4. ENERGY ANALYSIS

4.1 Energy from rubber plantation wastes

The most important parameter indicating the feasibility of the rubber waste utilization is the net energy obtained. The energy gained in this project is the inherent energy of the rubber plantation wastes. The samples of the fallen leaves and branches were analysed by the Department of Science Services. The results are tabulated in Table 3.

Table 3

Analysed data of the rubber plantation wastes

Components	Leaves	Branches
Proximate analysis		
Moisture %	6.7	8.8
Ash %	6.2	4.1
Volatile matter %	75.2	70.2
Fixed Carbon %	11.9	16.9
Ultimate analysis		
Carbon %	50.8	44.5
Hydrogen %	7.7	6.5
Oxygen %	33.9	44.2
Nitrogen %	1.1	0.58
Sulphur %	0.28	0.15
Calorific value cal/g	5,103	4,287

The ash content is in the same range with other agricultural residues (except for rice straw and rice husk which have significantly higher ash content) reported by Bhattcharya (1990) but the fixed carbon is lesser than other residues. It is interesting to note that the calorific heating value of the rubber leaves is the highest among other major agricultural residues in Thailand. This might be the result of the present of dry latex in the leaves. The comparison of the two types of wastes revealed that the leaves contain higher percentage of carbon, ash and heating value, but lesser in fixed carbon. The higher heating value of the leaves (than the branches) corresponds to the higher fraction of dry latex in the leaves than that in the branches.

4.2 Availability and Status of Energy from Rubber Plantation Wastes

As the total amount of rubber plantation wastes and their inherent energy value were obtained, the availability of energy from the wastes can be estimated as appeared in Table 4.

Table 4

The Availability of Energy from Rubber Plantation Wastes

Total planted area is 10.7x10^6 rai.
Leaves 227.3 kg/rai, branches 15.7 kg/rai, seeds 132.2x10^6 kg all over the country

Type of wastes	Availability (x10^6 kg)	Fuel Value Kcal/kg	x10^{16} J
Leaves	2432.11	5,103	5.1929
Branch	167.99	4,287	0.3132
Seeds	132.2	5,825@	0.3222
Total			5.8283

@ from Lim (1986)

The total energy of 5.8283x10^{16} J is equivalent to 1,364.9x10^3 toe. In 1988, Thailand's energy consumption was quoted at 22,927x10^3 toe (NEA, 1989). Thus, availability of energy from the rubber plantation wastes represents 5.95% of the energy consumption of the country.

However, it was reported that about 23% of the planted area is mountainous (Sinturahat, et al 1986) and accessible only by feet or motorcycles. A certain portion of the plain area is hinterland and too far from the road for the wastes to be acquired economically. According to a report by Prasertsan et al (1991) it is believed that 40% of the total wastes is claimable. Thus, energy which can be possibly acquired is 544,800 toe.

When compare the energy available from the rubber plantation wastes with other major agricultural residues in Thailand, the energy from the rubber plantation wastes ranks number 5 in terms of production and energy availability as shown in Table 5.

<u>Table 5</u>

Comparison of energy available from major residues

Residues@	Production ($x10^6$ kg)	Fuel Value Kcal/kg	($x10^{16}$ J)#	$x10^6$ Toe
Rice straw	33,151.4	3,824(B), 3,783(L)	53.042	12.420
Bagasse	9,168.7	4,322(B), 4,135(L)	16.580	3.880
Rice husk	5,037.8	3,692(T) 3,564(L)	7.782	1.822
Cassava stalk	4,106.4	4,188(B), 4,080(L)	7.195	1.685
Rubber wastes	(see Table 4)		5.828	1.365
Corn cobs	1,176.3	4,232(B)	2.083	0.488

@ Residues apart from rubber waste are from Bhattcharya (1990)
 # Calculated from heating value of Thai's agricultural wastes.
(B) = Bhattcharya (1990), Thailand's data.
(L) = Lim (1986), Malaysia's data.
(T) = Terdyothin et al (1987), average of 3,489-3,896 kcal/kg.

In practice, corn cobs should have higher status since very high percentage (say 90%) of the cobs can be claimed as they are, unlike the rubber plantation wastes, readily available at the processing plants.