ECONOMICS OF RUBBERWOOD CHARCOAL PRODUCTION USING THE TRANSPORTABLE METAL KILN

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WOON, W. C., HOI, W. K. & PUAD ELHAM. 1989. Economics of rubberwood charcoal production using the transportable metal kiln. The Tropical Development and Research Institute has developed a transportable metal kiln which is suitable for converting most types of wood residues to charcoal. We have successfully adapted this technology to produce rubberwood charcoal. To determine the optimum number of kilns suitable for economic charcoal production in rubber smallholdings, six operating schedules involving various number of kilns and workers were considered. The unit production cost varied from 6.7 to 10.9 cents per *kg* while monthly profit derived ranged from US$42.08 to US$579.05 depending on the operating schedule used. The payback period and breakeven area varied from 0.7 to 19.6 months and 0.5 to 5.1 *ha* respectively.

Key words: Rubberwood - charcoal - transportable metal kiln - economics

Introduction

In Peninsular Malaysia large volumes of wood residues are generated in logging operations and in wood processing mills. In 1983, the timber industry itself generated approximately 10.1 million m^3 of wood residues in the form of off-cuts, slabs, bark, sawdust, rejects, trimmings, plywood cores and shavings (Jalaluddin *et al.* 1983). Currently, only a small portion of these residues are used as fuel (charcoal and firewood), for fencing, wood chips (particleboard), horticultural uses and small wooden artifacts. The rest are frequently left to rot or burnt at a cost.

The Tropical Development and Research Institute (TDRI) of the United Kingdom has over the years successfully developed a simple but versatile transportable metal kiln (TMK) that is suitable for producing charcoal from most types of wood residues (Paddon & Harker 1980). This technology was successfully introduced into Malaysia through the British Colombo Plan Aid in 1983 (Wong & Hoi 1983).

FRIM has successfully adapted the TDRI version of the TMK for producing rubberwood charcoal. Many studies have been carried out on the technical feasibility of the TMK (Hoi *et al.* 1985, 1986, Donald 1939, Ramaswami 1935, Tryon 1933). However, no study was carried out on the financial feasibility of charcoal production using the TMK. In this paper, we attempt to investigate the optimum operating schedule that would be most commercially viable and economically tenable in Peninsular Malaysia.

The transportable metal kiln

The kiln has a capacity of about 7 m^3 and can produce about 0.5 *t* of charcoal per burn. The most appropriate rubberwood billet size is between 45 to 90 *cm* long and up to 30 *cm* in diameter (Hoi 1983). Large billets can be used, but they have to be split in order to achieve better packing density. The whole carbonisation process takes three to five days.

Methodology

Location

The field trials were carried out at Kampung Serigala, Selangor Darul Ehsan, Peninsular Malaysia. Two rubber smallholders participated in the trials.

Method

Two aspects were considered: the options of either buying or renting the kilns. The various operating schedules are as listed in Table 1.

Table 1. Method of study

Operating schedule	1 kiln/2 men	2 kilns/3 men	3 kilns/3 men
Own kiln(s)	Option I	Option III	Option V
Kiln(s) rental	Option II	Option IV	Option VI

The following indicators and parameters were used in the evaluation : (a) unit cost of production ($ per *kg*); (b) profitability; (c) payback period (months); and (d) area of rubber plantation required to breakeven. All prices and costs are in US$.

Limitation

Only two kilns were used throughout the field trials. The operating schedules involving three kilns (options V and VI) were not carried out. The cost of production was estimated using the data obtained from the one and two kilns operating schedules.

The smallholders were involved on a part time basis in the study and occasionally took up other activities throughout the trial period. They were also assisted by their children. However, in the calculation of the production cost, it was assumed that the smallholders work on a full time basis. This was because the felling cost had to be included. As such, the current wage rate of $6.00 per man-day was assumed. The cost of rubberwood was assumed to be negligible as during replanting they are usually burnt.

The costs of moving the kilns to the trial site were not taken into account as these were accounted for in the rental and purchase price of the kiln. In this study the price of the kiln was quoted ex-Kuala Lumpur, Peninsular Malaysia.

We were unable to compare the production cost of charcoal of other wood species using the TMK technology.

Capital investment

The initial capital investment for one kiln was $800 excluding an additional $372 for a chainsaw and accessory tools (Table 2). All prices quoted were ex-Kuala Lumpur. For the options where the kilns were rented, the initial capital investment was $372 for the chainsaw and accessory tools.

Table 2. Capital investment (own and rented kilns) ($)

Item	1 kiln	2 kilns	3 kilns
Transportable metal kiln @ $800 ex-K.L.	800	1600	2400
Chainsaw @ $320 - 1 unit	320	320	320
Spade - @ $10 - 2 units	20	20	20
Axe - 1 unit	6	6	6
Wedge - 1 unit	2	2	2
Heat proof gloves - 1 pair	16	16	16
Sledge hammer - 1 unit	4	4	4
Sieve chute - 1 unit	2	2	2
Needle for sewing gunny sack	2	2	2
Total investment (own kilns)	1172	1972	2772
Rented kiln(s) & own equipment	372	372	372

Note: All costs based on field trials

Depreciation

The life span of a kiln is estimated to be three years and that of the chainsaw and accessory tools is estimated at 1000 operating hours. Depreciation of the kiln was based on the straight line method at 33.3% per year whilst that of the chainsaw and accessory tools was on the number of operating hours. The salvage value was assumed to be negligible. As each burn required two operating hours, the total depreciation for chainsaw and accessory tools was $0.74 per burn (Table 3), and the monthly depreciation for a kiln was $22.22.

Table 3. Depreciation of equipment ($)

Depreciation	1 kiln	2 kilns	3 kilns
Cost of kiln	800.00	1600.00	2400.00
Annually	266.67	533.33	800.00
Monthly	22.22	44.44	66.67

Kiln life is estimated at three years
Depreciation is 33.3% per year
Chainsaw & tools: 2 *h* per burn
Life span = 1000 operating hours
Cost of chainsaw & tools = $372.00

$$\text{Depreciation per burn} = \frac{\text{Hours operating}}{\text{Life span}} \times \text{Cost of chainsaw and tools}$$

$$= \frac{2}{1000} \times \$372.00$$

$$= \$0.74.$$

Raw material requirement and charcoal output

An average of 3.5 days was required per burn. The breakdown is as follows:

Operation	Duration (*h*)
Set-up of kiln	1
Loading	2
Firing	2
Carbonization	48-52
Cooling	24
Unloading	2
Total	78-83

A total of eight burns per month was obtained for a one kiln schedule. Theoretically, it was possible to obtain 16 burns using two kilns and 24 burns using three kilns. However, in practice, only 22 burns could be achieved using three kilns. This was due to the fact that loading and unloading could not be done during the night. Table 4 shows the number of burns that could be obtained from a one, two and three kilns operating schedule.

Table 4. Raw material requirement and charcoal output

Number of kilns	1 kiln	2 kilns	3 kilns
Number of burns per month[a]	8	16	22
Charcoal production (*kg*)[b]	4000	8000	11000
Number of rubber trees [c]	64	128	176
Area of rubber plantation/month (*ha*)[d]	0.26	0.52	0.71

[a]Based on a duration of 3.5 days per burn and a 28 working month
[b]Based on an average charcoal yield of 500 *kg* per burn
[c]Based on an average of 8 trees per burn
[d]Based on an average of 247 standing trees per hectare during replanting
The average moisture content of the rubberwood is between 35 to 43%

The average yield per burn was 500 *kg* (Hoi *et al.* 1986). Based on field trials, an average of eight rubber trees were required for one burn. The area of rubber trees required monthly for a one, two and three kilns operating schedule was therefore 0.26, 0.52 and 0.71 *ha* respectively.

Results and discussion

Cost of rubberwood charcoal production

In the determination of the the production cost, the kiln rental cost ($40) was based on the rate charged by the Rubber Industry Smallholders Development Authority (RISDA). The total monthly labour cost was based on a 28 working day month. Based on field trials (Hoi *et al.*, 1986) fuel consumption amounted up to $2 per burn. Packaging cost was at $0.20 per bag (20 *kg* per bag). The unit production cost of charcoal is given in Table 5.

Option V at 6.7 cents per *kg* was the lowest unit production cost. This was followed by Option VI at 7.2 cents per *kg*. Option II had the highest unit cost of production (10.9 cents per *kg*). The unit production cost was always higher in rented kilns options compared to purchased kilns options. Because of the economics of scale, production cost decreased as more kilns were used.

Table 5. Cost of rubberwood charcoal production ($)

Number of kilns	1 kiln		2 kilns		3 kilns	
Number of burns per month	8		16		22	
Charcoal production (*kg*)	4000		8000		11000	
Number of labourers	2		3		3	
Option	I	II	III	IV	V	VI
Labour cost @ $6/day[a]	336.00	336.00	504.00	504.00	504.00	504.00
Cost of bucking @ $2/burn[b]	16.00	16.00	32.00	32.00	44.00	44.00
Packaging cost @ $0.001/*kg*[c]	40.00	40.00	80.00	80.00	110.00	110.00
Rental of kiln @ $40/month	-	40.00	-	80.00	-	120.00
Depreciation[d]						
Kiln	22.22	-	44.44	-	66.67	-
Chainsaw & tools @ $0.74/burn	5.92	5.92	11.84	11.84	16.28	16.28
Total production cost	420.14	437.92	672.28	707.84	740.95	794.28
Cost of charcoal (cents /*kg*)	10.5	10.9	8.4	8.8	6.7	7.2

[a] Based on 28 working days in a month
[b] Petrol consumption of chainsaw for felling and bucking
[c] Based on 20 *kg* to a gunny sack (20 cents each)
[d] Refer Table 3

Profitability

The charcoal was sold at 12 cents per *kg*. Table 6 shows the net profit per hectare derived for the various options.

Table 6. Profit and payback period of rubberwood charcoal production

Number of kilns	1 kiln		2 kilns		3 kilns	
Charcoal production (*kg*)	4000		8000		11000	
Option	I	II	III	IV	V	VI
Sale @ $0.12//*kg*	480.00	480.00	960.00	960.00	1320.00	1320.00
Cost of production	420.14	437.92	672.28	707.84	740.95	794.28
Profit/month per *ha*	59.86	42.08	287.72	252.16	579.05	525.72
Payback period (months)[a]	19.6	8.8	6.9	1.5	4.8	0.7
Area of rubber plantation (*ha*)[b]	5.1	2.3	3.6	0.8	3.4	0.5

[a] Initial capital investment/profit per month
[b] Payback period times area required per month

Option V gave the highest monthly profit at $579.05 followed by Option VI at $525.72. Option II at $42.08 per month was the lowest. A higher profit was derived in purchased kilns options (Options II, IV & VI) as compared to rented kilns (Options I, III & V). This was because the rental fees in Options II, IV and VI were higher than the monthly depreciation in Options I, III and V.

Payback period

Option VI had the shortest payback period of 0.7 month while for Option IV it was 1.5 months (Table 6). On the other hand, Option I had the longest payback period of 19.6 months. Options involving kilns purchased had longer payback period than those which used the rental method. This can be explained by examining the formula used for determining the payback period,

$$\text{Payback period} = \frac{\text{Initial Investment}}{\text{Profit per month}}.$$

It is obvious that a large increase in the initial capital investment would result in a longer payback period if there was only a small increase in the monthly profit. This was the reason why the payback periods for options involving high initial capital investment were longer than those that required a lower initial capital investment. The initial capital investment for options II, IV and VI was only $372 while that for options I, III and V were $1172, $1972 and $2772 respectively (Table 2).

Area of rubber plantation required

The area of rubber plantation required was determined from the payback period and the number of burns per month. In Table 6, Option VI required the smallest area (0.5 *ha*) and Option I the biggest area (5.1 *ha*) to breakeven.

Selecting the best option

There were actually a few economically feasible options available. The cut-off point between which option(s) to choose depended on the level of the constraints set. In this paper, the study concentrated only on the rubber smallholders. The average size of a rubber smallholding was about 2 *ha*. Using this as the main selection criterion, Options I, II, III and V were not considered as these options required more than 2 *ha* to breakeven (Table 6). Of the two options remaining, the highest net return ($1108.90 after deducting initial capital investment) was derived from Option VI while that of Option IV was $597.85 (Table 7).

Table 7. Profitability and duration required to convert 2 *ha* of rubberwood to charcoal ($)

(1) Option	(2) Area of rubber plantation/month (*ha*)	(3) Duration required (month) (2) / 2	(4) Profit per month	(5) Total profit (3) x (4)	(6) Initial investment	(7) Net Return (5) - (6)
I	0.26	7.69	59.86	460.46	1172.00	-711.54
II	0.26	7.69	42.08	323.69	372.00	-48.31
III	0.52	3.85	287.72	1106.62	1972.00	-865.38
IV	0.52	3.85	252.16	969.85	372.00	597.85
V	0.71	2.82	579.05	1631.13	2772.00	-1140.87
VI	0.71	2.82	525.72	1480.90	372.00	1108.90

The duration required to convert all the rubberwood to charcoal for Options IV and VI (rented kilns) were 3.85 and 2.82 months respectively. Option VI was therefore the best option as it returned the highest profit in the shortest time. This was followed by Option IV.

The operating schedule

It should be noted that only up to three kilns were considered in the study. The reason was that the full cycle was completed in 3.5 days. This means that one kiln could be fired per day. On the fourth day, the first kiln would be ready for unloading and available for the next burn. The second kiln would be ready for the next burn on the fifth day while the third kiln on the sixth day. The rotation was repeated. However, in the case where the area of rubber plantation to be replanted is substantial it is possible to use the 6 kilns/6 men operating schedule or more. Each schedule has to be in multiples of the 3 kilns/3 men operating schedule, that is, 6 kilns/6 men., 9 kilns/9 men, *et cetera* in order to sustain optimum output and return.

Conclusion

The TMK was found to be technically feasible and financially viable for use in rubberwood charcoal production in the rubber smallholding during replanting. The 3 kilns/3 men kiln rental operating schedule is the most profitable schedule to adopt.

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