH Region II Pematang Siantar, covering an area of 34,323.4 ha, and KPH Region III Kisaran, covering 11,955.1 ha and North Labuhanbatu KPH covering an area of 27,631.6 ha . Thus, the potential area suitable for energy forests is 73,910 ha. Whereas in Gunung Tua, it will be supplied from three KPHs, namely Region VI Sipirok KPH covering an area of 45,061.4 ha, KPH Region VII Gunung Tua, covering an area of 137,885 ha, and KPH Region X Padang Sidempuan, covering an area of 12,419.1 ha, bringing the total available land to 195,365 Ha.

7. Consider (a) rapid growth with heavy branching; (b) high specific gravity (BJ); (c) adaptive; (d) sprouts quickly after prunning and (e) high heating value, there are 3 (three) prospective species as energy plantations namely Kaliandra (*Calliandra callothyrsus*) with a increment of 30 - 54 Tons/ha/year, Gamal (*Gliricidea sepium*) with increment of 23 Tons/ha/year, and Lamtoro (*Leucaena leucocephala*) with increments of 12 - 36 Tons/ha/year. If the cycle is set for 10 years, 7,391 ha/year is planted to meet the needs of the wood pellet plant in SEI Mangkei SEZ with Kaliandra biomass production of 221,730 - 332,595 Tons/year, Gamal at 169,993 Tons/year and Lamtoro at 88,692 - 266,076 Tons/year year and 19,536 ha/year forest area to meet the needs of the Gunung Tua factory with Kaliandra productivity of 586,080 - 879,120 Tons/year; or Gamal 449,328 Tons/year or Lamtoro 234,432 - 703,296 Tons/year if a monoculture system is applied.

8. With an increament of 30 - 54 Tons/ha/year, the development of Kaliandra energy forest plantations will produce biomass potential 221,730 - 332,595 Tons/year to be supplied to the Sei Mangkei SEZ industry and 586,080 - 879,120 Tons/year for the industry in Gunung Tua.

9. The wood pellet production process includes three main stages namely, drying, grinding, and densification (pelleting). The stage of wood pellet production which has the largest energy consumption is the drying stage. At this stage heat energy is needed for drying raw materials. Based on the available land potential in the two selected locations, a production capacity of 10 Tons/hour of pellets can be applied, especially for export-oriented factories, using a ring die pelletizer.

10. The Sei Mangkei factory has an NPV, at a real discount rate of 7.50%, amounting to Rp 81,684 Million. While the IRR and BCR values were 32.78% and 1.21, respectively. Thus, this project is feasible to run with a 2.9 year payback period. Although not as good as the planned plant to be built in Sei Mangkei, the plan to build a pellet plant in Gunung Tua is also still financially feasible; with a real discount rate of 7.50%, the financial indicators are as follows: NPV Rp 60,863 Million, IRR 26.68 %, and BCR 1.17%. The payback period is a little longer, which is 3.4 years.

11. The strategy of developing energy forest plantations will be carried out with a partnership pattern. This participatory scheme was chosen by considering the consequences of the availability of fully clear and clean lands due to occupation of state production forests by unscrupulous people. In this case optimal land use such as agroforestry systems is recommended especially at the beginning of land clearing.

6.2 Recommendations

1. The potential supply of raw materials for wood pellets in North Sumatra is very high, both for factories in the SEI Mangkei SEZ and in Gunung Tua. However, community agricultural activities around the forest area are also very high, especially in production forest areas. Some people "control" the forest area by planting oil palm, so it is not easy to get an area that is completely empty and ready to be planted with energy trees. One recommended strategy is to utilize palm oil biomass (stems, empty fruit bunches, shells) as an alternative raw material for wood pellets, so that the continuity of supply of raw materials is more secure. Another strategy that can be taken is to collaborate in partnership with communities around the forest, where investors provide seeds and all costs needed for energy wood cultivation from planting to harvesting. While the community around the forest is obliged to look after trees.
2. The government immediately issued a policy in favor of private investors, especially those related to the purchase price of electricity by PLN. Another policy that will encourage the establishment of PLTBm is a substitution scheme for partial use of coal with biomass (co-firing), as a renewable energy source that is environmentally friendly.
3. Increasing the domestic wood pellet market segment, particularly the textile, food & beverage, and small-medium industries (IKM) that have been using gas or coal, can be done by introducing the simple technology design of wood pellet stoves (burners), as can be seen in Figure 26.

(a) (b)

Figure 26. Wood pellet stove, (a) Horizontal, (b) Vertical

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