Testing Woodfuel Stoves Available in the Market in Cambodia

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ABSTRACT

This article describes the results of the first phase of a planned dissemination of woodfuel stoves in Prey Veng District, Cambodia. The lack of woodfuel was articulated as a medium priority need within the context of a community development program - Agriculture Business and Community Development (ABCD), Christian Outreach (UK NGO). In order to preposition an informed response to future requests for action, the ABCD program undertook a series of in situ tests of woodfuel stoves. Only stoves found within Cambodia were tested. The article presents the results of 11 stoves, two of which are designed for the combustion of rice husks. The tests indicated comparative wood consumption for the different stoves, including a control of a three stone fire. Management of the combustion process was shown to be a critical factor when dealing with some stoves. As expected the Thai Stove was shown to consume the least wood for a typical Khmer meal, however the difference between this stove and many others was marginal. In conclusion the paper suggests that given the Khmer way of cooking, almost any of the tested stoves could give about a 25% saving over the three stone fire (currently in popular use at the moment), although much depends on the management of the cooking process. No stoves are made within the District of Prey Veng, and the next phase of the program is to start local manufacture of the Thai Stove.

1. INTRODUCTION - FUELWOOD USE IN PREY VENG

The Christian Outreach Agriculture, Business and Community Development (ABCD) program is an integrated program tackling the needs of a part of Prey Veng District in Cambodia [1]. As a broad based program it follows an agenda set by the beneficiaries. Village discussions, both formal and informal, allow the beneficiaries to analyze their situation, and make changes according to their own priorities. The stated goal of the program is focused on the peoples awareness. From these discussions some villagers expressed concern at the amount of fuelwood they needed throughout the year. The ABCD program responded by undertaking a participatory survey of fuelwood supply.

Preliminary studies showed that the sales of fuelwood into Prey Veng town are controlled by three families [2]. Both in the peri urban and urban area of the towns the cost of fuelwood is a significant drain on the people's limited income. In the rural areas people gather their own firewood from government or unclaimed land. Some people are aware that the district of Prey Veng is "tree poor" a phrase used by the village chief of Tang Lang 2. Although the lack of accessible fuelwood was a need in response to questions, it is a medium priority on people's agenda. Fuelwood is gathered during the dry season from areas up to three days away by ox cart. This is a major consumer of dry season labor, and can take a man away from the household for more than two weeks a year. One of the greatest impacts of this localized fuelwood shortage and the resultant travel, is exposure to Malaria. Many men

become sick with malaria after having been to forested areas for the collection of wood. The ABCD program has witnessed the death of 7 persons in the last year resulting from malaria contacted while collecting firewood.

In the light of the above and other environmental concerns both local (micro climate) and global [3], there was felt to be a need to understand the domestic fuel market and to preposition appropriate interventions on both the supply and demand side. These interventions would form the basis for actions once the fuelwood situation moved up higher in the people's priorities. In the period 1993 to 1995, many higher priority needs were fulfilled by the program (water supplies, vegetable gardens, buffalo banks, rice improvements) and the fuelwood need is now being expressed as a high priority as predicted.

For planning purposes examples of stoves commonly used in Cambodia were purchased and studied. Using the now well documented approaches to stove improvement used in countries such as Thailand and Vietnam, "first guess" improvements were estimated [4]. The difference between an open three stone fire and the same fire with a simple clay surround was said to be of the order of a 40% saving in fuel (in the project proposal). Public awareness of such simple improvements would be the start of a campaign to save fuelwood.

The activities were to purchase or construct the stoves commonly used in Prey Veng Province, and to have all the alternatives installed in one place. Project staff undertook simple trials to determine the fuel use of each stove. These tests would be in situ rather than lab conditions. This understanding and the collated units could be used for planning a program of demonstration and increasing consumer awareness.

2. OBJECTIVES

- to determine the stove currently on the Cambodian market which consumes the least wood for a given cooking situation.
- to demonstrate the comparative worth of the stoves on the market in terms of fuelwood consumption.

3. TEST PROCEDURE

The project staff were commissioned to extend their travel to Phnom Penh, Svay Rieng, Battambang, Kampot, Kompong Cham and Pursat to search out different stoves. Only one particularly unusual stove was identified.

In total, 11 stove types were identified (Table 1 and Fig. 1). The majority are clay or clay and metal mixtures. In two cases the stoves are entirely metal construction. One stove is a concrete ring. Two of the stoves were sold specifically for the burning of rice husks. Although this was not in the original proposal, these stoves were purchased and tested for their efficiency. The purchase price and location of each stove was documented and is given in Table 1.

A small shaded shelter was made to simulate the windless environment inside a Khmer house. Stoves were set up four at a time. A measured quantity of rice and water were cooked (at known starting temperatures). The amount of wood used was measured. The wood was uniform diameter sticks, of the same species and material density. Moisture levels were checked by drying samples of the wood in a gas oven.

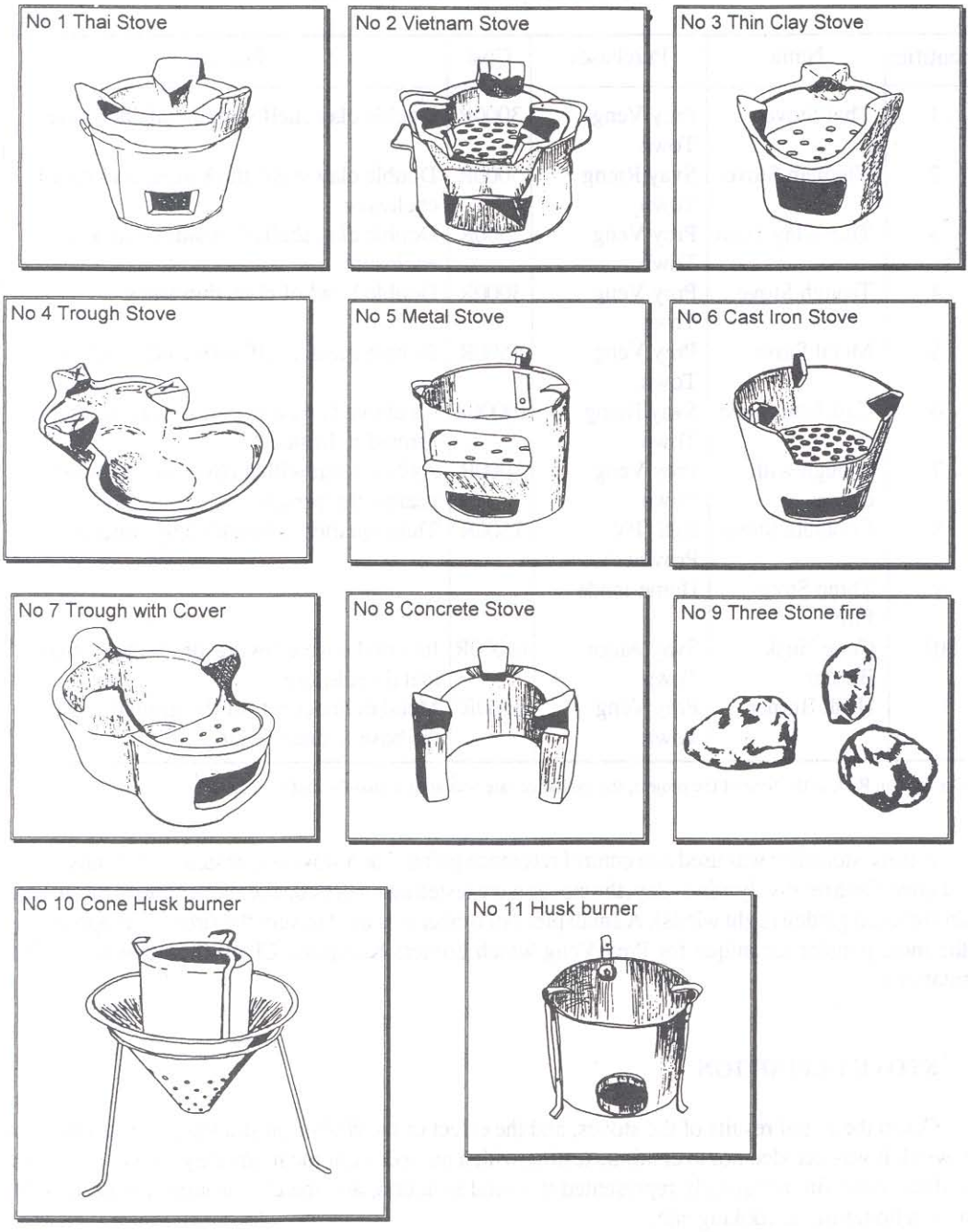

Fig. 1. Biomass stoves available in Cambodia.

Table 1. Description of tested stoves.

Identifier	Name	Purchases	Cost	Feature
1	Thai Stove	Prey Veng Town	3000R	Double clay shelf with metal enclosure
2	Vietnam Stove	Svay Rieng Town	5000R	Double clay shelf, thick sides and metal enclosure
3	Thin Clay Stove	Prey Veng Town	2500R	Double clay shelf, thin sides and metal enclosure
4	Trough Stove	Prey Veng Town	3000R	Double bowl of clay, thin sides
5	Metal Stove	Prey Veng Town	4500R	Double metal shelf with metal enclosure
6	Cast Iron Stove	Svay Rieng Town	10000R	As above but using cast iron rather than formed mild steel
7	Trough with cover	Prey Veng Town	3000R	As No. 4 but with a cover on the bowl nearest the person
8	Concrete Stove	Bati (PV Province)	1500R	Three quarter surrounded by concrete
9	Three Stone Fire	Home-made	-	-
10	Cone Husk Burner	Svay Antor Town	12000R	Inverted cone drawing air and husk from a metal enclosure
11	Husk Burner	Prey Veng Town	3000R	Metal cylinder set off the ground, hole in the base to draw in air

R=Cambodian Riel, at the time of the project, the exchange rate was approximately 2500R=1 US$

A three stone fire was used as a control reference point. Each stove was tested three times inside the shelter. On a relatively windy day, the stoves were tested again outside the shelter but on the ground of an enclosed garden (light winds). A small piece of rubber was used to start the fires. This apparently is the most popular technique for Prey Veng which borders Kompong Cham (home of the rubber plantation).

4. STOVE DEFINITION

Given the initial results of the stoves, and the effect of the shelter on shielding the stoves from the wind, it was decided not to continue testing with a number of home made clay stove variations. The three stone fire adequately represented the rural situation, and the clay trough represented the common home-made cooking site.

Each stove was tested three times , while the three stone fire was tested four.

Given also the initial results, the stoves numbers 1, 2, & 5 were tested again, with a control test on the three stone fire.

5. RESULTS

The results are presented in Figs. 2, 3 and 4, with the "Y" axis representing kilograms of biomass consumed to cook a given quantity of rice. Table 2 shows the average consumption of wood in kilograms for each stove during the test.

Table 2. Average kilograms of biomass consumed for cooking fixed quantity of rice.

Stove identifier	1	2	3	4	5	6	7	8	9	9b*
"windless", kg	.42	.32	.41	.48	.33	.32	.39	.37	.64	.43
"wind", kg	.44	.46	.50	.50	.50	.49	.48	.45	.50	
Check test, kg	.40	.34			.38					

* 9b is the average for the three stone fire discounting the 1st test.

5.1 Three Stone Fire vs. Stove

From the graphs, it is notable that the three stone fire has a wide variability in its consumption of fuel. It seems the three stone fire is very sensitive to fuel management during the cooking process. Given that fuelwood is a valuable commodity for the rural person, it is safe to assume that such care

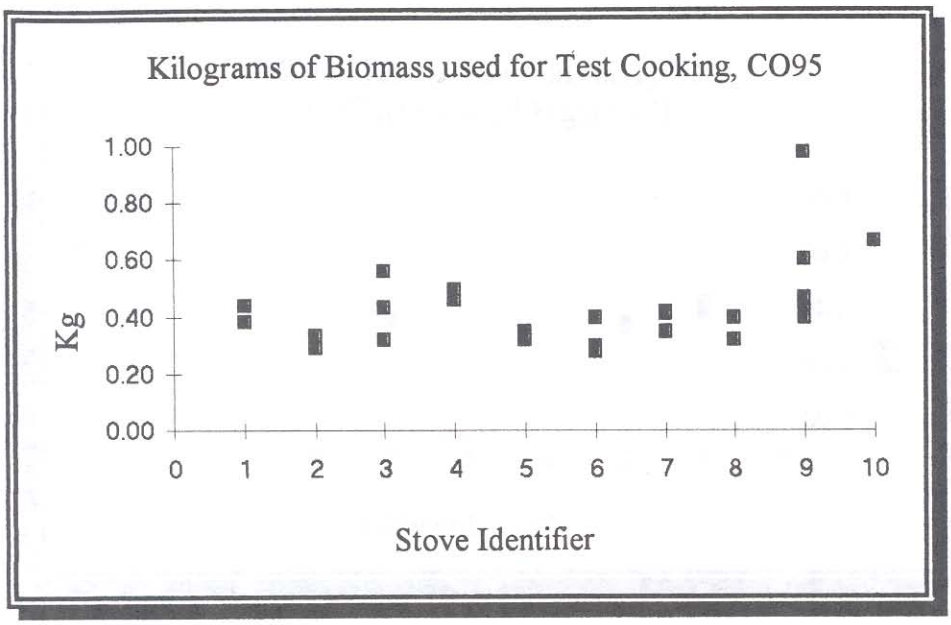

Fig. 2. Test results for woodfuel stoves (shelter condition).

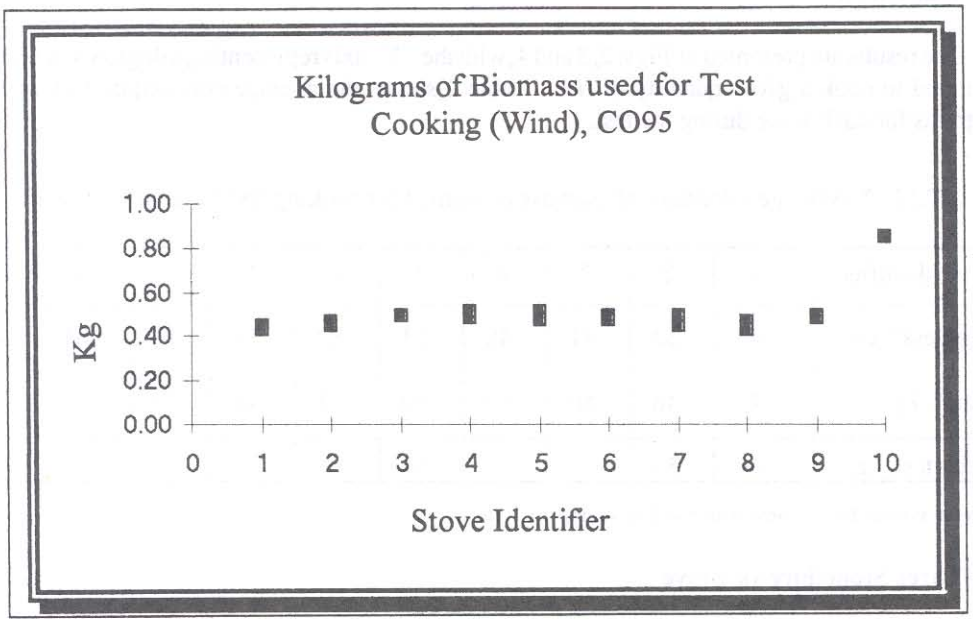

Fig. 3. Test results for woodfuel stoves (windy condition).

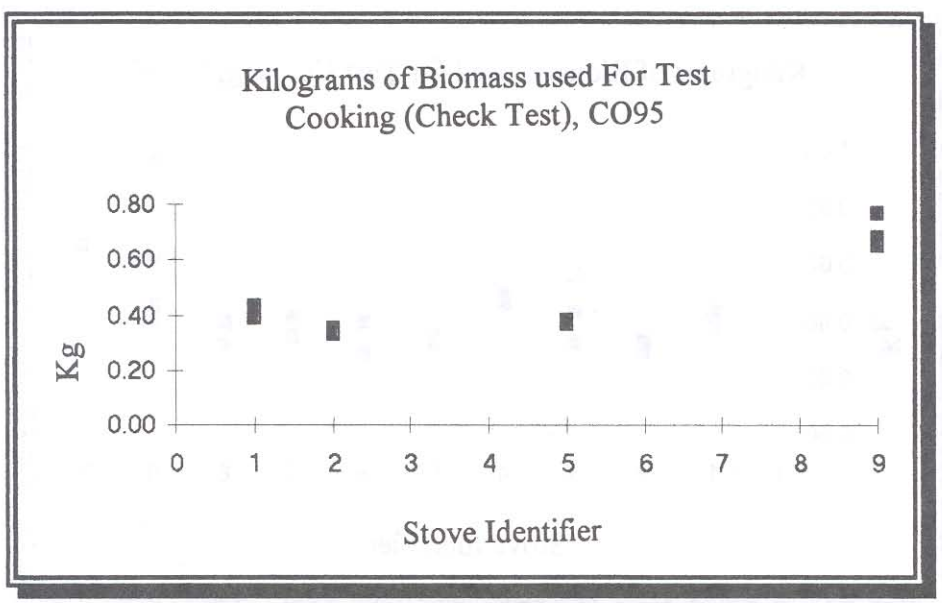

Fig. 4. Test results for woodfuel stoves (check test).

will be given in the majority of cases. Dunn [5] shows that past academic stove research has often been flawed in terms of the "human input". In one case Indian researchers had shown that a stove consumed a given quantity of fuel to boil a set amount of water. They later watched as the laboratory cleaner made her cup of tea on the same stove and by careful pulling in and out of sticks used one fifth of the quantity of wood that they had used!

The strength of the given test lies in the reality of the setting. The two key researchers were Khmer men with degree qualifications, however the setting was in the rural suburbs of Prey Veng town. The neighboring people came throughout the test to observe, participate and "help". Stoves were often watched and tendered by rural Khmer women. This is particularly true for the latter tests. For this reason we can say that the tests represent the real rural use of stoves and fires.

If the average of the six tests for the three stone fire is taken as 0.64kg, then the consumption of a three stone fire in a windless environment is approximately 50% more wood than any of the other stoves. However the results need to be analyzed considering some details. For instance the three stone fire progressively uses less fuel as the test goes on. At first this was thought to be residual heat from the previous test, however tests the following day gave a similar reduction in fuel consumption. This can possibly be attributed to increasing skill in the researchers and onlookers in managing the fire for optimal use of fuelwood. If this premise is accepted and the first test is discounted as a "practice run" then the consumption of wood in the latter three tests is only 30% more than the best stove average (Nos. 2 Vietnam Stove, 5 Metal Stove & 6 Cast Iron Stove), is 13% more than the overall stove average (0.38kg) and is actually less than some other stoves.

In the "wind" environment there is even less of a difference (5%) between the three stone fire and the overall stove average. This is contrary to expectations where one would assume that the wind would disrupt the effectiveness of an open fire. The three stone fire is nevertheless 13% higher than the average for the stove with least consumption (No. 1).

Having established three effective stoves, the tests were run again some two weeks later, to confirm the stove results. For this "check test" in a windless environment, the three stone fire gave an average of 0.7kg and proved to consume 80% more fuel than the stoves.

5.2 Stove vs. Stove

The results show that there is only a small variation between the stoves. The tests conducted in a windless environment would seem to indicate that Stoves Nos. 2 and 5 consistently consume 10% less fuel than the average of the others. However, the tests in the "wind" environment seems to decrease the difference between the stoves and make nearly all stoves near parity. Stove 5 shows no distinctive advantage, although Stove 2 is still one of the three "best" stoves. Once again the increasing skill in fuelwood management of the researchers can probably explain this progressive merging of data.

A "check test" was run on the three stoves (Nos. 1, 2 and 5). For this test the performance of the stoves are nearly the same, Nos. 2 and 5 show a slightly better result than No 1, and are significantly "better" (consume less fuel) than a three stone fire.

5.3 On Fuelwood Consumption

The graph of fuelwood consumption plotted against time of cooking, Fig. 5, is interesting. One can note that more fuel does not mean either faster or slower cooking time. In the case of the three stone fire consuming nearly 300% of the fuel for Stove 2, there is no significant quickening of cooking. This

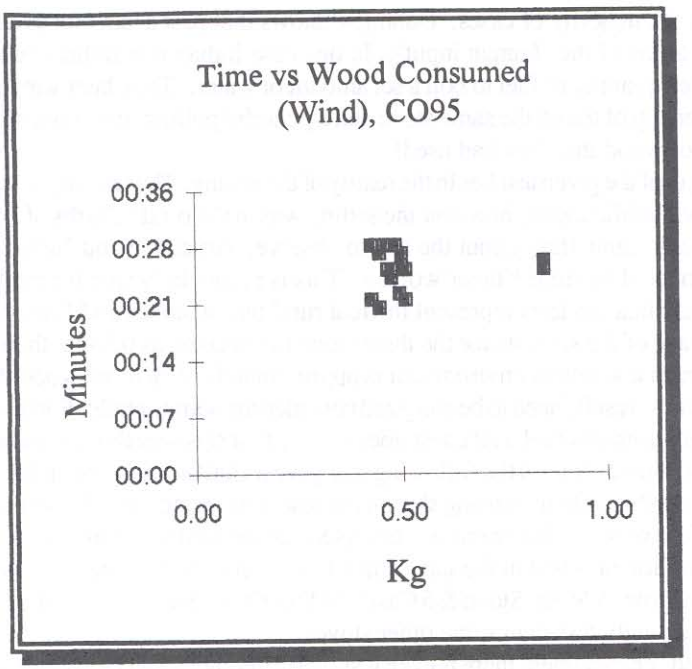

Fig. 5. Test results for woodfuel stoves (time vs. fuel)

would indicate that all the extra energy represented by the 0.6kg of extra wood consumed, is wasted heat and does not contribute to the cooking. Similarly, there is no significant correlation for any of the stoves between fuel consumption and time. In some cases (Nos. 1 and 2) it would be true to say that less fuel (slower burning) led to a slightly longer cooking time, but it would be unscientific to draw any definite conclusions or principles from the limited data. It is interesting to note that even the rice husk stove still has a similar cooking time even though it consumes significantly more biomass.

5.4 Risk Husk Stoves

Of the two risk husk stoves included in the project, only one could be made to work. In Stove No 11 the central section of the rice husks started combustion. The small hole in the base was not big enough to provide sufficient oxygen, nor to remove the ash. In Stove No 10 a steady combustion was achieved and the stove proved to be very effective. It is not known where the design originated but the stove is not common in Cambodia. The large distance between combustion chamber and the base hole provided for oxygen, and adequate ash removal.

For comparison the Cone husk stove consumed approximately 0.75kg of fuel for the test. Husks cost approximately 30Riel per kilogram (US $ 1= 2500 R). This compares with an average of 0.4kg of wood for use with a wood stove. Wood costs 200R per kilogram. We know from fuelwood studies that an average peri urban family with say a No 1 Stove spends US$40 per year on fuelwood. If a Cone Husk stove was used, the family might save 70% of their fuel expenditure. Although this looks very attractive one has to take into consideration the limited supply and seasonality of rice husks.

6. ANALYSIS AND CONCLUSIONS

Assuming that the majority of rural Khmer people use a variation on the three stone fire, then a stove promotion program would lead to considerable savings in fuelwood consumption. The proposal for this project stated that perhaps 40% could be saved by the use of stoves. Although savings could be expected, the precise amount of savings cannot be predicted. Much depends on the management of the cooking process. In the first set of tests (ignoring the first three stone test), the savings (between the best stoves and the three stone fire) were of the order of 10%. For the test with wind there are no significant savings, and for the check test (windless) the saving was about 80%. Most people will be cooking in windless conditions (inside their house). Referring to the "windless" tests then some saving of fuelwood could be expected over the lifetime of the stove , perhaps in the order of 25%.

Regarding which Stove should be promoted, the tests show that there is little to choose between the existing stoves on the country wide market. Stove designated No 1 and called the Thai Stove is very popular with urban and peri urban people. The tests show this to be one of the best stoves for fuelwood reduction. The heavier and more cumbersome No 2 stove although marginally more efficient than the No 1 (according to the tests) is perhaps a less elegant in design and may be more difficult to promote. Although Stove No 5 did well in the "windless" test it proved less efficient in the "wind" test. This is understandable in that it has very little insulation and the metal would form a good conductor of heat away from the stove in a windy environment.

Lastly Stove No 8 which is of the novel design and fascinating in its simplicity was found to be very effective. The shape is similar to the new design currently being introduced in a number of countries, for example in Vietnam, the Ministry of Energy is introducing a $1 clay design similar in shape to the No 8. A question hangs over the durability of concrete which is subjected to constant heating and cooling. A research and dissemination program for stoves should consider the No 8 as a potential product.

Regarding the effectiveness of the small scale initiative, one can say that it was very effective in given baseline facts for discussion with the rural people. The program had two objectives - one to collate the stoves and second to begin the process of dissemination to the rural areas. Both of these objectives were achieved, and it would be worth replicating the project in other locations.

In summary, the project tests indicate the following:

- Given the potential savings from the proliferation of the stoves the feasibility of a large scale program should be considered.
- In any large scale promotion of stoves for the rural areas, stoves No 1, 2 and 8 should be considered as potential products.
- A replication of the small project would be worthwhile for different locations in Cambodia

This project has formed the first phase of an ongoing program in the promotion of woodfuel stoves in Prey Veng District, Cambodia.

7. ACKNOWLEDGEMENT

This work was part funded by UNDP as a small project entitled "Small Scale Initiative Project CMB/94/006 Collation and demonstration of stoves commonly in use in Cambodia".

8. REFERENCES

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