JARQ 43 (1), 37–43 (2009) http://www.jircas.affrc.go.jp

Current Situation and Concerns with Woody Biomass Use in ASEAN Countries

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Abstract

We investigated the current situation and issues associated with the use of woody biomass in countries belonging to the Association of Southeast Asian Nations (ASEAN), as part of a project entitled "Feasibility Studies on Biomass in ASEAN Countries." The main materials used in sawmills or other wood industries are different in each country because some countries depend on natural forests, whereas others depend on artificial forests. However, in general, almost all woody biomass in ASEAN countries is used as fuel or as low-quality raw materials. These uses are essential for the present social infrastructure. However, in the future, it will be necessary to seek more efficient means to convert energy and to use materials such as unused logging residues or oil palm residues.

Discipline: Forestry and forest products
Additional key words: industrial residues, logging residues, plywood, renewable energy, sawmill

Introduction

Recently, renewable energy, including biomass, has received increasing attention because of worldwide efforts to prevent global warming and alleviate soaring oil prices. When biomass is used as an energy source, for example, it is converted to ethanol as an alternative to gasoline or burned in a boiler to generate heat and power. Cereals such as corn are promising candidates for easily convertible biomass for ethanol production. However, it is possible that the supply of such potential biofuels will become unstable because of conflicts with food production. Recently, corn prices have doubled or have reached levels not seen in years[11]. In contrast, woody biomass is inedible and thus may be a promising candidate as a future renewable energy source. Woody biomass can be collected in large amounts from forests or as a by-product of the forest industry. However, forests are unevenly distributed throughout the world; consequently, the distribution of woody biomass is also uneven. Countries belonging to the Association of Southeast Asian Nations (ASEAN) have abundant and huge varieties of forest resources. However, these resources have been considerably reduced because of unrestrained logging in some countries. Sustainable forest management is necessary to continuously use the available biomass as a renewable energy source.

Our objective was to investigate the current status of the use and consumption of woody biomass to discuss future possibilities and difficulties in the use of the woody biomass as an energy source. We focused on Cambodia, Indonesia, Laos, Malaysia, the Philippines, Thailand, and Vietnam. Hereafter, our use of the term "ASEAN countries" typically refers to these seven countries.

Forests, forestry, and biomass

We summarized the biomass, including aboveground, belowground, and deadwood biomass, and growing stock in forests of the ASEAN countries (Table 1). Indonesia has the most extensive forest area and biomass stock, but since 1990, the growing stock has exhibited a strong decreasing trend, likely because of illegal logging or forest fires. Malaysia has the highest biomass and growing stock by area, whereas Thailand has the lowest.

The values for the main forest products differ among the ASEAN countries because they were obtained from different data sources; nevertheless, we conducted our investigation using these data because they were uniform within each country (Table 2). Indonesia and Malaysia

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Received 21 November 2007; accepted 31 March 2008.

produce substantial amounts of sawnwood and plywood, whereas Thailand is active in the production of chips and particles. In Vietnam, the production of sawnwood is active and very high compared to that of industrial roundwood. Cambodia and Laos consume a large proportion of roundwood as fuel.

Energy consumption

In terms of energy supply and consumption in the ASEAN countries (Table 3), Indonesia has the largest total primary energy supply (TPES) at 174 million tons of oil equivalent (Mtoe), whereas Malaysia has the largest per capita TPES at 2.28 toe. The bulletin of the ASEAN Center for Energy (ACE) states that the energy consumption was 2.48 Mtoe in Cambodia in 2001 and approximately 1.41 Mtoe in Laos in 1999. The energy consumption in Cambodia and Laos was 0.19 and 0.27 toe per capita, respectively, based on population data reported by the Kingdom of Cambodia Ministry of Economy and Finance[12] in 2001 and the National Statistics Center of the Lao PDR[17] in 2000. The consumption of renewable energy accounts for 2% of the TPES in Malaysia and 45% in Vietnam. Cambodia consumed 6,511 Kt of fuelwood and 47 Kt of charcoal in 2003. This biomass produces approximately 1.24 Mtoe of energy per year, which accounts for 50% of the energy consumed in 2001. Laos consumes approximately 66% of its total energy from fuelwood, charcoal and sawdust. However, the difficulties encountered in comparing these values are that the data source and the year the data were collected are different for each country, and Malaysia's dependency on biomass energy is insignificant, whereas Cambodia, Laos and Vietnam depend heavily on these sources of energy. This is partly because few households have electricity; for example, in 2004, only 47% of households in Laos[16] and only 12% in Cambodia[15] had electricity.

Table 1. Biomass* and growing stock in forests[5]

	Cambodia	Indonesia	Laos	Malaysia	Philippines	Thailand	Vietnam
Forest area (Kha)	10,447	88,495	16,142	20,890	7,162	14,520	12,931
Biomass stock (Mt)	2,811	13,090	3,301	8,073	2,156	1,592	2,606
Biomass stock by area (t/ha)	269	148	204	386	301	110	202
Growing stock (Mm^3)	998	5,216	957	5,242	1,248	599	850
Growing stock by area (m^3/ha)	96	59	59	251	174	41	66
Annual change in growing stock							
1990–2000 (m^3/y/ha)	-0.11	-3.33	0.00	1.94	0.13	0.00	-0.26
2000–2005 (m^3/y/ha)	-0.11	-4.61	0.00	1.94	0.08	0.00	-0.40

*: Biomass includes dead-wood biomass, above- and below-ground biomass.
[5]: Reference source modified by the author of this paper.

Table 2. The production of forest products in ASEAN countries (2005)[4]

	Cambodia	Indonesia	Laos	Malaysia	Philippines	Thailand	Vietnam
Industrial roundwood (Km^3)	113	32,497	392	25,169	2,869	8,700	5,237
Sawnwood (Km^3)	4	4,330	130	5,173	263	288	3,110
Plywood (Km^3)	4	4,514	24	5,006	233	100	15
Chips and particles (Km^3)	–	448	–	530	–	2,080	1,100
Fiberboard (Km^3)	–	427	–	1,359	0	724	54
Particle board (Km^3)	–	297	0	89	6	538	48
Wood charcoal (Kt)	33	76	19	28	156	1,278	109
Wood residues (Km^3)	–	388	–	–	–	–	–
Woodfuel (Km^3)	9,221	73,720	5,944	3,068	12,950	19,866	26,350
Total (roundwood) (Km^3)	9,334	106,216	6,336	28,237	15,819	28,566	31,587

–: Insufficient data.
[4]: Reference source modified by the author of this paper.

Woody biomass use

1. Logging residues

The use of logging residues in Cambodia[19,24], Indonesia[18] and Malaysia[6,7,14] was investigated. Although rubber plantations are generally expected to regenerate every 30–35 years, the tapping cycle of para rubber trees (PRT; *Hevea brasiliensis*) in Cambodia[19] is longer because of interruptions due to civil war. Woody residues that remain after cutting, such as tops or branches, are discarded. Fig. 1 shows the material flow in rubber tree plantations in Cambodia. The volume of these residues is equal to 30% of the cut volume. The harvesting cost of the residues is lower than that of the logging residues in natural forests. Hence, the selling price is US \$5–7/m^3, including the transportation cost to the customer. The residues are used as fuel for kilns at neighboring brick factories, which are strongly dependent on logging residues for fuel.

Clear-cutting of pine (*Pinus merkusii*) is carried out every 35 years in the national forest in Central-Java, Indonesia. The trees are cut by chainsaw, and the logs are skidded by human power. The tops and branches that are generated, as residues are < 10 cm in diameter and account for 10% of the tree volume. The local community can acquire the residues free of charge and use it as residential fuelwood. The investigation was conducted in Java, which is heavily populated, and all logging residues appeared to be used up in this manner, i.e., residues are collected

Table 3. Energy supply and consumption

	Cambodia	Indonesia	Laos	Malaysia	Philippines	Thailand	Vietnam
TPES (Mtoe)		174.04[8]		56.73[8]	44.27[8]	97.07[8]	50.22[8]
TPES per population (toe/capita)		0.80[8]		2.28[8]	0.54[8]	1.52[8]	0.61[8]
Consumption of renewable energy from primary solid biomass* (Mtoe)		45.07[8]		1.32[8]	7.64[8]	7.84[8]	22.47[8]
(Proportion to TPES)		(26%)		(2%)	(17%)	(8%)	(45%)
Energy consumption (Mtoe)	2.48[15]		1.41[13]				
Energy consumption per population (toe/capita)	0.19[12,15]		0.27[13,17]				
Data year	2001	2004	1999	2004	2004	2004	2004

TPES: Total Primary Energy Supply = Indigenous production + imports – exports – international marine bunkers ± stock changes.
*: Data are also available for charcoal.
[8,12,13,15,17]: Reference source modified by the author of this paper.

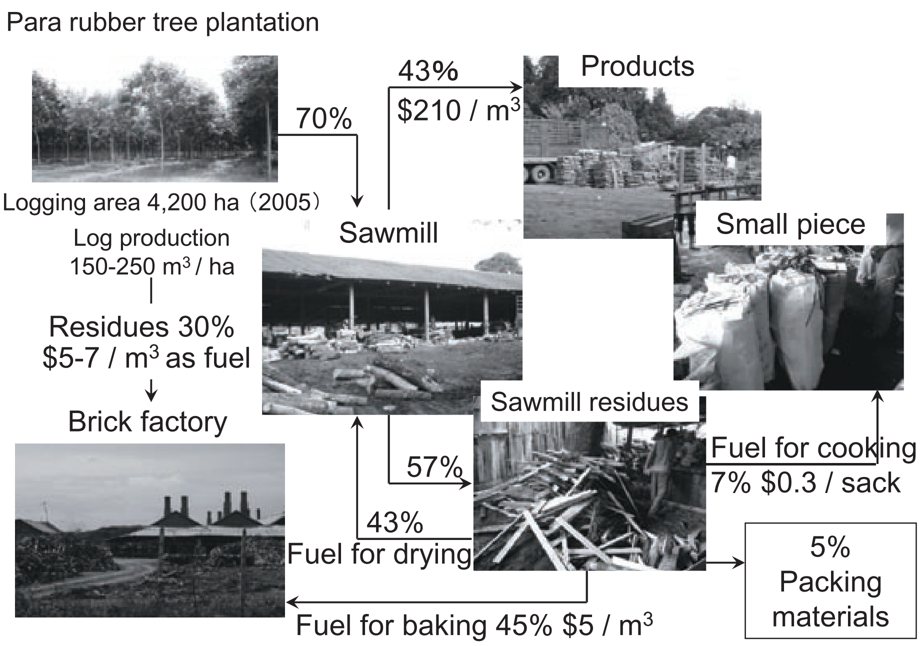

Fig. 1. An example of material flow in para rubber tree industry in Cambodia

manually.

At a large-scale, natural wood production site in Saba, Malaysia, 20–50 m^3/ha of cracked and hollow logs are discarded in the forest and in the landing[7]. In Kalimantan, Indonesia, 63.3 m^3/ha of residues are discarded in secondary forests after clear-cutting[10]. Average logging residues in Asia represent 25–200% of log production[14], i.e., the residues represent 20–67% of the growing stock, and residues from natural forest cutting appear to be equal to the log production volume[14]. However, the difficulty in using these residues is that the transportation cost of industrial residues is higher than their selling price. The former is approximately US $20/$m^3$[3,14] or US $16–20/$m^3$[3,7], whereas the latter is only US $3–5/$m^3$[3,7] in Malaysia. Thus, even if transportation were free of charge, the price disadvantage of the logging residues is considerable.

2. Industrial wood residues

The industrial wood residues in Cambodia[19,24], Indonesia[18,26,27], Laos[28], and Malaysia[14] were investigated. The residues from PRT plantations are a major source of woody biomass in Cambodia[19] because the processing of forest trees has been limited by a logging ban. The tapping cycle of PRT is longer than in other countries, i.e., approximately 50 years. Thus, there are many thick logs of rubber trees. Fig. 1 also shows the material flow of rubber trees in the wood industry. The production yield of sawing is 43%, and the residues are mainly used as drying fuel for timber or are sold as fuel for brick kilns. The residues are partially used as packing materials, and 55% of the logs are used for energy production. All wood used as kiln fuel in brick factories is derived from rubber trees.

Indonesia currently has 1,600 sawmills and 120 plywood factories[26]. For sawmills in Java, the production yield of teak (*Tectona grandis*) sawing is 50–60%, and the residues are used as fuel for drying ovens and by local people. For the plywood industry in the same area, the production yields from natural and planted wood are approximately 55% and 38%, respectively, because the average diameter of the former is approximately 70 cm, whereas that of the latter is < 30 cm. One factory that we investigated used both natural and planted wood as raw materials and generated residues representing approximately 50% of raw wood consumption; a portion of these residues was used as raw material for laminated wood or blockboard. The rest of the residue was used as fuel to produce heat to dry veneer and for hot-pressing. Some factories use both residues that are generated within and obtained from outside the factory to fuel combined heat and power supply (CHP) systems. Recently, the source of this raw material has been shifting from natural wood to planted wood because of the increase in natural wood prices and the rising concerns about deforestation[18]. In Kalimantan, plywood factories are experiencing a shortage of large natural wood (Fig. 2). Most factories around Samarinda have ceased operations because of the decreasing amount of raw wood, which fell sharply from 150,000 m^3/month to 30,000 m^3/month[27].

Laos has 200 wood-processing factories, many of which are located near the capital Vientiane or in the southern part of the country, and only one plywood factory. Charcoal factories are found everywhere because of its high demand for residential use. Processing factories, which saw up to 15,000 m^3/year of logs for furniture, packing material, flooring, and doors, depend on wood from natural forests, including rosewood (*Dalbergia*) or meranti (*Shorea*), for raw materials. This natural wood is made available in the market in great quantities as a result of clear-cutting for power dam development. The production yield in this industry is approximately 60%. All residues are used as fuel for boilers, and the sawdust is provided to the salt industry at no charge. However, in the southern part of Laos, unused sawing residues pile up in the backyards of sawmills.

In Malaysia, the total volume of the wood industry residue is 7.5 million m^3 annually[25]; sawmill residue was the highest in Sabah, and plywood mill residue was the highest in Sarawak. The product yields in sawmills were 65% (western part of Peninsular Malaysia), 45% (Sabah) and 40% (Sarawak), and the yields in plywood mills were 50–60% (eastern and western parts of Peninsular Malaysia). The yields in moulding factories were 74% (Sabah and Sarawak) and 70% (Peninsular Malaysia). According to a questionnaire conducted in the Kemena wood industry park of Sarawak by Wong, T. C. (unpublished data), approximately 200,000 m^3 of logs were consumed per month and processed into plywood, timber and fiberboard. The volume of wood residue was approximately

Fig. 2. The raw wood in the plywood factory

90,000 m^3 per month, of which 75% and 20% were generated by plywood mills and sawmills, respectively. The percent use of the original residue was 75%; veneer core and slabs/offcuts were commonly used. In terms of application, steam/thermal use was dominant (48%), followed by fiberboard (40%), co-generation (7%), other use (4%), and manufacturing of charcoal briquettes (1%). However, approximately 20,000 m^3 of residue was disposed of directly or by incineration. Wong (unpublished data) noted that at least one additional briquette plant should be installed to use the remaining residue. In an industrial park in Bintulu, Sarawak, wood residue was sufficiently used as briquette charcoal, fiberboard material and fuel for boilers. This was because of government incentives; to promote biomass use, the government remits duties in the implementation of related systems. In the Keningau area of Sabah, because wood-processing plants were small and separate from other plants, the residue, particularly sawdust, was not used and was usually incinerated at the plant. We estimated that the total unused sawdust remaining in the Sabah area is approximately 4,700 t/month.

Estimation of the biomass energy potential

We estimated the biomass energy potential from the research data. We regarded all residues from the logging and wood industries as having biomass energy potential, although some residues have been already used as raw materials. The energy potential was estimated using the following equations[2]:

$$RV = MPV \times RPR/(100 - RPR) \quad (1)$$

$$EP = RV \times LHV \quad (2)$$

where RV is the residue volume (m^3), MPV is the main product volume (m^3), RPR is the residue production ratio (%), EP is the energy potential (toe), and LHV is the lower heating value (toe/m^3). Table 4 shows the EP of certain types of residues in some countries for which we were able to collect the required data. The main products of the PRT plantation residue and logging residue are logs. LHV is calculated from values stipulated by the International Energy Agency[9], where the weight of 1 m^3 of wood is assumed to be 500 kg[9]. LHV of the PRT plantation residue and the logging residue are less since they contents more water and consume the heat for evaporation. Cambodia has 0.16 Mtoe EP from PRT plantations and sawmills, accounting for approximately 6% of the domestic energy consumption in 2001. In Thailand, PRT industries have an EP of 2.45 Mtoe, which is the largest (Table 4). Malaysia has an EP of 0.79 Mtoe from the logging residues in Sarawak, which is almost equal to the EP from sawmills.

It should be pointed out that ASEAN countries have high EP from oil palm industries[20,21] in which residues such as empty fruit bunches (EFB), fronds and trunks are generated, and a large portion of the EFB and almost the entire two latter residues are discarded in the plantation field. Table 5 shows the estimated amounts of EFB and fronds produced in Indonesia, Malaysia and Thailand. EFBs are generated from oil processing, and fronds remain in large amounts in the plantation area. A comparison to the data presented in Table 4 shows that the oil palm industries have much larger EP than woody biomass. The problem remains that because the fronds cannot be used without transportation, preferable uses must be found either as a source of energy or as a source of material such as fiber. The residues from oil palm industries are certainly a valuable source of biomass with great potential.

Table 4. Potential energy from woody biomass in selected ASEAN countries

	Item	MPV (Km^3)	RPR (%)	RV (Km^3)	LHV (GJ/m^3)	EP (Mtoe)
Cambodia	PRT plantation residue	840[19,24]	30[19,24]	360	7.4[9]	0.06
	PRT sawmill	361[19,24]	57[19,24]	479	8.4[9]	0.10
Indonesia	Plywood	4,514[4]	50[18]	4,514	8.4[9]	0.91
	Sawmill	4,330[4]	45[18]	3,543	8.4[9]	0.71
Laos	Sawmill	130[4]	40[28]	87	8.4[9]	0.02
Malaysia	Plywood	5,006[4]	50[14]	5,006	8.4[9]	1.01
	Sawmill	5,173[4]	45[14]	4,232	8.4[9]	0.85
	Logging residue*	4,440[14]	50[14]	4,440	7.4[9]	0.79
Thailand	PRT sawmill	10,800[4]	53[21]	12,179	8.4[9]	2.45

MPV: Main product volume, RPR: Residue production ratio, RV: Residue volume,
LHV: Lower heating value, EP: Energy potential.
*: Values are limited to Sarawak.
[4,9,14,18,19,21,24,28]: Reference source.

Table 5. Energy potential of palm oil industries in Indonesia, Malaysia and Thailand

		Moisture content	Production		LHV	EP
		(wt%)	Dry (Mton)	Wet (Mton)	(MJ/kg)	(Mtoe)
EFB	Indonesia		3.46[20]	3.79		1.49
	Malaysia	8.81[3]	4.71[20]	5.17	16.44[3]	2.03
	Thailand		0.30[20]	0.33		0.13
Frond	Indonesia		24.14[20]	46.74		8.90
	Malaysia	48.34[3]	32.93[20]	63.74	7.97[3]	12.14
	Thailand		2.05[20]	3.97		0.76

[3,20]: Reference source.

Discussion

Here, we discuss the difficulties for woody biomass use in the future. Although some districts produce massive quantities of logging residues, their use will hardly increase because of high transportation costs. The commercial collection and use of logging residues does not appear to have advanced for some time and is confined to regional uses such as for cooking fuels by local residents. Hence, a surplus of biomass is present in regions that have small populations compared to the amount of available resources. The Philippines[23] and Vietnam[22] follow policies to promote the use of tree plantations, and the shifting of sources of raw materials to planted wood is being promoted in Indonesia. Thus, the use of planted wood is increasing in the wood industries. Planted wood has a short-term harvesting cycle and produces small logs compared to natural forests; these small logs result in inferior yields of the main wood products. Hence, industrial residues will likely increase in the future. However, it is expected that the shortage of wood materials will become serious because of the decrease in the number large logs and because of advances in the technologies that use the remaining residues for other purposes. Consequently, the residues that are used as raw materials for by-products will increase, whereas the residues that can be used as energy sources will decrease.

The use of fuelwood from industrial residues cannot be immediately replaced by another alternative. Because there are no equally low-cost alternatives for fuelwood from residues, these residues are necessary for use in drying ovens in the wood industry. The amount of residues was intentionally increased in some factories because of their need for sufficient fuelwood to supply the energy required for drying. Alternatives to the use of residues cannot be found unless the cost of residues appreciates and cheaper heat sources become available. However, residues are discarded or incinerated in some wood-processing factories. In such cases, the conversion of sawdust to briquette charcoal can be an efficient means of residue use. In the cases of Laos and Cambodia, to develop electricity in local areas, the implementation of CHP systems in wood-processing factories may be promising. Government incentives are needed to develop such systems, as in the case of a wood-industry park in Sarawak, Malaysia.

Woody biomass is essential for local residents and for wood and other industries in ASEAN countries and hence it is entirely used. A possible approach to expand the uses for woody biomass as an energy source is as follows. First, the amount of biomass resources consumed should be reduced through the use of more efficient heat-use technology. Traditional cooking stoves are inefficient; if these were replaced with improved versions, a surplus energy of 5.07 and 0.85 Mtoe (2005) could be generated in the Philippines and Thailand, respectively[2]. Woody biomass needs to be used as efficiently as possible not only to save resources, but also to protect forests and precious ecosystems. Second, logging residues that are currently not collected because of the current high transportation costs must be used. This problem cannot be resolved in the short term; however, the whole world, including ASEAN countries, must adopt this approach in the long run. ASEAN countries must deal with forestry problems such as illegal logging or improper swidden agriculture. A system for the collective resolution of these problems is desired. A policy for the collection of logging residues, especially those in the landings is required. Technology with which oil palm residues can be efficiently used is also required.

According to the estimation of the ACE[1], biomass energy will play a significant role as a renewable energy source by 2010 in all ASEAN countries. It will account for 70% of the renewable sources in 2010, although it accounted for 77% in 2000. Biomass energy will be a necessary energy source for the future in ASEAN countries, which must advance toward the resolution of the problems described herein.

Acknowledgments

We thank the Ministry of Education, Culture, Sports, Science, and Technology of Japan for support under the project "Feasibility Studies on Biomass in ASEAN Countries." We also thank Toshiro Harada, Masaki Jinkawa, Hirofumi Kuboyama, Motoe Miyamoto, Ryohei Tanaka, Eiji Togawa, and Koichi Yamamoto for providing data and helpful comments.

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