Chapter 2

Study on Biomass Potential in the Southern Part of Thailand

August 2019

This chapter should be cited as

ERIA (2019), 'Study on Biomass Potential in the Southern Part of Thailand', in Han, P., S. Kimura, W. Wongsapai and Y. Achawangku (eds.), *Study on Biomass Supply Chain for Power Generation in Southern Part of Thailand.* ERIA Research Project Report FY2018 no.9, Jakarta: ERIA, pp.7–29.

Chapter 2

Study on Biomass Potential in Southern Thailand

Biomass energy is energy derived from agricultural products, which can be converted to biomass, so-called 'biomass crop' or 'energy crop'. This includes a broad variety of raw materials such as wood, agricultural crops, by-products of wood processing, forestry industry products, manure, and the organic fraction of waste. The two sources of biomass production are plantation areas and agricultural processing plants. The amount of biomass production, therefore, varies according to the amount of biomass-converting-agricultural product, which also varies in proportion to the plantation or harvesting area. One basically needs to know the plantation area or the harvesting area to estimate the amount of biomass production.

The Office of Agricultural Economics, Ministry of Agriculture and Cooperatives extracted data on the plantation areas of 14 provinces in Southern Thailand. The extracted data was used to report the plantation area, harvesting area, and amount of biomass plant and other major agricultural products in the annual report, the report on situation and trend of major agricultural products, etc.

1. Biomass in Thailand

Biomass can be derived from several agricultural products. The collection, study, and development of a database of potential biomass is needed to estimate the amount of remaining biomass each year. In Thailand, there are 23 types of potential biomass from 9 energy crops as follows:

(1) **Major rice and second rice**
- Straw
- Rice husk

(2) **Sugarcane**
- Leaves
- Bagasse

(3) **Maize**
- Stem and leaves
- Corn cob

(4) **Cassava**
- Cassava root
- Cassava pulp
- Cassava peel

(5) **Coconut**
- Cluster
- Spathe
- Shell

(6) **Soybean**
- Stem and leaves

(7) **Oil palm**
- Trunk
- Leaves and fronds
- Empty fruit branch
- Fiber
- Shell

(8) **Rubberwood**
- Roots, stump, and branches
- Offcut
- Slab
- Residue, sawdust

(9) **Cashew nut**
- Shell

2. Biomass for Fuel

Three types of biomass have been widely used as fuel for energy generation: (i) rubberwood offcut, (ii) rubberwood slab, and (iii) rubberwood residues and sawdust.

These types of biomass are traded commercially like the conventional fuels of petroleum products and coal. Domestic consumption is so high that biomass is imported from neighbouring countries. For example, rubberwood offcut is imported from Myanmar. The prices of biomass depend on demand and supply. When the demand is high, the price goes up. To maximise the efficiency of fuel consumption and minimise the impact of price fluctuation, the use of the above three types of biomass should be monitored.

3. Potential Biomass for Fuel

The different types of biomass – roots, stumps, and branches – used as fuel should be promoted. At present, the use of empty fruit bunches, roots, stumps, and branches as fuel is limited despite its high potential. The factors influencing less utilisation are (i) the difficulty to collect biomass and inconvenient transport; (ii) needed preparation, with associated preparation cost, before biomass is used as fuel; and (iii) the disadvantageous characteristics of biomass such as high moisture content and high ash content after burning.

To promote the use of potential biomass, the following solutions have been proposed.

(1) Encourage the study of the feasibility and suitability to use biomass for power generation. As an example, the Department of Alternative Energy Development and Efficiency (DEDE) has studied the possibility of using cassava rhizomes as fuel to generate power.

(2) Encourage investors of power plants by supporting both technical, engineering, and financial aspects, such as increasing the difference in the purchase of electricity (adder or feed-in tariff).

(3) Support studies and research on harvesting and processing methods, such as briquette for economic value.

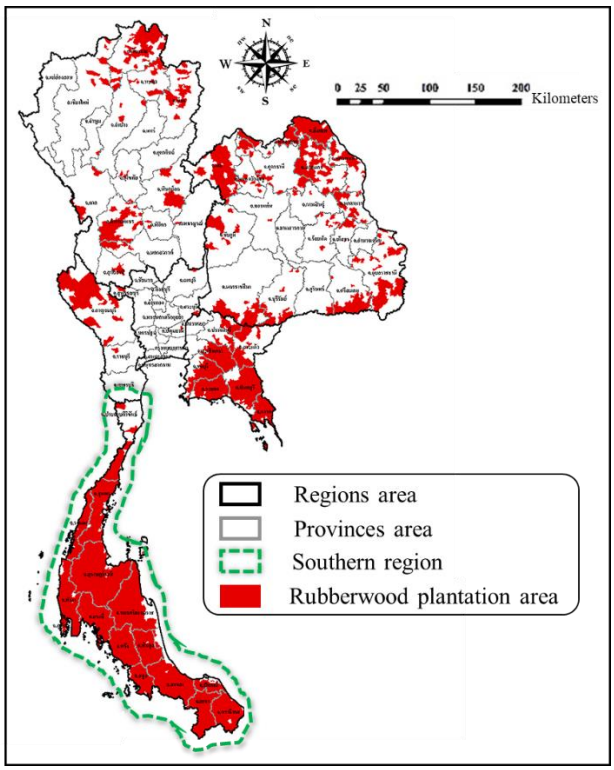
(4) Support studies and research on environment-friendly technologies to reduce anti-community problems.

(5) Promote and research on the use of ash or appropriate disposal methods

4. Biomass in the Southern Region

Data on biomass plantation areas was collected from 14 provinces of Southern Thailand. The data is based on the statistics from the Office of Agricultural Economics and Land Development Department (Figure 2.1), Ministry of Agriculture and Cooperatives. The data is reported in terms of plantation, harvesting, and production areas. In the south, four types of biomass come from rubberwood: (i) stumps, roots, and branches; (ii) offcut; (iii) slabs; and (iv) sawdust and wood residues.

Figure 2.1 Map of Rubberwood Plantation in Thailand



Source: Land Development Department (LDD), www. http://www.ldd.go.th

5. Analysis of Life Cycle of Biomass from Rubberwood

Rubber tree, a perennial plant, was first planted in Thailand in 1900 by the governor of Trang Province. The plantation area of rubber trees had been expanded and reached 22 million *rai* (as of 31 December 2017). Most rubber tree plantations are in southern Thailand (Figure 2.2).

The rotation of rubber trees is about 25–35 years, after which the trees give less latex. Therefore, they are felled and replanted. Rubber trees take 6–7 years to grow enough to give latex. In the past, felling the rubber trees was a problem as the trees were used only for fuelwood and for making charcoal. Rubberwood is also easily damaged by insects and fungi. But with state-of-the-art technology, rubberwood is now converted into valuable furniture at inexpensive cost. The stakeholders of rubberwood plantations are state enterprises, farmers, and private entities.

Figure 2.2 Rubberwood Plantation

Source: Para rubber Electronic Bulletin, Rubber Authority of Thailand (2018).

5.1. Life cycle of biomass from rubberwood

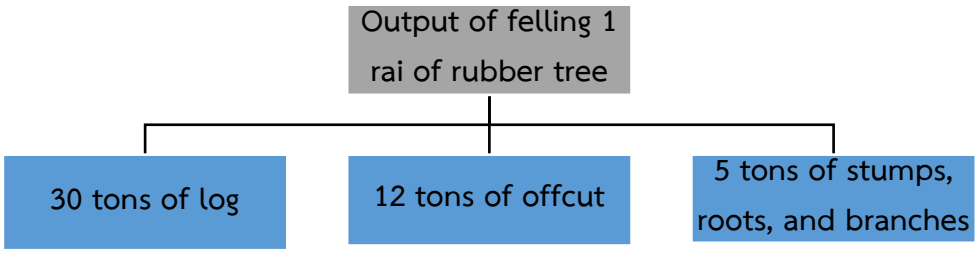
The life cycle of biomass from rubberwood starts from felling the retired rubber trees. The felled rubberwood can now be used. The logger will negotiate 3 months in advance with the farmer who will cut down the rubber trees. The factors influencing the biomass price are (i) density of rubber trees, at least 70 trees per rai; (ii) shape of strait trunk with small branches; (iii) accessibility of vehicle to transport the biomass; (iv) flat area to easily drag the felled wood; and (v) good quality of rubber trees (ex. RRIM 600[1]).

The logger needs expertise and skill to estimate the weight of biomass before cutting down the trees.

The biomass from rubberwood will be classified into logs; offcuts; and stumps, roots, and branches.

Felled rubber trees of 1 rai, on average, will give 30 tons of logs; 12 tons of offcut; and 5 tons of stumps, roots, and branches.

Figure 2.3 Output of Felled Rubber Trees (1 *Rai*)



Source: Author's field survey photo, 2019.

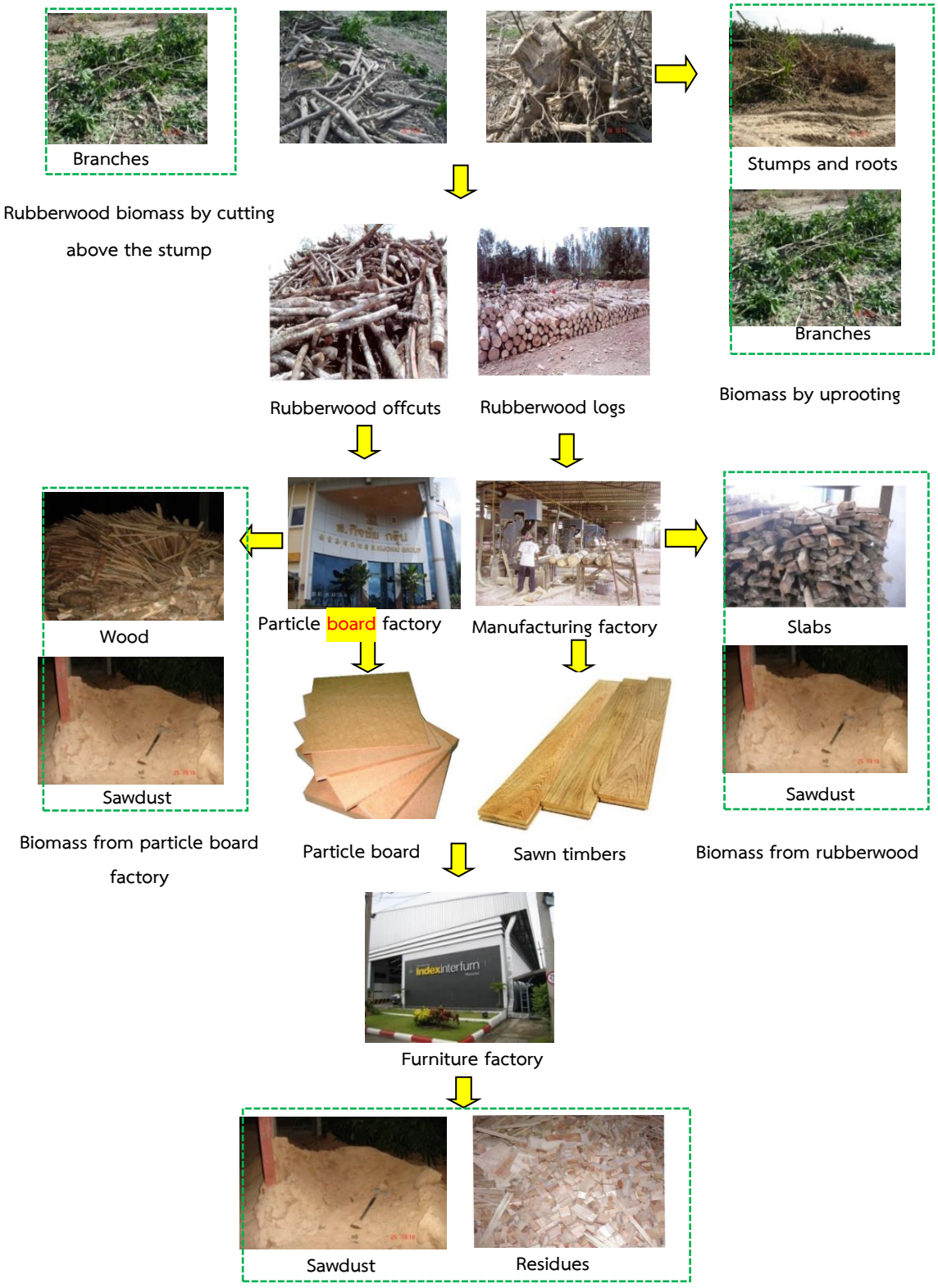
[1] RRIM 600: Natural rubber tree, cultivar of *Hevea brasiliensis*: high yield and high wood quality. RRIM 600 is recommended and identified as a moderately resistant cultivar.

Figure 2.3 shows that the biomass produced at the felling area is only stumps, roots, and branches. The rubberwood trunks are sent to the sawmill. Two types of rubberwood biomass, obtained at the processing factory, are slabs and sawdust as waste. The sawn timbers are sent to the furniture factory, which will produce sawdust and wood residues as waste from the process. The offcuts are used as raw material in producing particle boards and, in many industries, as source of heat.

This study focuses on two sources of rubberwood biomass: (i) stumps, roots, and branches at the felling area; and (ii) rubberwood slabs, sawdust, and wood residues at the rubberwood manufacturing factory, furniture factory, and particleboard factory.

The retired rubber trees can be felled into two ways: (i) cutting above the stump, and (ii) uprooting the stump. The first method uses a chainsaw to cut the trees but leaving the stumps under the soil. The second method uses a tractor to push and pull the rubber trees until their stumps are removed from the ground. The second method will give more rubberwood biomass than the first method but will cost about 10%–20% more than the first method. The trunks of at least 6 inches in diameter are then cut 1.05 metres long, so-called 'rubberwood log'. Small trunks of less than 6 inches in diameter are also cut into small pieces, so-called 'rubberwood offcuts. Both rubberwood types are processed by the manufacturing sector (Figure 2.4). The stumps, roots, and branches are also gathered for utilisation.

Figure 2.4 Life Cycle of Biomass from Rubberwood



Source: Author's field survey process diagram, 2019.

5.2. Production and use of stumps, roots, branches, and offcuts

○ *Production of stumps, roots, branches, and offcuts*

Farmers get stumps, roots, branches, and offcuts from felled rubber trees (Figures 2.5 and 2.6).

Figure 2.5 Stumps, Roots, and Branches

Source: Author's field survey photo, 2019.

The small trunks less than 6 inches in diameter are cut into small pieces, so-called 'rubberwood offcuts'.

Figure 2.6 Offcuts

Source: Author's field survey photo, 2019.

Felled rubber trees from 1 rai, on average, will give 30 tons of logs; 12 tons of rubberwood offcuts; and 5 tons of stumps, roots, and branches.

○ *Use of stumps, roots, branches, and offcuts*

When trees are cut above the stump, the branches are relatively difficult to collect to be used as a biomass energy source and are thus burnt at the field. When the stumps are taken out, the roots serve as additional rubberwood biomass. Stumps and roots are used as fuel in power plants and industries as their uprooting and reduction entail extra costs. Therefore, farmers prefer cutting the rubber trees above the stump to incur lower costs.

In this study, the survey and potential of rubberwood biomass are, therefore, focused on cutting above the stump.

Offcuts are used as raw material for particle board and as fuel in some industries, such as in oven of ribbed smoked sheet factory, boiler, brick-making kiln, lime factory, rubber glove factory, seafood processing factory, etc.

5.3. Production and utilisation of slab, wood residues, and sawdust

Rubberwood logs are trunks of rubberwood at least 6 inches in diameter. The trunks are cut 1.05 metres long for sending to sawmills within 48 hours to avoid the quality of rubberwood log from degrading, thus resulting in the logs' lower price. A limited amount of rubberwood logs (Figure 2.7) are sent to plywood factories.

Figure 2.7 Rubberwood Logs

Source: Author's field survey photo, 2019.

- *Production of slabs, wood residues, and sawdust in rubberwood process plants*

As mentioned, felled rubberwood trees of 1 *rai* will give 30 tons of logs. Most logs are sent to sawmills or rubberwood processing plants where the logs are cut to produce sawn timber (Figure 2.8). The wastes from cutting are slabs and sawdust. In general, the slabs produced are about 40% of logs, or 12 tons of slabs. Sawdust produced is 10% of logs, giving 3 tons of sawdust. This production rate is inverse to the size of logs. Thirty percent of slabs and sawdust are used in-house in the drying process of sawmills, so 70% of slabs and sawdust will be available for selling.

Figure 2.8 Rubberwood Processing Plant

Source: Author's field survey photo, 2019.

Sawmills cut the rubberwood log to the specific size of ½" x 2" to 2" x 5" as per order. The sawn timber is then soaked in chemicals and dried. This helps protect timber from damage caused by insects and fungi. The sawn timber is then sent to furniture factories domestically and abroad to manufacture furniture, such as tables, chairs, photo frames, parquets, etc. The off-specification sawn timber is used to produce palette.

The wastes from sawing are slabs and sawdust, which can be used as energy in the boilers and ovens of mills. The remaining wastes can be sold to outsiders.

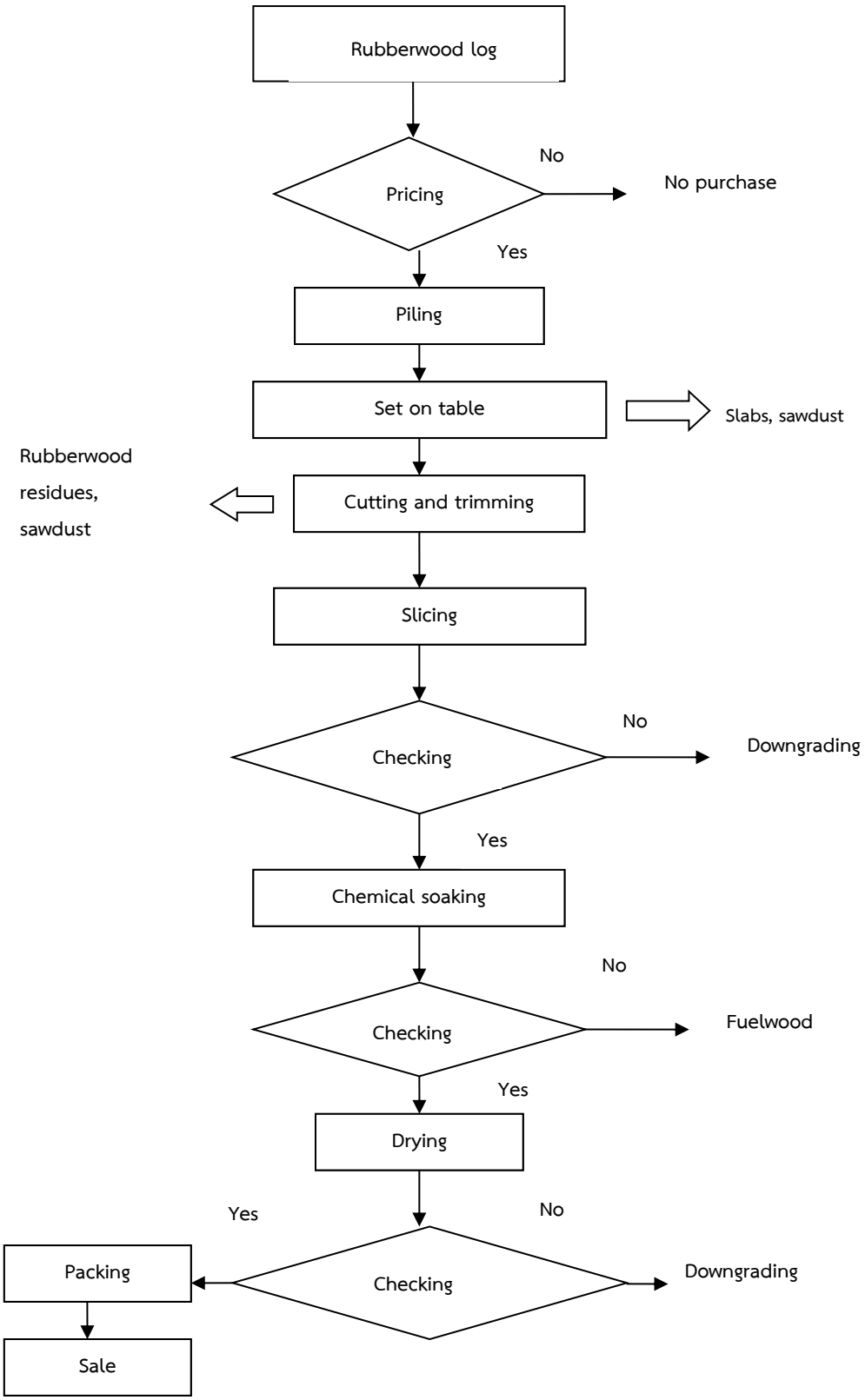
Since small sawmills do not have chemical soaking and drying, the sawn timber is then sold to the large sawmills. In this case, the slabs and sawdust from small sawmills are wholly sold to outsiders.

Data from the Ministry of Industry reveal that there are about 400 sawmills in southern Thailand. The combined sawmill capacity is over-installed compared to the availability of rubberwood logs. Therefore, most sawmills do not operate at full capacity. The competition to buy rubberwood logs is high; so, many small sawmills have to close down. At present, sawmills should have their own strategy to buy the rubberwood logs for their production, such as having direct contact with farmers and their own woodcutting team expanding the sawmill to locations near the felling area to reduce transport costs, etc.

The important machine of the sawmill is table saw, which is composed of saw and slice. The table saw can process 20 tons in 8 hours. Large sawmills have 10–20 table saws. Working hours are normally in shifts during the day. Some sawmills move their working hours to night-time (off-peak period) to reduce the electricity bill; however, the quality of the products also decreases.

Figure 2.9 shows the production process of sawmills.

Figure 2.9 Production Process of Sawmills



Source: Author's field survey process diagram, 2019.

○ *Use of slabs, wood residues, and sawdust in sawmills*

Slabs, wood residues, and sawdust produced in sawmills can be used as follows:

1) Sawmills that have a drying process use the rubberwood biomass as fuel in the boiler (Figure 2.10) to generate steam for the drying process. If the boiler can burn sawdust, sawdust is used as the main fuel and slabs, as the secondary fuel. If the boiler cannot burn sawdust, slabs are used as main fuel. The supplementary sawdust and slabs can be purchased from other sawmills. The excess biomass is sold to outsiders – slabs and wood residues are sold to factories; sawdust is sold to chicken farms, etc.

2) Sawmills that do not have a drying process sell all slabs, residues, and sawdust to outsiders.

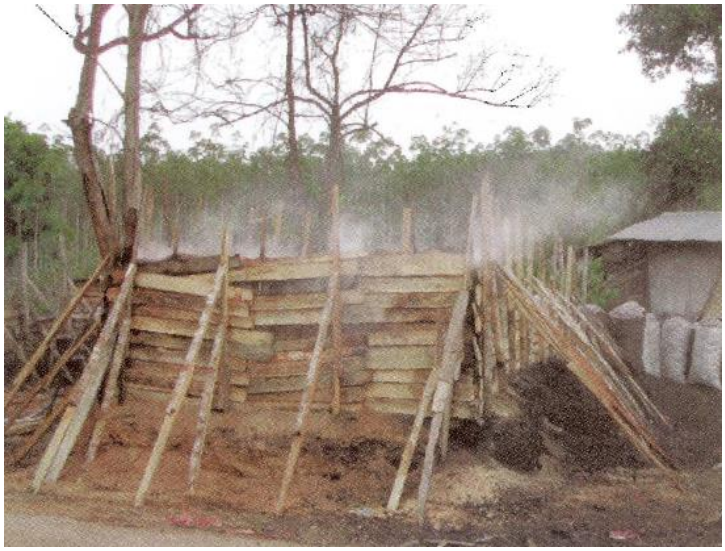
The survey found that slabs and sawdust from sawmills are used as follows:

1) Power plants use slabs and sawdust in the boiler of power plants.
2) Factories – cement plants, food manufacturers, ribbed smoked sheet factories – use slabs and sawdust as heat source in the manufacturing process.
3) Particle board factories use slabs and sawdust as raw material to produce particle boards.
4) Medium-density fibreboard (MDF) factories use the offcuts to produce MDF.
5) Households use slabs and sawdust to produce briquette.
6) Charcoal makers use slabs as raw material. Charcoal is made using two methods. First, in the simple charcoal-making stove (Figure 2.11), slabs are stacked in box-shaped containers and sawdust fills the gap. This method has low efficiency and low yield of about 10%. Second, in the charcoal-making kiln, clay is used to produce dome-shaped kiln, which costs about 10,000 baht (B)/set. This method is more efficient and has a yield of about 20%. The charcoal maker will get a high impact if the price of rubberwood slabs increases. Because if the price of charcoal increases, consumers may opt to use liquefied petroleum gas (LPG) instead.
7) Farmers use sawdust in agricultural farms, such as poultry and pig farms, or mushroom cultivation farms.

Figure 2.10 Rubberwood Slabs Used as Fuel in Boilers

Source: Author's field survey photo, 2019.

Figure 2.11 Simple Charcoal-making Stove



Source: Author's field survey photo, 2019.

5.4. Production of rubberwood residues and sawdust in furniture factories

Furniture factories are downstream manufacturing facilities from sawmills. The factories produce tables, chairs, toys, and kitchen utensils. The furniture produced from rubberwood has been growing for years as its cost is cheaper than hard wood, which is also less available.

○ *Production of rubberwood residues and sawdust in furniture factories*

Four types of furniture factories are classified by production:

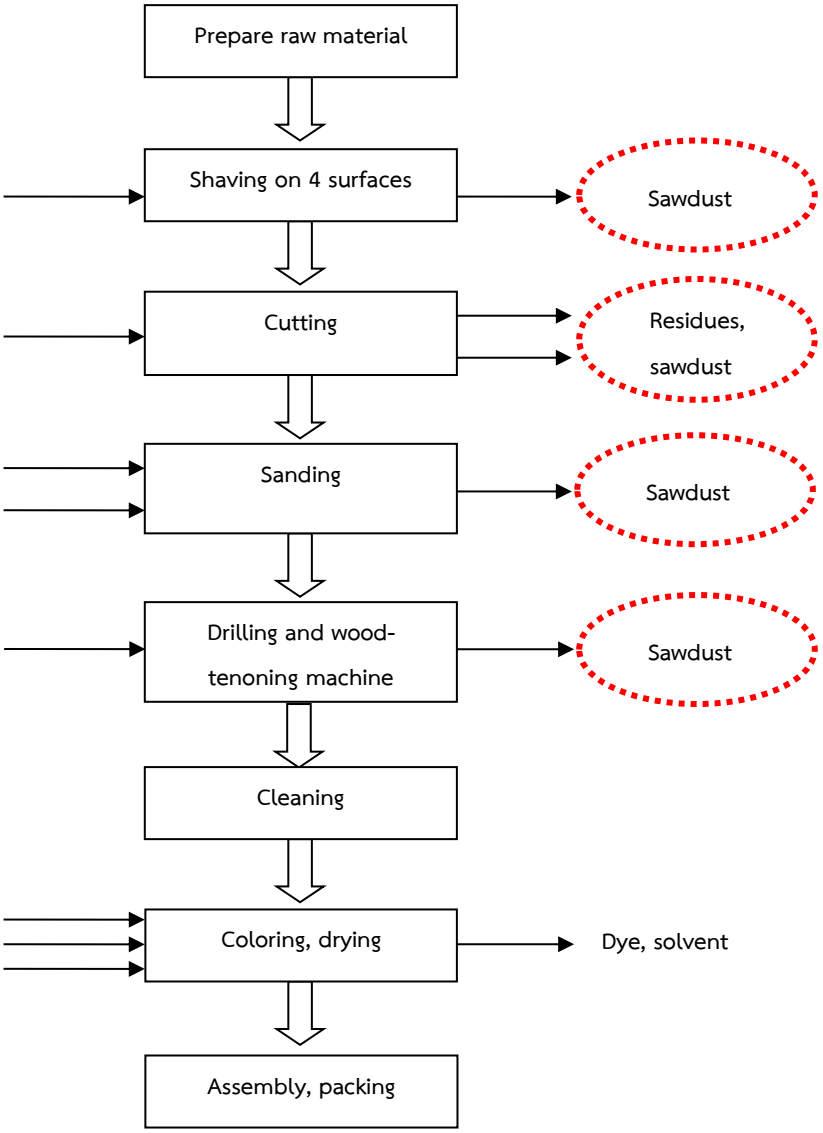
1) Knockdown-type furniture factory – uses knockdown concept to make products, which commands the highest price.
2) Plywood or veneer factory – normally buys rubberwood timber with a diameter of more than 10" for peeling, gluing, drying, and cutting to the desired size.
3) Particle board factory – buys offcuts and slabs to shred and grind them to powder. It is then mixed with glue, formed, and pressed to the desired size.
4) MDF factory – buys offcuts to be shredded to smaller size (does not use slabs).

All four types of furniture factories have a lot of waste materials – woodchips, wood dust, shavings, and wood or wood heads. These can be used as fuel for drying wood or be sold to outsiders.

The following are technology and production processes of rubberwood in each type of furniture factory.

1) Furniture factory – Figure 2.12 shows the production of rubberwood residues and sawdust in furniture

Figure 2.12 Production of Rubberwood Residues and Sawdust in Furniture



Source: Author's field survey process diagram, 2019.

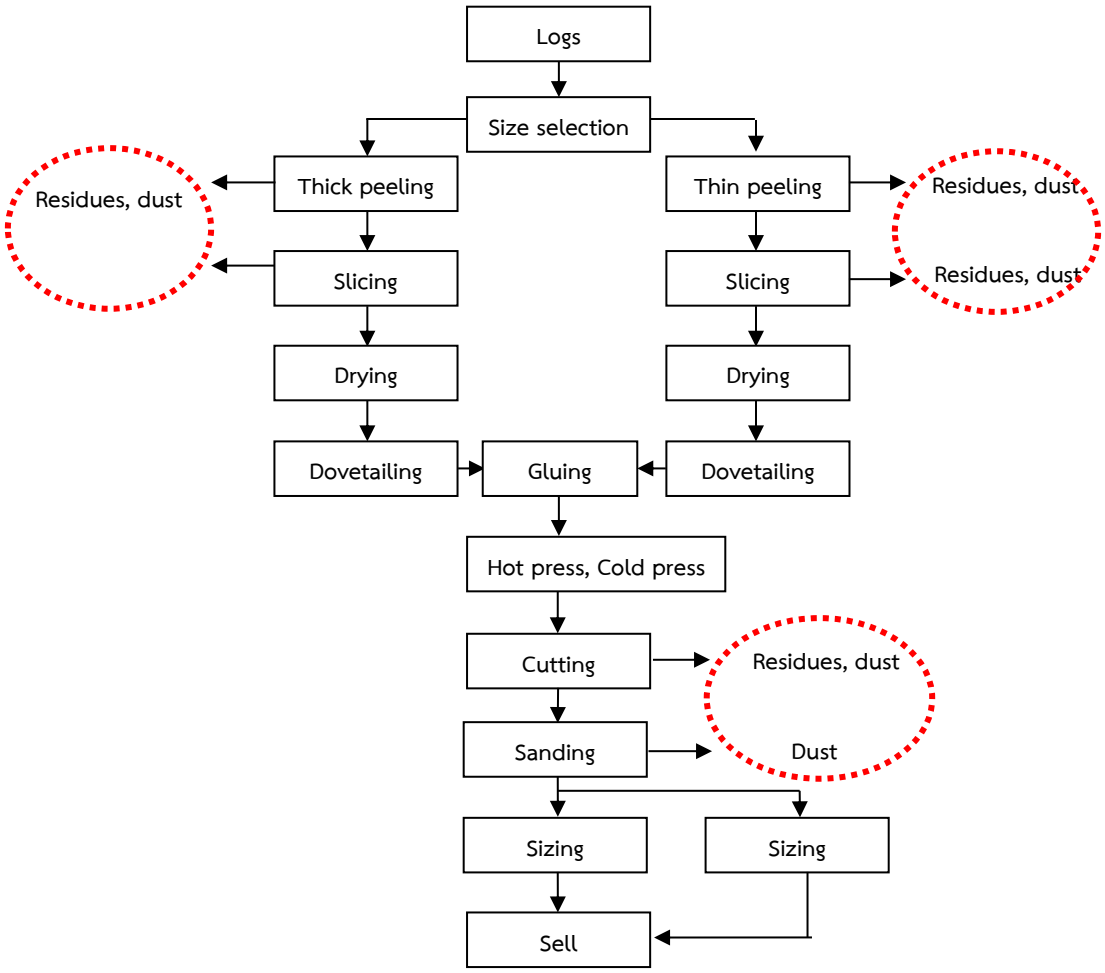
Figure 2.13 Cutting Edge of Rubberwood

Source: Author's field survey photo, 2019.

The study found that rubberwood residues and dust are produced at about 8% of rubberwood input to the furniture factory. In other words, a rubberwood input of 1 ton to the furniture factory will produce residues, sawdust, and dust of 0.08 ton.

2) Plywood or veneer factory – Figure 2.14 shows the biomass production process from the plywood factory.

Figure 2.14 Biomass Production from the Plywood Factory

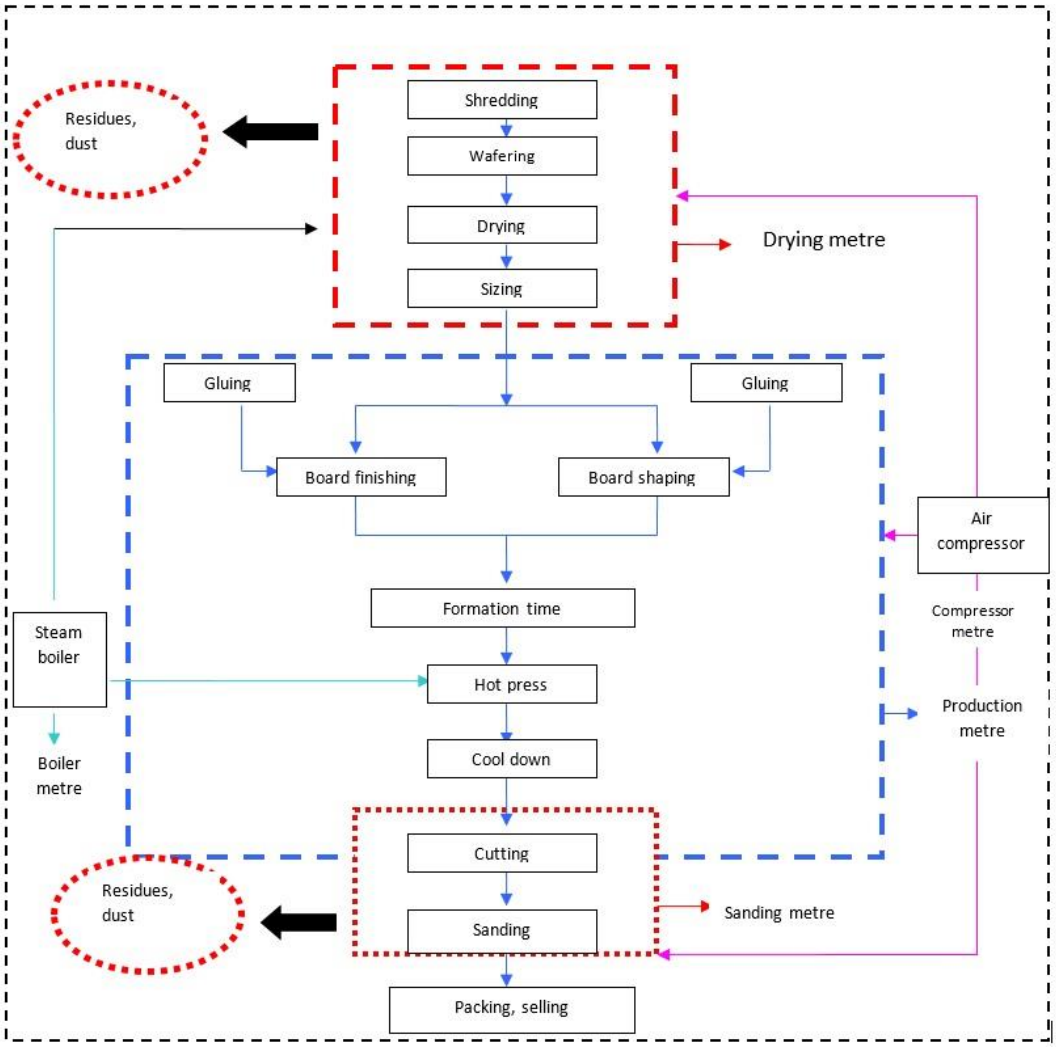


Source: Author's field survey process diagram, 2019.

The study found that rubberwood residues and dust are produced at about 5% of rubberwood input to the plywood factory. In other words, a rubberwood input of 1 ton to the plywood factory will produce residues, sawdust, and dust of 0.05 ton.

3) Particle board factory – Figure 2.15 shows the biomass production process from the particle board factory.

Figure 2.15 Biomass Production from the Particle Board Factory

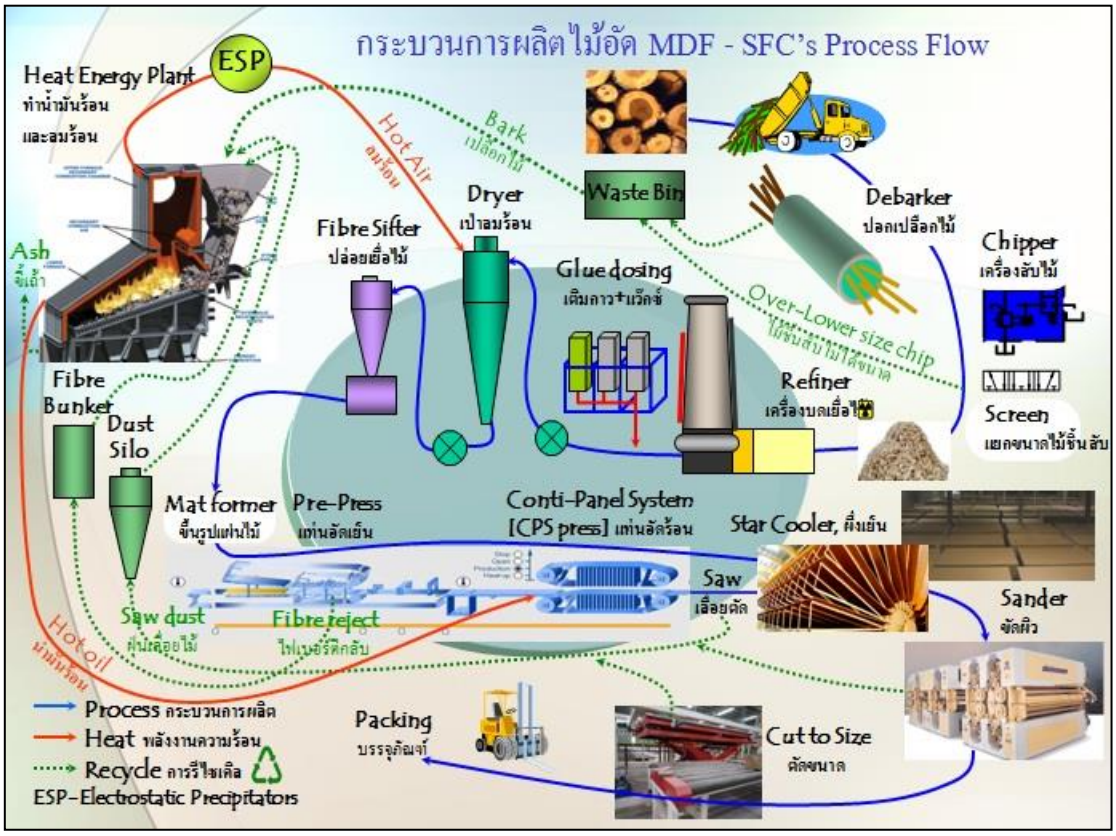


Source: Author's field survey process diagram, 2019.

The study found that rubberwood residues and dust are produced at about 5% of rubberwood input to the particle board factory. In other words, a rubberwood input of 1 ton to the particle board factory will produce residues, sawdust, and dust of 0.05 ton.

4) MDF factory – Figure 2.16 shows the biomass production from the MDF factory.

Figure 2.16 Production Process of the MDF



MDF = medium-density fibreboard.
Source: Author's data field survey process diagram, 2019.

Figure 2.16 shows that rubberwood residues are produced during shredding and screening. The off-specification-sized chip will be separated to produce hot oil and hot air in the energy plant. Sawdust is produced in cutting and sanding. Sawdust is also used in the energy plant. The study also found that rubberwood residues, sawdust, and dust are produced at about 3% of rubberwood input to the MDF factory. In other words, a rubberwood input of 1 ton to the MDF factory will produce residues, sawdust, and dust of 0.03 ton.

6. Potential of Biomass Obtained from Rubberwood

Felled rubber trees from 1 rai will give 30 tons of logs, most of which are sent to sawmills or rubberwood-processing plants. The logs are cut to obtain sawn timber. The wastes from cutting are slabs and sawdust. In general, the slabs produced from about 40% of logs give 12 tons of slabs. Sawdust produced is 10% of logs and gives 3 tons of sawdust. This production rate is inverse with the size of logs. Thirty percent of slabs and sawdust are used in-house in the drying process of sawmills so 70% of slabs and sawdust are sold.

Unlike the data on plantation and harvesting areas, the data on felling area of rubber trees is limited because rubber tree felling is uncertain. However, the Rubber Authority of Thailand (RAOT), established under Rubber Authority of Thailand Act 2015, has a mission to promote and support the farmers and all stakeholders to fulfil their needs. RAOT, therefore, has some information about the felling area.

Based on 2009 statistics, the felling area of rubber trees had increased. The target of felling area by RAOT is 400,000 rai/year.

Table 2.1 shows the ratio of biomass production and its heating value.

Table 2.1 Ratio of Rubberwood Biomass Production and its Heating Value

Source of Biomass	Type of Biomass	Ratio of Biomass per Area (ton/felling area)	Heating Value (MJ/ton)
Plantation area	Stumps and roots	5	6,570
Plantation area	Offcuts	12	6,570
Rubberwood processing plant	Slabs	12	6,570
Rubberwood processing plant	Sawdust	3	6,570

MJ = megajoule.
Source: Author's data field survey results, 2019, while heating value is from DEDE.

Biomass consumption and biomass are described below:

Biomass consumption

Biomass is consumed in:

1) Power generation: Biomass (slabs, roots, and sawdust) consumption as fuel in the boiler is calculated from the installed capacity of the power plant (MW) based on the operating hours of 24 hours a day for 330 days per year with a plant efficiency of 20%.

2) Steam generation: Biomass (slabs and sawdust) consumption is calculated from steam consumption per ton of raw material and amount of rubberwood input per ton of steam consumed.

3) MDF and particle board factories: Biomass (slabs and sawdust) consumption as raw material in the MDF factory is obtained from the energy audit report of the management of controlled energy.

4) Wood pellet: Biomass (sawdust) consumption is estimated from the production of wood pellets.

Remaining biomass

The remaining biomass is the difference of biomass availability and biomass consumption. The estimation of rubberwood biomass by province in 2017 is elaborated below.

6.1. Rubberwood biomass by province in the southern region

- **Rubberwood biomass in Krabi Province**
  - Krabi has a rubber tree plantation area of 596,827 rai and a felling area of 847 rai.
  - The available biomass is 4,233.2 tons of roots; 2,539.9 tons of sawdust; 10,160 tons of slabs; and 10,160 tons of offcuts.
  - The remaining biomass is 4,233.2 tons of roots and 10,160 tons of offcuts.
- **Rubberwood biomass in Chumphon Province**
  - Chumphon has a rubber tree plantation area of 567,131 rai and a felling area of 5,245 rai.
  - The available biomass is 26,224.7 tons of roots; 15,734.8 tons of sawdust; 62,939 tons of slabs; and 62,939 tons of offcuts.
  - The remaining biomass is 26,224.7 tons of roots and 62,939 tons of offcuts.
- **Rubberwood biomass in Trang Province**
  - Trang has a rubber tree plantation area of 1,495,082 rai and a felling area of 4,726 rai.
  - The available biomass is 23,629.2 tons of roots; 14,177.5 tons of sawdust; 56,710 tons of slabs; and 56,710 tons of offcuts.
  - One power plant uses biomass from rubberwood. The installed capacity is 4.94 MW, requiring 107,191 tons/year of biomass for power generation.
  - Biomass consumption for steam generation is 99,808 tons/year.
  - The remaining biomass is 12,910.03 tons of roots.
- **Rubberwood biomass in Nakhon Si Thammarat Province**
  - Nakhon Si Thammarat has a rubber tree plantation area of 1,500,327 rai, and a felling area of 287,257 rai.
  - The available biomass is 1,436,284.6 tons of roots; 861,770.7 tons of sawdust; 3,447,083 tons of slabs; and 3,447,083 tons of offcuts.
  - Two power plants use biomass from rubberwood. The installed capacity is 19 MW, requiring 412,273.97 tons/year of biomass for power generation.
  - Biomass consumption for steam generation is 683,322 tons/year.
  - The remaining biomass is 1,319,058.04 tons of roots; 1,129,313.54 tons of slabs; and 1,553,140.44 tons of offcuts.

- **Rubberwood biomass in Narathiwat Province**
  - Narathiwat has a rubber tree plantation area of 1,007,135 rai, and a felling area of 1,068 rai.
  - The available biomass is 5,341.2 tons of roots; 3,204.7 tons of sawdust; 12,819 tons of slabs; and 12,819 tons of offcuts.
  - One power plant uses biomass from rubberwood. The installed capacity is 7.5 MW, requiring 162,740 tons/year of biomass for power generation.
  - Biomass consumption for steam generation is 3,857 tons/year.
  - The remaining biomass is 8,961.31 tons of offcuts.
- **Rubberwood biomass in Pattani Province**
  - Pattani has a rubber tree plantation area of 369,956 rai and a felling area of 1,908 rai.
  - The available biomass is 9,539.1 tons of roots; 5,723.4 tons of sawdust; 22,894 tons of slabs; and 22,894 tons of offcuts.
  - Biomass consumption for steam generation is 26,452 tons/year.
  - There is no remaining biomass in Pattani.
- **Rubberwood biomass in Phang Nga Province**
  - Phang Nga has a rubber tree plantation area of 686,095 rai and a felling area of 2,063 rai.
  - The available biomass is 10,316 tons of roots; 6,189.6 tons of sawdust; 24,758 tons of slabs; and 24,758 tons of offcuts.
  - Biomass consumption for steam generation is 250 tons/year.
  - The remaining biomass is 10,315.96 tons of roots and 24,758.31 tons of offcuts.
- **Rubberwood biomass in Phatthalung Province**
  - Phatthalung has a rubber tree plantation area of 891,023 rai and a felling area of 5,820 rai.
  - The available biomass is 29,098.3 tons of roots; 17,459.0 tons of sawdust; 69,836.0 tons of slabs; and 69,836.0 tons of offcuts.
  - One power plant uses biomass from rubberwood. The installed capacity is 9.9 MW, requiring 214,816 tons/year of biomass for power generation.
  - Biomass consumption for steam generation is 7,174 tons/year.
  - The remaining biomass is 7,616.69 tons of roots.
- **Rubberwood biomass in Phuket Province**
  - Phuket has a rubber tree plantation area of 67,115 rai and a felling area of 290 rai.

- The available biomass is 1,447.9 tons of roots; 868.7 tons of sawdust; 3,475 tons of slabs; and 3,475 tons of offcuts.
- The remaining biomass is 1,447.9 tons of roots and 3,474 tons of offcuts.

- **Rubberwood biomass in Yala Province**
  - Yala has a rubber tree plantation area of 1,248,238 rai and a felling area of 5,896 rai.
  - The available biomass is 29,482.4 tons of roots; 17,689.4 tons of sawdust; 70,758 tons of slabs; and 70,758 tons of offcuts.
  - One power plant uses biomass from rubberwood. The installed capacity is 9.9 MW, requiring 214,816 tons/year of biomass for power generation.
  - Biomass consumption for steam generation is 5,647 tons/year.
  - The remaining biomass is 6,606.99 tons of roots and 63,526.81 tons of offcuts.
- **Rubberwood biomass in Ranong Province**
  - Ranong has a rubber tree plantation area of 311,600 rai and a felling area of 2,057 rai.
  - The available biomass is 10,285.1 tons of roots; 6,171 tons of sawdust; 24,684 tons of slabs; and 24,684 tons of offcuts.
  - The remaining biomass is 10,285.06 tons of roots and 24,684.15 tons of offcuts.
- **Rubberwood biomass in Songkhla Province**
  - Songkhla has a rubber tree plantation area of 1,978,684 rai and no felling area.
  - Three power plants use biomass from rubberwood. The installed capacity is 28.4 MW, requiring 616,241 tons/year of biomass for power generation.
  - Biomass consumption for the MDF and the particle board factories is 676,805.40 tons/year.
  - Biomass consumption for steam generation is 1,281,522 tons/year.
  - There is no remaining biomass.
- **Rubberwood biomass in Satun Province**
  - Satun has a rubber tree plantation area of 435,640 rai and no felling area.
  - Biomass consumption for steam generation is 27,964 tons/year.
- **Rubberwood biomass in Surat Thani Province**
  - Surat Thani has a rubber tree plantation area of 2,544,461 rai and a felling area of 20,045 rai.
  - The available biomass is 100,224.2 tons of roots; 60,134.5 tons of sawdust; 240,538 tons of slabs; and 240,538 tons of offcuts.

- Biomass consumption for the MDF and the particle board factories is 648,811.20 tons/year.
- Biomass consumption for steam generation is 141,093 tons/year.
- The remaining biomass is 100,224.17 tons of roots and 113,931.31 tons of offcuts.

6.2. Rubberwood biomass by province in the southern region

The study, based on 2017 data, concluded that the remaining biomass from rubberwood in the southern region is as follows:

• Roots (from felling area)	1,498,922.71	tons
• Rubberwood slabs (from wood-processing plant)	1,129,313.54	tons
• Rubberwood offcuts (from wood-processing plant)	1,865,576.15	tons