A Survey of Uncarbonized Briquettes and Biocoal Markets in Thailand

S.C. Bhattacharya, Ram M. Shrestha, Prasong Wongvicha, and Suchitra Ngamkajornvivat
Energy Technology Division, Asian Institute of Technology
P.O. Box 2754, Bangkok 10501
Thailand

ABSTRACT

This paper reports the results of a recent study on the status of biocoal in Thailand including a market survey of briquetted biomass, both carbonized and uncarbonized. Existing and potential users have been identified and the economics of traditional fuel substitution by briquetted biomass has been evaluated. The paper also reports the reasons for the present acceptability of sawdust charcoal as revealed by the market survey.

INTRODUCTION

As in many other developing countries, agricultural and forestry activities in Thailand are accompanied by the generation of large amounts of residues. These residues could become valuable fuels if proper conversion methods are adopted.

Direct use of agricultural residues as fuel is normally characterized by low efficiency. Also the low bulk density of the residues often makes them uneconomical to store or transport. One method to overcome these difficulties is to densify them (Reed and Bryant, 1978).

Densification is the process of compacting material of low bulk density to a denser product. Agricultural residues are subjected to a compaction pressure at a temperature above 100°C for binderless densification. It is believed that during the process, the lignin portion of the material softens and acts as an internal glue that gives the final product its mechanical strength and cohesion. Densified fuels can be produced in various forms, e.g. briquette, pellet and cube. Since, compared with the original material, the product occupies less volume for a given weight, it is more convenient to handle and cheaper to transport and store. Briquettes, however, in general have poor combustion characteristics. They are difficult to ignite and smoke profusely while burning.

One way of upgrading the briquetted residues as fuel is to carbonize them to produce biocoal. Carbonization is generally carried out in brick or metal kilns similar to those used for wood carbonization. The carbonized briquette develops a higher temperature in stoves and furnaces and has the advantage of relatively smokeless combustion. As it does not rot and is not attacked by termites, fungus, etc., the storage losses are relatively very low.

Because of the demand of fuelwood and charcoal growing faster than the sustainable supply, the application of densification technology to agricultural and forest residues, which often remain unutilized, appears to have an important role to play in Thailand.

This paper reports the present status of biocoal technology in Thailand. The results of a survey conducted during February-May 1988 to collect information about the supply and consumption of uncarbonized briquettes as well as biocoal, are also presented (Wongvicha, 1988).

UTILIZATION PROFILE OF UNCARBONIZED AND CARBONIZED BRIQUETTES IN THAILAND

The densification of residues, specifically rice husk and sawdust, has been technically established in Thailand for about a decade to produce both uncarbonized and carbonized briquettes. Uncarbonized briquettes are mostly supplied to refugee camps while the carbonized briquettes are sold in both domestic and export markets.

Briquetting Machines Manufacturers

The three manufacturers of densification machines in Thailand are located in the Bangkok district (Bhattacharya, *et al.*, 1985). They are:

a) V.S. Machine : 90/20 Soi 1, Ladprao Road, Bangkok 10900.
b) Thailand Institute of Scientific and Technological Research (TISTR) : 196 Paholyothin Road, Bangkhen, Bangkok.
c) S.P. Energy : 53 Moo 6, Ladkrabang, Bangkok 10520.

The first two are the only manufacturers who have sold a significant number of machines. The last has developed machines only for their own use, although they have the potential to supply machines. V.S. Machine is the biggest supplier of densification machines in Thailand.

Briquetting and Biocoal Technology

Briquetting Process

All the machines of Thai manufacture are based upon an original design from Taiwan. All are extrusion devices consisting of a screw and a heated die. The feedstock is forced by the screw into the die to form large hollow cylindrical briquettes. The briquettes have an outside diameter of about 5 cm, an inside diameter of about 2.5 cm, a length of about 50 cm, and average weight of 1.3 kg. The throughput is about 100 kg/hr. Figure 1 shows the densification machine used for briquetting.

The die is normally heated by electrical heaters. Machines with dies heated by burning charcoal or other waste materials have also become available recently. Briquetting is carried out at die temperatures in the range of 260-300°C. Only dry materials having 8-12% moisture content can be used.

a) *Rice Husk Briquetting*

Rice husk is briquetted without drying since it has a low moisture content of about 11% when produced in rice mills. The briquetting process for rice husk is simpler than for sawdust since it does not need a drying system.

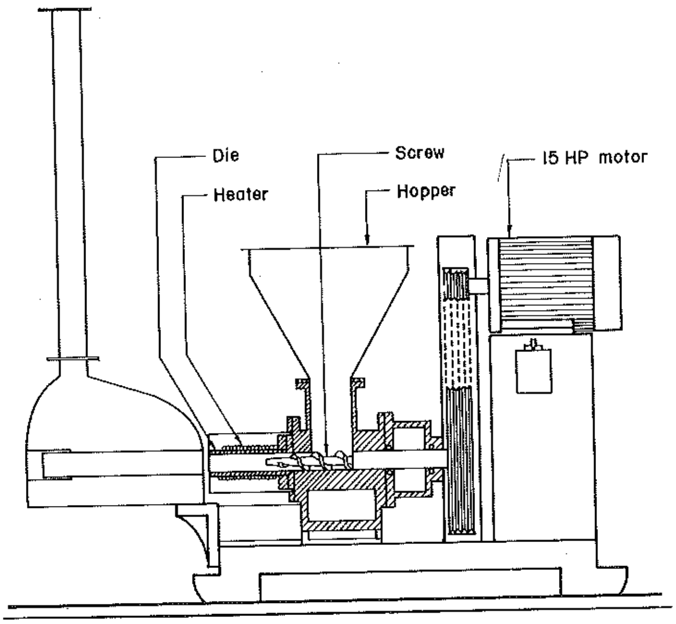

Fig. 1. Extrusion-type densification machine used in Thailand.

b) *Sawdust Briquetting*

Generally, sawdust has a moisture content varying from 30% to 60% before drying. It has been found that when the final moisture content is 6% to 10% briquettes are strong and free of cracks and the briquetting operation is smooth.

The drying system for sawdust briquetting consists of a separator, a conveyer, a rotary dryer and a furnace. The rotary dryer consists of a revolving cylindrical shell slightly inclined towards the outlet. Wet feed enters at the upper end of the cylinder, dry material discharges from the other. As the shell rotates, internal flights lift the sawdust and shower them down through the interior of the shell; drying takes place due to direct contact of hot gas with wet material. The hot gas required for drying is produced by burning waste wood in a furnace and is moved through the dryer by a fan.

Methods of Biocoal Making in Thailand

Biocoal making is a well-defined process in Thailand. It consists of two major steps: briquetting of biomass and carbonization of biomass briquettes. So far only sawdust is used as the raw material. Carbonization is carried out in brick or metal kilns.

Briquetted Biomass Production and Consumption

Uncarbonized Briquettes

During the period 1978-1983, when there were dramatic increases in commercial energy prices biomass briquettes appeared to be an increasingly attractive fuel. During this period many briquetting machines were installed in Thailand. Most of the briquetting machines were however subsequently shut down because of lack of demand for the product.

As shown in Table 1, at the time of the survey there were only two rice husk briquette producers while the number of sawdust briquette producers was seven. The number of machines involved in rice husk and sawdust briquetting were 9 and 44 respectively.

Table 1. Briquette producers and operating machines as of survey period.

Region	No. of Briquette Producers		No. of Briquetting Machines	
	Rice Husk	Sawdust	Rice Husk	Sawdust
Northern	-	1	-	4
North-Eastern	-	-	-	-
Central	2	4	9	34
Eastern	-	1	-	3
Southern	-	1	-	3
Total	2	7	9	44

Figure 2 shows the structure of uncarbonized briquette market in Thailand as revealed by the survey. There were 4 middlemen involved in the distribution of briquettes and about 133,000 refugee consumers involved in the market. A small quantity of briquettes is also consumed in a few temples.

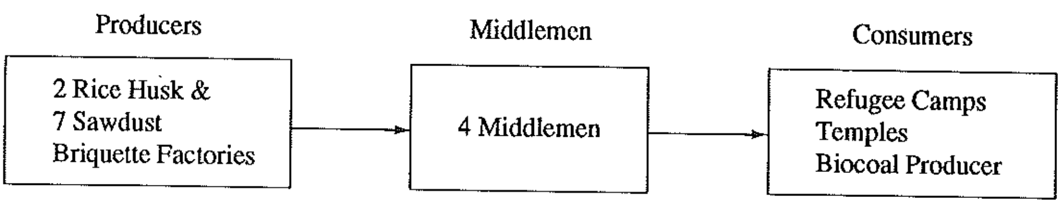

Fig. 2. Structure of uncarbonized briquette market.

Biocoal

The carbonized briquettes were first produced in the year 1982. Presently, there are three commercial biocoal plants in Thailand located in two provinces[1]. One is located in Chiangmai and more than 90% of its product appears to be exported to Korea. Biocoal in excess of export

[1] For details on the economics of biocoal production in Thailand see Bhattacharya, *et al.* (1988).

demand and of quality unsuitable for exports is locally sold at a price of 3 Baht/kg. The other two factories export their products to Korea, Hong Kong and Taiwan. For the domestic market biocoal is sold to a middleman at a price of 4 Baht/kg; from the retailers the consumers normally buy biocoal packed in plastic bags of 2.5 kg each at a cost 13 Baht/bag, i.e. 5.2 baht/kg. Another biocoal distribution channel is a department store chain where well-packed biocoal is sold at 18 Baht/kg.

The structure of the carbonized briquette market is organized as shown in Fig. 3.

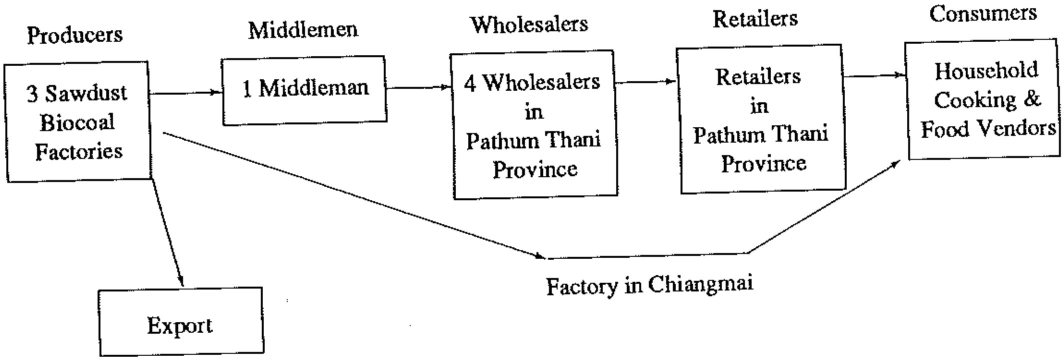

Fig. 3. Structure of biocoal market.

EXISTING UNCARBONIZED BRIQUETTE AND BIOCOAL USERS

Uncarbonized Briquette Users

Based on the information obtained from the survey the existing consumers are categorized as follows:

Refugees

Initially, when refugee camps were first established in Thailand, the Ministry of the Interior issued a policy preventing the use of forest products as cooking fuel for the refugees. Briquettes were introduced as substitute fuel and have since become an important fuel for household cooking within the refugee camps.

There are now 8 refugee camps in Thailand situated in 7 provinces. A total of about 133,000 refugees live in these camps.

Briquettes are provided to the inmates of the camps free of charge whereas they have to pay for wood charcoal, LPG and other fuels. The amount of briquettes provided for each refugee is 7-8.5 kg per month. Assuming every refugee utilizes briquettes at this provided rate, the total annual demand of briquettes in refugee camps can be estimated at about 11,145 - 13,532 tons per year.

Uncarbonized rice husk briquettes are also supplied in small quantities to some temples in the Northern and Central regions of Thailand. It is found that rice husk briquette can be conveniently used for cremation because of its uniformity in size and consistent quality. The other advantage that was cited is that it can eliminate odour to some extent probably because of high ash content. Presently, briquette consumption by the temples is estimated to be less than 50 tons/year.

Biocoal Users

A survey of biocoal users was conducted in Pathum Thani province of Thailand to study why, how and for what purpose biocoal is being used. The sample in the survey comprised of 123 users. The respondents were asked through a questionnaire to provide information about biocoal use.

Table 2. Types of cooking using briquette charcoal.

Type of Cooking	Consumers	
	Number	Percentage
Cooking Rice	28	22.8
Boiling	82	66.7
Frying	33	26.8
Roasting	47	38.2
Steaming	3	2.4

Total respondents = 123

Biocoal supplied to the domestic markets is mostly used by food vendors in Pathum Thani Province and Bangkok, with some limited consumption of biocoal in Chiangmai. No evidence was found of significant biocoal use elsewhere. Boiling is the most popular type of cooking for which the food vendors utilize biocoal. Other types of cooking are also performed as summarized in Table 2. It may be noted that many respondents use biocoal for more than one type of cooking. The average amount of biocoal consumed is 17.2 bags (each containing 2.5 kg biocoal) per week, per vendor as shown in Table 3.

Table 3. Average amount of biocoal used by food vendors.

Bags/Week	Respondents	
	Number	Percentage
< 5	2	1.6
7	16	13.0
10	17	13.8
12	1	0.8
14	41	33.3
21	25	20.3
28	10	8.1
35	6	4.9
42	3	2.4
47	2	1.6

Total Respondents = 123
Average = 17.2 bags/week

POTENTIAL UNCARBONIZED BRIQUETTE AND BIOCOAL USERS

Total rural consumptions of fuelwood and charcoal in 1982 were estimated to be 2,451 and 2,366 million litres of crude oil equivalent respectively (Lucas *et al.*, 1987). Of these quantities rural industrial consumption accounted for 620 and 157 million litres of crude oil equivalent of fuelwood and charcoal. This indicates the extent of demand for fuelwood and charcoal in Thailand.

Although use of uncarbonized briquette and biocoal is rather limited at present, the situation may change if fuelwood and charcoal become relatively more expensive or if the government intervenes favorably to promote the use of residues.

Uncarbonized Briquettes

The potential users of uncarbonized briquettes are primarily the industries that are using fuelwood at present. These include industries engaged in: 1) manufacturing of bricks, tiles and pipes, 2) pottery, 3) tobacco curing, 4) lime making, 5) production of noodles and other food products, 6) production of crispy crackers, 7) bakery, 8) tapioca drying, 9) palm sugar making, 10) fish meal preparation, etc.

Biocoal Users

The acceptability of biocoal for industrial use would largely depend on how closely its thermal and other physical characteristics match the requirements of a particular industry.

Based on combustion quality biocoal could be considered a close substitute for wood charcoal. Hence it can be concluded that the industries which use wood charcoal at present have a potential of switching to biocoal. These include blacksmithy, foundry, metal forging, iron smelting, etc.

REASONS OF PRESENT ACCEPTABILITY FOR SAWDUST CHARCOAL

Out of the 123 users identified in Pathum Thani province 121 were food sellers and 2 were household users. Different reasons were given by food sellers for why they used biocoal instead of other fuels. The results are shown in Table 4. The main reasons given by more than 91% of the users were that biocoal was more convenient and also readily available. One of the reasons behind finding the use of biocoal to be more convenient than charcoal could be its longer lasting fire compared to wood charcoal. This is because less attention is needed for periodically adding more fuel in the stove and the vendor is able to concentrate more on preparing food. Also, the uniformity of size made biocoal easier to cut into small pieces. In addition, biocoal sold in 2.5 kg bags appears to conveniently meet the requirements of food vendors as compared with LPG cylinder and biocoal or wood charcoal purchased in large quantities which are quite inconvenient to accommodate or carry in their vending carts. Around 22.3% of the users cited the improved flavour of the food as a reason for using biocoal. The main reason given by these users for improved flavour of food was that biocoal generated more steady and strong heat, which meant that certain types of cooking which required a high temperature could be done quickly, thus preserving the flavour of the food. In addition, the non-sparking fire of biocoal kept the food clean. About 13.2% of the respondents claimed that stronger heat generated by biocoal (compared

Table 4. Reasons for using biocoal rather than wood charcoal by food sellers.

Reason	Respondents	
	Number	Percentage
Cheaper	9	7.4
As easily available as wood charcoal	111	91.7
More convenient	118	97.5
Improved flavour of food	27	22.3
Stronger heat	16	13.2

Total respondents = 121

to wood charcoal) was a reason for their using it. This is due to wood charcoal burning away faster and resulting in weak fire in between charges to the stove.

Attributes of Biocoal that Users Like

Certain attributes of biocoal were liked by the users and thus indirectly contributed towards its acceptance. The most important was the non-sparking characteristic of biocoal as shown in Table 5.

Table 5. Attributes of biocoal liked by food sellers.

Attributes	Respondents	
	Number	Percentage
Non-sparking	119	98.3
Easy to ignite	103	85.1
Less smoking than wood charcoal	91	75.2
Less quantity requirement than wood charcoal	86	71.1
Less ash content than wood charcoal	108	89.3
Easier to handle than wood charcoal	4	3.3
Longer lasting fire than wood charcoal	51	42.1

Total respondents = 121

One of the users cited that she changed to using biocoal because of the quality variations of wood charcoal. In particular she disliked the mixing of low quality wood charcoal inside the sack which resulted in a sparking fire when she used the charcoal. About 85.1% of the respondents regarded biocoal as easy to ignite. This response, however, does not imply comparison with any other fuel since the respondents were food vendors and ignited biocoal once a day; this means that advantages or disadvantages associated with ignition, if any, are not significant to them. This attribute, however, would be important for certain other users of biocoal, e.g. household cooking.

About 75.2% of the respondents liked the less smoking (compared to wood charcoal) attribute of biocoal. This is probably because biocoal production is more closely supervised compared to wood charcoal. Also, biocoal is produced in more sophisticated kilns, e.g. brick and steel kilns, while wood charcoal is normally produced in pit kilns or earth mounds.

Less quantity requirement of biocoal (compared to wood charcoal) is liked by 71.1% of the respondents. Since biocoal is less porous (more dense) and has slightly higher heating value compared to wood charcoal, it tends to burn more slowly resulting in a more steady and longer lasting fire. This is responsible for less quantity requirement in case of biocoal.

About 89% of the respondents liked the relatively low ash content of biocoal in comparison with wood charcoal. The raw materials for charcoal and biocoal making – wood and sawdust respectively – can be regarded as having nearly the same ash content. However, biocoal yield from sawdust briquettes in commercial plants is around 35% while charcoal yield from wood in traditional kilns is normally below 20%. The higher yield of biocoal compared to wood charcoal is responsible for its relatively low ash content.

Attributes of Biocoal That Users Disliked

A large percentage of the interviewed users (42.1%), as shown in Table 6, disliked the high smoke generation sometimes encountered when using biocoal. This is due to improperly carbonized biocoal sometimes sold in the markets. Relatively difficult ignitability of biocoal in comparison with wood charcoal is disliked by 14.9% of the users. A large number (31.4%) of users, however, commented that biocoal had no attribute that was disliked by them.

Table 6. Attributes of biocoal disliked by food sellers compared with wood charcoal.

Attributes	Users	
	Number	Percentage
More ash	1	0.8
Fire harder to ignite	18	14.9
More quantity required	4	3.3
More smoke or flame when not completely carbonized	51	42.1
More expensive	8	6.6
More fines in bag	9	7.4
Frequent shortages	3	2.5
None	38	31.4

Total respondents = 121

ECONOMICS OF TRADITIONAL FUEL SUBSTITUTION

Biocoal is at present mostly used for cooking purposes. The costs of using alternative fuels for cooking are evaluated in the following discussion.

Table 7 presents the annual cost of cooking by food vendors using 3 alternative fuels, i.e. wood charcoal, LPG and biocoal. Since the price of wood charcoal varies with whether it is bought in small quantity (i.e. in plastic bags containing 2 kg each) or in large quantity (i.e. in sacks containing 45 kg each), charcoal prices corresponding to each of these sizes are included for the purpose of cost comparison. The amount of biocoal used per day by a food vendor has been taken to be 6.25 kg, the average figure as was revealed by the survey.

The total annual fuel costs of using the alternative fuels by the food vendor are calculated taking into account the efficiencies of stoves burning each type of fuel. These costs are shown in column 6 of the table. It is clear that biocoal is less expensive compared to wood charcoal only when the latter is purchased in small quantities. Both LPG and wood charcoal purchased in large quantities are found to be more economical than biocoal.

Despite the cost advantages of LPG, and charcoal purchased in large quantities, it was revealed by the survey that the food vendors prefer to buy biocoal in small quantities since LPG cylinder and biocoal/charcoal in large quantities are quite inconvenient to transport in their food vending carts.

How do the costs of using biocoal and substitute fuels compare if both fuel and capital costs are considered? For this purpose we consider a single burner LPG stove for burning LPG and a Thai bucket stove for burning both wood charcoal and biocoal. The life of an LPG burner is assumed to be 7 years whereas the life of the bucket stove is assumed to be 2 years. The annual appliance cost is computed at an annual interest rate of 12%. With the prices of an LPG stove and a bucket stove taken as 550 Baht and 50 Baht respectively, the total annual costs including fuel and appliance costs for various fuels are given in column 7. Interestingly, inclusion of appliance costs does not alter the relative economics of cooking fuels. It can again be seen that biocoal is the less costly fuel for cooking only in comparison with wood charcoal bought in small quantities.

CONCLUSIONS

Uncarbonized Briquette

(i) At present the markets for uncarbonized briquettes are limited. The briquettes are mainly used as cooking fuel by refugees who get a fixed amount of briquettes free of cost. Small amounts of briquettes are also used in temples for cremation. Except in the refugee camps, direct use of briquettes is not attractive for household users since existing charcoal stoves do not burn the briquettes efficiently resulting in the generation of smoke.

(ii) A number of plants that were installed in early 1980's are now out of operation. At present there are only 2 rice husk briquetting plants and seven sawdust briquetting plants.

(iii) The production of sawdust briquettes has been steadily increasing over the last few years.

(iv) Most briquette producers sell briquettes through middlemen who are successful in bids for selling briquettes to refugee camps.

Table 7. Total annual cost of energy consumed by food vendor.

Fuel	(1) Calorific Value (Kcal/kg)	(2) Unit Cost of Fuel (Baht/kg)	(3) Unit Energy Cost (10^{-3} Baht/ Kcal)	(4) Energy Use Efficiency (%)	(5) Annual Primary Energy Consumption (10^3 Kcal)	(6) Annual Energy Cost of Cooking (Baht)	(7) Annual Energy Cost of Cooking Including Appliance Cost (Baht)
1. Wood Charcoal							
1.1 Packed in plastic bag (around 2 kg/bag)	6,823 1/	5.00	0.7328	27.0 3/	17,178	12,588	12,619
1.2 Packed in big sack (around 45 kg/sack)	6,823 1/	2.44	0.3576	27.0 3/	17,178	6,143	6,174
2. LPG	11,154 2/	10.00	0.8965	60.0 4/	7,730	6,930	7,051
3. Biocoal	7,530 1/	5.20	0.6906	27.0 3/	17,178	11,862	11,894

Source: 1/ Bhattacharya, *et al.*, 1985.
2/ Wibulswas, 1986.
3/ Islam, *et al.*, 1984.
4/ Economic and Social Commission for Asia and the Pacific, 1980.

Biocoal

(i) At present there are three biocoal plants producing biocoal from sawdust but none producing biocoal from rice husk.
(ii) All factories producing biocoal aim for export since export prices are much higher than domestic prices. Only the surplus left after export and biocoal below export quality are sold in domestic markets.
(iii) At present, in most of the domestic markets, biocoal is less expensive than wood charcoal sold in small quantity (in plastic bags each containing 1.4 to 2.0 kg) but more expensive than charcoal sold in large quantities (in large sacks, each containing 30 - 60 kg).
(iv) Biocoal is mostly used by food vendors who sell food from mobile stalls. The quantities of fuel bought by them each time are relatively small just enough to meet the daily requirement. This makes biocoal cheaper than wood charcoal.
(v) The attributes of biocoal that most users like include non-sparking characteristic, low smoke generation, low ash content, economy in use and long lasting fire. An attribute of biocoal that some users do not like is the difficulty in starting a fire.

ACKNOWLEDGEMENTS

This paper reports results from a biocoal project sponsored by the German Agency for Technical Cooperation (GTZ).

REFERENCES

1. Bhattacharya, S.C., R. Bhatia, M.N. Islam, and N. Shah (1985), Densified Biomass in Thailand: Potential, Status and Problems, *Biomass*, Vol. 8, pp.255- 266.
2. Bhattacharya, S.C., R.M. Shrestha and N. Chakrabarti (1988), *Economics of Biocoal Production in Thailand*, Asian Institute of Technology, Bangkok, Thailand.
3. Economic and Social Commission for Asia and the Pacific (1980), *Renewable Sources of Energy*, Vol. I, Bangkok.
4. Islam, M.N., S.C. Bhattacharya, G.Y. Saunier, N. Shah, R. Bhatia, C. Phosuphap, T. Suntharampillai, and S. Rongthong (1984), *A Study on Fuelwood Charcoal and Densified Fuels in Thailand*, Asian Institute of Technology, Bangkok, Thailand.
5. Lucas, N.J.D., J. Ambali, E. Chang, M. Forbes-Ricarte, and R.M. Shrestha (1987), *Energy Policies in Asia - A Comparative Study*, McGraw-Hill, Singapore.
6. Reed, T. and B. Bryant (1978), *Densified Biomass: A New Form of Solid Fuel*, SERI Report 35, The Solar Energy Research Institute, U.S.A.
7. Wibulswas, P. (1986), Rural Energy Issues in Thailand, *Renewable Energy Review Journal*, Vol. 8, No. 1.
8. Wongvicha, P. (1988), *A Study of Briquettes and Biocoal in Thailand*, Research Study Report, Division of Energy Technology, Asian Institute of Technology, Bangkok, Thailand.