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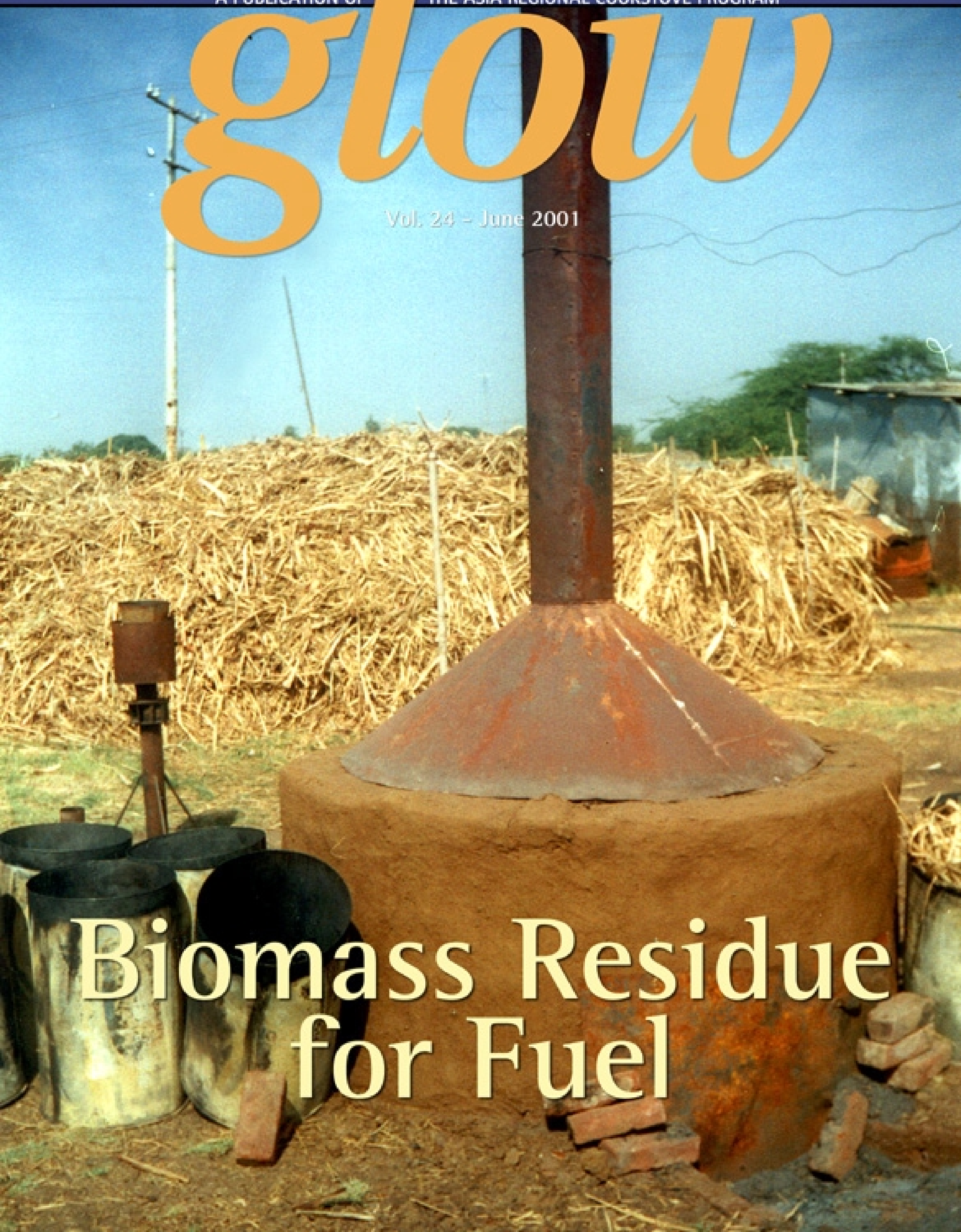

Biomass Residue for Fuel

Biomass Residue For Fuel

Biomass residue has often been placed at the lowest level in a typical energy ladder. Traditional use of biomass residues has often confirmed the fuel inferiority in comparison to fuel wood, fossil fuels and other renewable energies. The use of biomass residue has often been linked to high level of smoke emissions and indirectly, the deprivation of productive land of its trace elements and organic contents.

Perception on the negatives of biomass residue fuels has gradually changed, especially with efforts to introduce and popularise technologies such as briquetting (and other fuel upgrading technologies) and gasifier and improved stoves. Furthermore, a large quantity of biomass residue also originates from processing (e.g. in centralised rice mills and in saw mills) and is not necessarily returned to the soil, hence its procurement does not affect the cycle of productive soil rejuvenation. Still, biomass residue is under utilised as fuels.

Nevertheless, current situation provides a conducive environment for the popularisation of appropriate biomass (residue) energy technologies. Sixty percents of the world's population live in the so called developing countries, in rural areas and depend directly or indirectly on biomass fuel, of which fuel wood is becoming harder to obtain in some localities – hence leaving a choice to use biomass residue. Cuts and eventual abandonment of fossil fuel subsidies in some Asian countries, also means that small industries (in particular) will be looking for alternative fuels. Furthermore, a huge reserve of biomass residue energy, roughly estimated at 26 Exajoules (10^{18})* annually, is also available for use in Asia (compared with the total energy consumption of populations in "less developed nations", estimated at 142 EJ/year).

Noting the above, biomass residue could become the best candidate as fuel alternatives, since it is available in abundance, could often be obtained almost at no cost** and applied with technologies that are within the reach of users.

Glow editorial staff

* Estimate is based on crop residue and wood residue data from Koopmans, A. and Koppejan, J. (1997) *Agricultural and forest residues -generation, utilization and availability*. (Paper presented in Consultation on Modern Applications of Biomass Energy, 6-10 January 1997, Kuala Lumpur, Malaysia); assuming 30% efficiency upon conversion of biomass to usable energy; and based on calorific value of 16.3 kj/kg biomass. This excludes energy derived from animal wastes.

** Where demand exists, biomass residue has become a traded commodity.

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CONTENTS

FRONT COVER: BIOMASS CHARRING KILN IN INDIA (Photograph by: Karve,P. *et al.*, 2001).

ARECOP (Asia Regional Cookstove Program)

The Asia Regional Cookstove Program is a forum for voicing the concerns of improved cookstove programs in the Asia Region. It influences and facilitates effective and efficient programs in improved cookstove issues.

Economics of Rice Hull Cookers And Other Cooking Systems

ALEJANDRO DE MAIO *

Introduction

During the past three decades, governments and non-governmental organisations have made efforts to implement programs to improve cooking stoves in less developed countries with the following aims:

- to save fuel expenditures for low income households;
- to stem deforestation;
- to improve the overall well being of the people (Leach and Mearns 1988);
- and recently, to reduce greenhouse gases emissions.

Approximately 75% of biomass fuel used in the Philippines is consumed by households for cooking purposes (ARRPEEC 1996).

Rice hull cookers represent an alternative to the burning of biomass fuels. The LT-2000 stove is a multi-fuel stove designed primarily for rice hull as a fuel, but also capable of burning other crop residues, such as coconut husks, corn cobs, sawdust, etc (Samson *et al.* 2001). In the Philippines, approximately 1.5 million tonnes of rice hull per year could be recovered for bioenergy applications such as for household cooking (Samson *et al.* 2001). Rice mills usually treat rice hull as an unusable residue and is burnt in fields (Samson *et al.* 2001). The use of this residue as a fuel for cooking stoves would capture the energy that would otherwise be lost to the atmosphere, while at the same time replacing other fuels such as fuelwood, charcoal, kerosene, and LPG (Samson *et al.* 2001).

The potential users of the LT-2000 stove and the ones who would benefit the most from it are low-income families living in rural areas or in small urban areas, in the proximity of rice mills. Economy is a relevant consideration in the decision making process of these households when adopting the new technology. The present study looks at the economy (finances and other factors) of different alternatives for cooking stoves and fuels.

Financial analysis of LT-2000 and other stoves

Two main factors affect the cost of household cooking: first, the purchasing cost of the cooking equipment; and second, the annual cost of operating the fuel stove (Dutt and Ravindranath 1993).

Purchasing cost usually represents a lump sum payment that acts as an obstacle for low-income households. Annual stove operation composes of the annual consumption of fuel plus the annualised cost of the cooking equipment. From a financial point of view, the latter is a better parameter than the former when comparing different fuel stove alternatives.

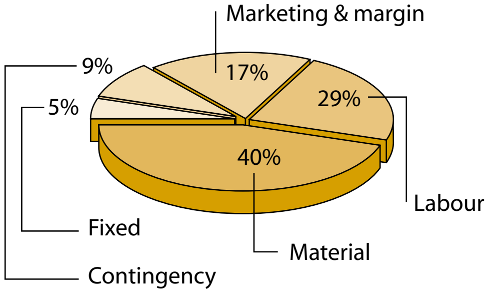
Purchasing cost

Purchasing cost was determined as the market price of a stove. The market prices of LPG, fuelwood, kerosene and charcoal stoves were obtained through marketing research in the Island of Negros, Philippines. The market price of LT-2000 stove was calculated as the sum of the cost of production, the cost of distribution, plus a commercial margin (Figure 1).

The analysis, as shown in Table 1, shows that the LT-2000 stove is cheaper than most alternatives.

The most efficient stoves (LPG, kerosene, high-efficiency fuelwood and high-efficiency charcoal) are between two and seven times more expensive than rice hull stoves. Low efficiency stoves that use fuelwood and charcoal are significantly cheaper (20-75%) than the rice hull stove. Low-income households usually cannot afford to buy the most efficient stoves, so they use low-efficiency ones. The rice hull stove presents an alternative that lies between these

Figure 1. The breakdown of LT-2000 rice hull stove cost



two extremes, and that may allow low-income households access to a more efficient cooking system that does not require a large initial investment.

Annual cost of operating cooking stoves

The annual cost of operating a cooking stove has two components. The first is the cost of the fuel consumed during one year of regular use in a household. The second component is the annualised cost of the initial investment required to purchase the cooking equipment.

The cost of fuel is determined by multiplying the quantity of fuel consumed with the price of the fuel to the consumer. Fuel consumption per year by a household was only available for LPG and fuelwood (Dept. of Energy, Republic of the Philippines 1995). Kerosene, charcoal and rice hull consumption was determined analytically, using data on energy used by a household per year, energy content and thermal efficiency of the corresponding fuel, and the following equation:

$$FC^* = \frac{\text{Energy used per year}}{\text{Thermal efficiency x Energy content}}$$

** Fuel Consumption,*
Assuming 3.17 GJ is required for a typical Philippine household each year using different fuels and stoves.

The annual cost of equipment was estimated using the function PMT, in Excel spreadsheet program. The function PMT in Excel can be applied to calculate an annuity, given a present value, an interest rate and a period of time for the investment. In this case, the present value is the purchasing cost of the cooking equipment and the period of time is the life span of the cooking equipment. The interest rate used is an average of the lending interest rates published by the Central Bank of the Philippines over the period 1996-2000 (14.4%).

Results of analysis as presented in Table 2, reveal that LT-2000 stove has the lowest annual operational cost. Annual operating cost of LT-2000 stove is about 33-42% as much as operating the cheapest fuelwood and

Table 1 - Purchasing costs of various cooking stoves

	LPG	Kerosene	Fuelwood	E-FW	HE-FW	Charcoal	E-CH	HE-CH	Rice Hull
Cost in USD*	**56**	**24**	**2,3**	**6,3**	**16**	**2,3**	**6,3**	**16**	**8**

(Source: Samson et al. 2001)
Calculated at the exchange rate of 1 USD = 50 Philippines pesos
Notes: Efficient fuelwood (EFW), Efficient Charcoal (E-CH), High-Efficiency Fuelwood (HE-FW), High-Efficiency Charcoal (HE-CH)

Table 2 - Annual cost of operating cooking stoves

	LPG	Kerosene	Fuelwood	E-FW	HE-FW	Charcoal	E-CH	HE-CH	Rice Hull
Annual equipment cost [a]	14,56	10,41	2,30	3,85	6,94	2,30	3,85	6,94	3,47
Cost of fuel per Year [b]	56	24	2,3	6,3	16	2,3	6,3	16	8
Total cost in USD	56	24	2,3	6,3	16	2,3	6,3	16	8

[a] *Estimated using the PMT formula in a Microsoft Excel spreadsheet using the following data:* **Stove life span:** *LPG=6 years, Kerosene=3 years, Fuelwood or Charcoal=1 year, Efficient Fuelwood (E-FW) or Charcoal (E-CH)=2 years, High-Efficiency Fuelwood (HE-FW) or Charcoal (HE-CH)=3 years, LT-2000=3 years;* **Interest rate***: 14.4% per annum;* **Purchasing cost of cooking equipment***: see Table 1*

[b] *Sources: Department of Energy, Republic of the Philippines 1995; and surveys of market prices of fuel in the Island of Negros, Philippines*

charcoal stoves, and 25% as much as operating an LPG stove. The main reasons for such a large difference are twofold. The purchasing cost of LT-2000 stove is less than most alternatives. Rice hull is largely available free of charge; the only cost to households is the cost of transportation from the mill to the house.

Other economic components

Financial aspects are easy to quantify. However, they do not constitute the only factors considered by households when making a decision on which cooking system to adopt. In economic terms, other aspects such as convenience, aesthetics, time requirements, smoke emissions and health risks also affect the acceptance of a cooking system.

Convenience refers to the availability and accessibility of fuel supply, the adaptability of the cooking stove to local food preferences and cooking habits and the installation and maintenance requirements among others. Time requirements refer to the time spent acquiring or gathering fuel, and the time required to complete cooking tasks. Smoke emissions are important when using biomass fuels, as they generate considerable dirt and respiratory problems. Health risks are also associated with chemicals released during combustion and present in the fuels and their ashes. Aesthetics often play an important role, depending on individuals' preferences. Cooking systems may also be seen as a status symbol.

Characteristics of the LT-2000 identified during a pilot field-testing program in 1999 are summarized in Table 3.

Table 3 - Characteristics Of The LT-2000 Stove.

ADVANTAGES	***ADVANTAGES***
• *Rapid cooking speed* • *High heat output* • *Modest emission of pollutants compared to fuelwood stoves or the original Lo-Trau rice hull stove* • *Better safety compared to fuelwood stoves* • *Reduce labour requirement in wood collection* • *Capable of burning other fuels (coconut husks, corncobs, pieces of wood), which saves the user buying other stoves and resolves concerns about rice hull availability*	• *Handling of the ash may present a health risk for users, due to the high content of silica in rice hull ash* • *Requirement for periodic tapping during the cooking process to control fuel burning and heat output.* • *Occasional surface fuelbed fires can occur*

These and other characteristics have an influence in the economic value of the LT-2000. Considerable effort has to be devoted to quantify the influence of various aspects and to determine how these affect households' acceptance of the new cooking system. Moreover, past experiences in stove programs have shown that disadvantages related to user convenience, aesthetics, smoke or health problems, can offset financial advantages provided by any new cooking system (Leach and Mearns 1988).

Conclusion

The present study has shown that the LT-2000 represents a low cost alternative for household cooking, in terms of annual cost as well as in terms of purchasing cost. This is particularly true for rural and urban areas in the proximity of rice mills, where rice hull availability is not an issue and transportation costs are not significant.

Financial cost is not the only component of the economic value of a cooking stove. There are other factors influencing households' decision to adopt the new stove. These factors are related to stove characteristics related to convenience, aesthetics, time requirements, smoke emission and health risks. It is important for any stove program to address these issues to effectively improve stove users' wellbeing.

Acknowledgements

Research and development of the LT-2000 stove program is being conducted by **REAP Canada** (http://www.reap.ca) and **PDG Inc.** in the Island of Negros, Republic of the Philippines through the **Canadian International Development Agency (CIDA)** Climate Change Program. Analyses of the economics of various cooking systems were funded by the **National Renewable Energy Laboratory**.

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TECHNICAL

A Biomass Charring System for Rural Areas

PRIYADARSHINI KARVE*, H.Y.MAHAJAN** & A.D.KARVE**

Abstract:
Light biomass that cannot be burnt directly in a wood burning domestic stove or in an industrial furnace, can be briquetted after charring it. This process presents an attractive entrepreneurial opportunity in rural areas of developing countries. An environmentally friendly and economically feasible system based on an oven-and-retort type charring kiln is described in this paper.

Introduction

The growing scarcity of fuel-wood requires more and more rural people in the developing countries to seek locally available low-cost alternatives to satisfy the household (cooking, room heating, lighting, *etc.*) as well as industrial (roadside eateries, potters' kilns, metal-working workshops, *etc.*) energy requirements.

One such readily available resource is agricultural residue. However, due to inherent bulkiness, most agricultural residues cannot be used directly as fuel-substitutes for wood or charcoal. Consequently several technologies are being developed and promoted, for converting light biomass into compact fuels to substitute wood or charcoal.

A common objection to the use of agricultural residues to fulfil energy requirements is that it leads to a reduction in the biomass available for use as fodder or manure. On the other hand, a residue like sugarcane residue (dried leaves of sugarcane) is so highly lignified and silicified, that it can neither be used as cattle fodder, nor can it be easily composted. Its removal from the field after sugarcane harvest becomes necessary because it hampers land preparation for the next crop. Therefore, farmers generally burn off the residue in situ after harvesting sugarcane, because of high cost of removing it manually. In the state of Maharashtra, on the West Coast of India, with 450 thousand hectares of sugarcane plantation, about 4.5 million tonnes of biomass are annually burnt off in this manner. Sugarcane residue is therefore an ideal candidate for use as fuel.

Briquetting of charred sugarcane residues

Any light biomass can be pulverized and compressed into fuel briquettes. However, in the case of tough and highly elastic materials such as sugarcane leaves, the process will require a very high energy expenditure. Charring the material not only makes it highly friable, but also converts it into a high value fuel, equivalent to charcoal. Pulverising the char requires very little energy and after mixing the powder with a suitable binder, it can be converted either manually into ball shaped briquettes or extruded into cylindrical briquettes. Converting light biomass into char-briquettes is more attractive as it leads to a charcoal-equivalent product, which is higher in energy content compared to wood-equivalent biomass briquettes produced by pulverisation followed by compaction.

We have developed a charring process that is especially suitable for handling large quantities of loose biomass at a high speed, without break in operation. The process is environmentally friendly, compared to the traditional charcoal making methods. The char produced can then be converted into briquettes by a variety of well-established briquetting techniques.

The Charring Kiln

The charring kiln developed by us is an oven-and-retort type kiln.. The oven (115 cm high with inner diameter 125 cm), is basically a cylindrical brick and mud structure, with a grate made out of iron rods, fitted near the bottom (**Figure 1& Figure 2**). The space below the grate is the combustion chamber. Although, any kind of fuel can be used for firing the oven, we use sugarcane residue. The chimney (230 cm tall; with an opening of 24 cm diameter at the top) fits on top of the oven, and provides the draft required for keeping the fire going in the oven. The oven holds seven retorts at a time. Each retort is a cylindrical container (60 cm high with a diameter of 38 cm;) with lid, constructed out of a mild steel sheet. The biomass (sugarcane residue in our case) to be charred is packed into the retorts.

The Charring Process

To start with, seven retorts are filled with the sugarcane residue. The lids of the retorts are closed, and secured with a steel wire. The chimney is temporarily removed so that the retorts could be loaded into the oven from the top. The retorts stand upside down in the oven, as shown in Figure 1(a). The gaps between the retorts are filled up with sugarcane residue. The chimney is replaced on the top of the oven, and the joint between the chimney and the oven is sealed with mud packing. The combustion chamber of the oven below the grate is filled with residue and the fire is started. The ports used for inserting the residue into the combustion chamber are closed by bricks.

As the hot air and flame rise up through the body of the oven, the heat is conducted to the residue inside the retorts. As there is no air for the residue to burnt, it gets charred, and the combustible volatiles emitted in the process, come out into the oven as the lids of the retorts are not airtight. The volatiles burn in the oven, generating more heat for charring. While the charring of one batch is in process, another set of seven retorts is filled with sugarcane residue and kept ready for loading into the oven. When all the sugarcane residue in the retorts is converted to char, the volatiles stop emanating into the oven, and the fire automatically turns off. Now, the chimney is removed, the retorts are taken out of the oven, and the next batch of retorts is lowered into it. The chimney is placed on top of the oven, the combustion chamber is refilled with residue, and the fire is started again, as before. In this manner, the kiln can be operated in continuous batches.

The first seven retorts are emptied, and refilled with residue, while the charring of the second batch is in progress. If the hot char comes in contact with the air, it immediately catches fire. This can be avoided by either emptying the retorts in water, or by allowing the retorts to cool down before removing the char. The char produced can either be briquetted by using any standard briquetting process, or sold as loose char, that the consumer can use as required.

required as fuel for firing the oven. Thus, each batch consumes about 31 kg of sugarcane residue and yields about 7 kg of char. The first batch requires about 2 hours, from the step of filling up the retorts with residue. Subsequent batches require about 1 hour from the step of loading the oven with retorts. Thus, it is possible to operate the oven for about 6 to 7

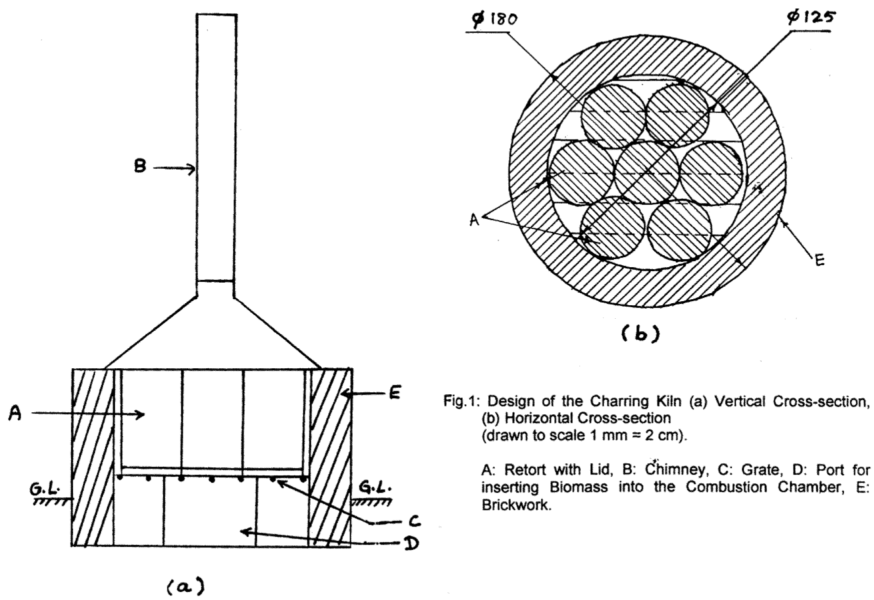

Fig.1: Design of the Charring Kiln (a) Vertical Cross-section, (b) Horizontal Cross-section (drawn to scale 1 mm = 2 cm).

A: Retort with Lid, B: Chimney, C: Grate, D: Port for inserting Biomass into the Combustion Chamber, E: Brickwork.

Economy of the oven

The capital cost involved in fabricating the chimney and the fourteen retorts is about Indian Rs.5000 (at the present exchange rate, 1 USD = Indian Rs.46). Any ordinary steel workshop can handle the fabrication work. The oven is to be constructed on location using bricks and mud. It requires about 400 bricks, costing about Rs. 600. The construction is simple and does not require the services of an expert mason. The construction of the oven as well as operation of the kiln can be handled by two unskilled labourers. For such labourers, the daily wages for an eight-hour shift in India are Rs.100.

In this process, each retort holds about 3 kg of sugarcane residue and at the end of the charring run, yields about 1 kg of char. Thus, one batch of 7 retorts converts about 21 kg of sugarcane residue into about 7 kg of char. An additional 10 kg of sugarcane residue (8 kg below the grate, 2 kg in the gaps between the retorts) is

batches in an 8 hour shift, yielding 40-50 kg of char. Considering the urgency on the part of the farmer to remove the residue from his field, we recommend two shifts per day, resulting into about 80 to 100 kg of char.

The Advantages

There are several advantages of the charring system described here. Firstly, the same kiln can be used for charring any type of biomass, including woody biomass like stalks of cotton or pigeon pea, looped branches of trees etc. The amount of biomass consumed, and the char produced will be different for each type of biomass, depending on its density, packing characteristics, calorific value, *etc.*

In most other charring systems, the volatiles emitted by the charring biomass are either vented out or flared up. The former situation leads to environmental pollution, whereas the second situation leads to a waste of useful gaseous fuel. In the system described here, both these negative aspects are eliminated, and therefore it is a cleaner and more energy-efficient charring process.

As the system operates on a continuous batch process, the operator has great flexibility in constructing the kiln. It can be a scaled-up version that can be a centrally located permanent structure with the biomass being transported from other locations. Alternatively, it can be a scaled-down version that can hold only one or two retorts at a time, and can be taken from place to place wherever the biomass is available. The kiln described here can be designated as 'semi-portable' as it can be completely dismantled, the chimney, the retorts and the bricks can be taken from one farm to other, and re-erected within a day. In either case, the volume of biomass to be charred will decide the number of batches to be processed.

The system, as we have developed it, relies on manual labour. However the nature of the system is such that automation of the operation is easily possible. This is of particular relevance for constructing and operating a large-scale system. g

Acknowledgements

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FEATURE

Pilot Project on the Introduction of Paddy Husk As an Alternative to Firewood for the Operation of Bakeries

S.D. ABAYAWARDANA*

A pilot project on the conversion five bakeries to be operated using paddy husk as an alternative to fire wood in the Polonnaruwa District in Sri Lanka was launched by the Integrated Development Association (IDEA), with the supports of Global Environmental Facility (GEF), Small Grant Programme (SGP) of the UNDP.

Introduction

In Sri Lanka, firewood is being used as a fuel in more than 90% of bakeries and this fact has contributed to the felling of trees in a considerable scale. Table 1 indicates the extent of biomass fuel use in various industries in Sri Lanka.

Furthermore, some of the firewood supplied also originates from illegal extraction from the state's forests. Sri Lanka has only about 23% of its forest cover left and it cannot afford to lose any more of it.

On the other hand, paddy husk discharged from rice mills, has also become a threat to the environment, especially in rice producing areas, where it is frequently dumped in public places.

Table 1 - The use of biomass fuel for industries in Sri Lanka

Industry	Amount of biomass fuel used ('000 Tons)/year
• *Tea*	*455 (43.2%)*
• *Hotels and restaurants*	*164 (15.6%)*
• *Brick and Tile*	*150 (14.2%)*
• *Bakeries*	*99 (9.0%)*
• *Rubber*	*72 (6.8%)*
• *Coconut*	*51 (4.8%)*
• *Tobacco*	*13 (1.2%)*
• *Others*	*49 (4.7%*

(Source : Forestry Master Plan of Sri Lanka - 1995)

Figure 1 - Types of bakeries in Polonnaruwa District

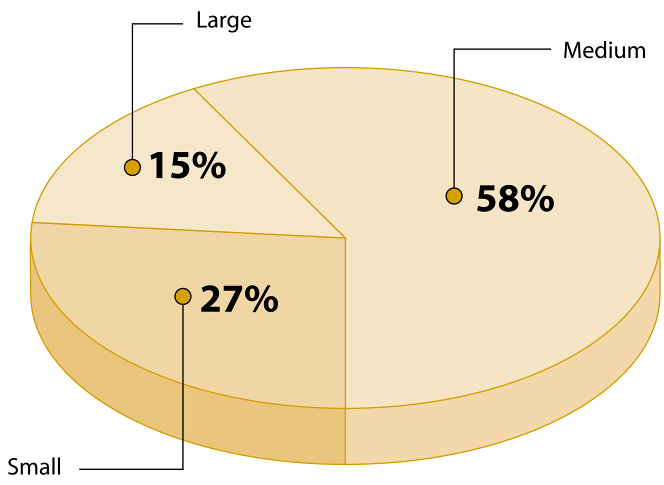


Table 2 - Amount of paddy husk discharged by rice mills Polonnaruwa district *

Amount of rice husk (kg)	Number of mills
• *Less than 650*	*5*
• *Over 650 to 1300*	*5*
• *Over 1950 to 2600*	*15*
• *Over 1950 to 2600*	*10*
• *Over 2600*	*5*

** this was determined by the sacks of rice husk discharged and one sack weighs on average 13 kgs*

The Pilot Project

A pilot project to introduce paddy husk operated bakeries was first initiated when information was received on a bakery that used oven technology fueled by paddy husk as an alternative to fire wood. The technology would have two advantages: it would reduce the incidence of tree felling as well as solve the problem of accumulation of paddy husk to a considerable extent. With the above thought in mind, a visit was made to the bakery to study the technology and its advantages.

The inventor of this technology is Mr. Ekanayake Divulgane. His bakery is situated in Dehiattakandiya in Ampara district, which is also a rice producing area. He owns a medium size bakery and could accommodate 45 trays at a time to bake 540 loaves of bread. He has conducted many experiments over a period of five years before he perfected the technology. Mr. Divulgane has obtained patent rights for his technology but agreed to disseminate the technology as a service to the nation.

After discussions with Mr. Divulgane, IDEA submitted a concept paper to the GEF/SGP and the National Steering Committee (NSC). They agreed to provide funds for a pilot project to convert wood fueled bakeries to ones fueled by paddy husk. The NSC was of the view that the project would contribute towards solving of problems associated with the lost of forest cover and paddy husk disposal.

A suitable project location was then decided in Polonnaruwa district. It is situated in the dry zone of Sri Lanka where most of the forests are legally protected areas (Forest Reserves, National Parks and Sanctuaries). The reduction of forest cover, which is mainly due to illegal felling in this district, is a constant threat to wildlife, especially the wild elephant. Polonnaruwa, a rice producing area, also has a problem in the disposal of paddy husk discharged from rice mills.

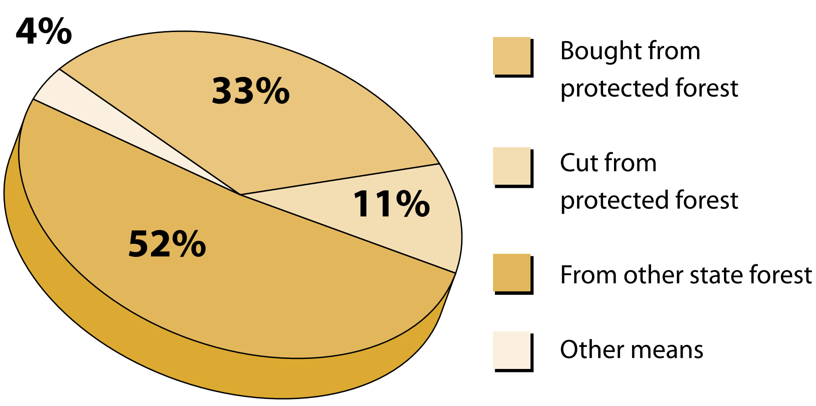
Baseline study

The first activity of the project was a base line study conducted in the Polonnaruwa district in order to determine:

- the number of bakeries and rice mills;
- their sizes, capacities;
- the amount of fire wood used by bakeries;
- the amount of paddy husk discharged from the rice mills.

The baseline study found that there were 60 bakeries in Polonnaruwa district. Figure 1 indicates the types of bakeries present in the Polonnaruwa

Figure 2 - Sources of firewood for bakeries in Polonnaruwa district



district.

Availability of fuel was also surveyed based on the study on the amount of rice husk discharged by the 60 rice mills found in Polonnaruwa district (Table 2).

The study also revealed that all the bakeries in Polonnaruwa district use firewood as fuel. The extent of firewood consumption of the bakeries is indicated in Table 3.

The firewood is obtained from various sources: purchased from those engaged in illegal felling of tress in protected forests; cut directly from protected forests; from other state forests; and from other sources such as private lands. A chart showing the sources of firewood used in bakery industry is shown in Figure 2.

Project Implementation

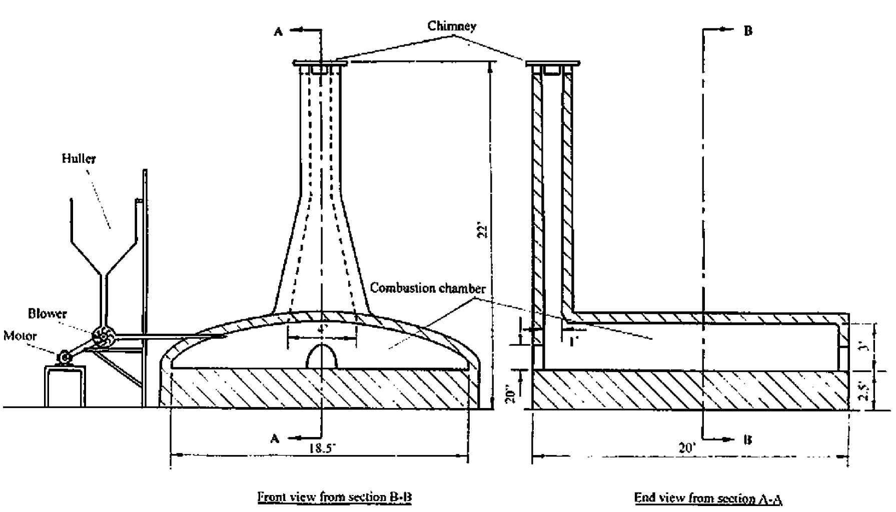
After the baseline study was conducted, a workshop was later held for 50 selected bakery owners within the district to create awareness on the new oven technology fueled by paddy husk. They were also taken on a field visit to observe and inspect the operation of Mr. Divulgane's bakery. 94% of the bakery owners who attended the workshop expressed their willingness to convert their wood fueled bakery ovens to paddy husk fueled ovens.

Table 3 - Amount of firewood used by bakeries (m3)

Amount per month (m3)	*No. of bakeries*
2 to 4	*-*
Over 4 to 6	*-*
Over 6 to 8	*1*
Over 8 to 10	*8*
Over 10 to 12	*10*
Over 12 to 14	*2*
Over 14 to 16	*15*
Over 16 to 18	*7*
Over 18 to 20	*5*
Over 20	*12*

Five bakeries considered suitable for conversion were selected out of those and three have been converted thus far. The conversion in the other two bakeries will be completed by the end of June 2001. The cost to convert a bakery oven is Rs. 50,000/= including the cost of equipment to be installed. Out of this cost, 50% will have to be borne by the project and the other 50% by the bakery owner.

FIGURE 3. THE RICE HULL BREAD OVEN



The paddy husk oven introduced in the pilot project

Description of the paddy husk oven

The basic technology consists of a huller into which paddy husk is fed and an electric blower that blows paddy husk into the combustion chamber. In case of a power failure, two-wheeled hand tractor is used to power the blower. The floor and walls of the combustion have also been further modified. Pipes are laid on the floor of the combustion chamber in order to evenly distribute the heat.

Operation of the oven

A little kerosene is sprayed on the paddy husk layer deposited at the bottom of to assist the start of fire. Operation usually starts at about 10.00 am when the fire is first started. In about one and a half hours the temperature of the combustion chamber rises to about 350^0 C. Then it is allowed to cool down to 300^{0}C before the trays are inserted. The operation proceeds with three shifts of bread baking followed by about 8 shifts of other bakery products such as buns, cup cakes etc. After the bakery products are baked, the remaining heat is utilized to dry other commodities such as groundnuts, coriander etc. The operation goes on till about mid night.

Economy of the oven

A bakery oven fueled by firewood would require about 1.5 m^3 of wood per day, costing around Rs. 600/=. The costs for firewood would be more expensive in wood scarce areas.

For a paddy husk fueled oven, the present cost of operation is only about Rs. 200/= per month for the electricity to power the motor. Mr. Divulgane uses a 3-horsepower motor for his bakery. However, a 2-horsepower motor would be adequate to run a blower that has new conversion features. This will again reduce the electricity consumption of the motor. Apart from that, the paddy husk is delivered free of charge by rice mill owners. About 250 bags of paddy husk can be transported in a medium sized lorry and about 18 bags are used per day. Each bag contains about 10 kgs. of paddy husk.

Project experiences and future actions

Thus far, the only problem identified was from an owner of a converted oven, who received complaints from his neighbour because his oven was emitting ash, which landed on the neighbour's land. The problem was solved when the chimney was raised to a height of 18 feet.

At the end of the project, a workshop is planned in order to review and evaluate the pilot activities. The workshop will involve the participation of bakery owners, members of the NSC, the Government and Non Government agencies from related fields. Such a workshop will reveal information needed to determine project achievements as well as to decide whether it should be extended to other districts as well.

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The Sarai Oven

R.M. SALUNKHE *
PRIYADARSHINI KARVE *(AUTHOR FOR CORRESPONDANCE)***

Abstract: Sarai oven is a multi-purpose and multi-fueled portable cooking device. Its design and operation are described in detail.

PHOTOGRAPH 1: DIFFERENT COMPONENTS OF SARAI OVEN: (FROM L TO R) OUTER JAKET; FUEL HOLDER; COMBUSTION CHAMBER; STEAMING VESSEL WITH LID

Introduction

An oven operates on the principle of using the energy source (electricity, fossil fuels, wood, *etc.*) to heat an enclosed space, within which the food items are kept. It is normally used for baking, roasting, and grilling operations.

A special appliance that has been traditionally used for such operations is called a steamer or a rice cooker, that uses the basic principle of an oven, with a slight modification - the heat is used for generating steam within the enclosed space in which the cooking vessels are placed.

There are various advantages of the steamer or oven based approach to cooking. As the radiative and convective heat loss from the cooking vessels is reduced, the cooking process is more energy efficient than cooking in pots placed on stoves. secondly, a steamer/oven allows food to be simultaneously cooked in more than one pot. As the food items cook on low-to-medium heat and in closed vessels, the taste as well as the nutritional value of the food is superior.

In this paper, we describe a stove design that is based on this principle.

The ICMIC stove

The ICMIC stove was designed through a systematic R&D effort supported by the Government of India. However, it did not become widely popular. Presently, its use is restricted to parts of the state of West Bengal in India. It is basically a steamer-oven that operates on coal or charcoal as fuel. In large parts of India, unleavened bread (roti, chapati, *etc.*) is the major food item, and it cannot be cooked using the ICMIC. As a result, even if people bought the ICMIC, they have to use a separate stove for roasting the bread as well as for operations such as frying. Also, coal and charcoal are not easily available everywhere in the country. These may have been the major reasons for the limited acceptance of the ICMIC. A need was therefore felt to modify the basic ICMIC design in such a way that (a) it would be possible to detach the oven part from the combustion chamber so that the chamber can be used independently as an ordinary stove for other cooking operations, and (b) it would be possible to operate the stove with a wide variety of commonly available fuels/ energy sources. These considerations led to the development of a modified version of the ICMIC, that we have named 'Sarai oven'.

The Sarai Oven:

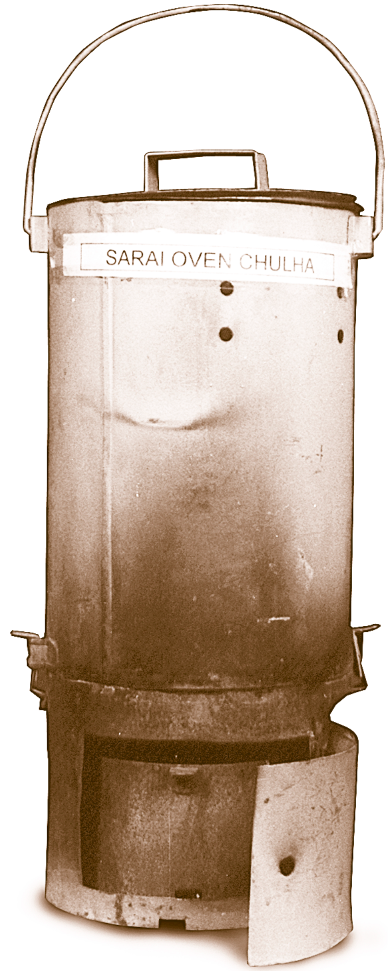
In the local language, the word 'sarai' means "the season of harvest" or "a period of prosperity". The basic design of the Sarai oven is identical to that of the ICMIC. The four parts of the stove are shown in **Photograph 1** and the fully assembled stove is shown in **Photograph 2**. All the components of the stove are fabricated out of mild steel. The different components are described below.

(a) **Combustion chamber**: It is an open ended mild steel cylinder, with an aluminium lining from inside. There is a door on the side, and a series of holes along the periphery at the bottom. The holes serve as air inlets. There are two clamps on the side near the top for holding the outer jacket.

(b) **Fuel holder**: This is a mild steel cylinder with an open top and a cast iron grate at the bottom. Solid fuel in the form of wood chips, coal, charcoal, char- or biomass briquettes, *etc*., is placed in the holder, which in turn is placed inside the combustion chamber through its side door.

(c) **Outer jacket**: It is an open ended cylinder that fits on top of the combustion chamber. There are two rows of holes circumscribing the cylinder near the top (see **Photograph2**).

(d) **Steaming vessel with lid**: The steaming vessel is a cylindrical vessel that can be inserted into the outer jacket, leaving an annular space of



PHOTOGRAPH 2: THE FULLY ASSEMBLED SARAI OVEN

just about 2.5-3 mm between the walls of the two. It has a wide rim at the top, which seals up the annular space. The lid fits snugly into the open top of the steaming vessel.

The operation

To operate the stove, the fuel holder, loaded with fuel, is inserted into the combustion chamber. The outer jacket is fitted on to the chamber, and the steaming vessel is inserted into it. About 200ml (a drinking glassful) of water is poured into the steaming vessel, and the cooking vessels are stacked in it, one on top of the other. The steaming vessel is closed with the lid and the fire is started.

The air required for combustion of the fuel enters from the holes at the bottom of the combustion chamber and is sucked into the fuel stack through the grate at the bottom of the fuel holder. The hot gases and flames emitted by the fire pass through the annular space between the outer jacket and the steaming vessel, and come out through the holes near the top of the outer jacket. The heat is conducted into the steaming vessel through its bottom and walls, and converts the water inside into steam. The steaming vessel fills up with steam and this generates sufficiently high temperature within the cooking vessels to cook the food items. Steam cooking has the advantage, that the substances to be cooked are never heated beyond 100 deg. C, and therefore they never get charred. Because the fuel placed in the burner is limited, the stove extinguishes itself after a certain time.

If no water is placed in the steaming vessel, it can be used as an ordinary oven. For operations like frying, making unleavened bread, *etc*., the outer jacket can be detached from the combustion chamber and the chamber can be used as an ordinary portable single pot stove.

The outer jacket and steaming vessel can also be used with an ordinary gas or kerosene stove, to increase the fuel use efficiency. It is also possible to operate the stove using a small electric heating coil in the place of the fuel holder.

Quantitative information

The steamer/oven can be made in a variety of sizes as per requirement. The only critical design parameter is the annular gap of 2.5-3 mm between the outer jacket and the steaming vessel. For the oven shown in photograph 2, the fuel holder can hold 100-1000 g solid fuel (based on density), and the steaming vessel can hold four cooking vessels about 15 cm in diameter and about 6.5 cm in height. Each cooking vessel can hold about 250 gm of rice, pulses, cut vegetables, etc., or 350-400 gm of potatoes, eggs, *etc*.

If all the four vessels are used, it is possible to cook enough food for a family of 4-5 persons. The fuel required for this purpose, is about 100 g of charcoal or char briquettes, or 150-200 g of wood chips. The cooking time is about 30-35 min.

Present status

The oven is now being promoted in Maharashtra and neighbouring states. The selling price has been fixed at Rs.450/-, i.e., slightly less than US$10. This is affordable by the middle income group in this region of the country. Further R&D work is on to reduce the fabrication cost and to increase the durability, by using different materials other than mild steel.

Acknowledgements

The authors are grateful to the Ministry of Non-conventional Energy Sources, Government of India for financial assistance, under the National Programme on Improved Chulha. The help of Mr. R.D. Hanbar, Senior Scientific Officer, and other members of the ARTI Technical Back-up Support Unit under NPIC is duely acknowledged. We are also thankful to Dr. A.D. Karve, President, ARTI, for discussions and valuable suggestions.

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CALL FOR CONTRIBUTIONS TO GLOW

Glow is a forum for exchange of experiences and ideas on cookstoves and related issues. Glow wants to share your work and discoveries with our readers. Let us know about your work as well as the obstacles you face. Each edition of Glow is published with a specific theme. However, Glow welcomes contributions on thematic as well non-thematic articles. Send us also your news items, books, review materials, announcements and pictures for publication in Glow.

VOL. 25, SEPTEMBER 2001: INCORPORATION OF GENDER IN ICS

Benefits to women's development have been cited in favor of improved cookstove (ICS): reduced cooking and fuel collection time; reduced negative health impacts caused by smoke; and provide women the opportunity to become primary actors in a development project. Unfortunately, adoption of ICS is far less than expected. This is mainly caused by the fact that in many ICS programmes the specific needs of the users (mostly women) were not taken into account in the formulation of the planning and solutions. In many cases the improved cookstove introduced is a new piece of equipment and new ways of cooking and in most cases does not serve the need of their cooking habit and food type. On the other hand, there have been reports of more successful ICS programs because the users were involved in all stages of the formulation of the solutions. In other words had there been a gender approach applied, in which all involved are taken into account in the program formulation, a more successful result may be expected. Yet, in the field of ICS, little attention has been given in the integration of gender in ICS program.

For this volume of *Glow*, we are calling for submissions of case studies and articles on gender incorporation in stove programs.

Information to be collected (*this should serve as a guideline for submissions*):

a) Conditions of the location (the environment, economic, livelihood, tradition especially those related to cooking and fuel) where a program is implemented;
b) Activities and division of labour in fuel supply (who is responsible to collect fuel, women, children, men, young women, etc);
c) Fuel source, fuel types, how it is obtained (free, commercialized, fuel availability/ sustainability);
d) Activities and division of labour in cooking activities;
e) Process of introduction and dissemination of ICS to the community (participatory, top down);
f) Process of design formulation , provide the technical design (who are consulted, when, how are women and men involved in the ICS programme, from start to implementation and thereafter)
g) ICS dissemination strategy (fully subsidized, owner built, cadres, market, etc)
h) Problems encountered and how are they solved
i) Degree of success and or failure (adoption rate, are the stove being used, are there growth in the number of users, users opinion, sustainability, have second or third stove being used?)
j) Other relevant information such as availability of local institution or group, influential leaders, etc.

SUBMISSION OF ARTICLES

Articles can be submitted as typescripts, on 3.5 floppy disk (MS. Word) or by e-mail. Please provide photos and other illustrations. Articles and correspondence should be addressed to:

The ARECOP Secretariat (Glow Article)
JL. Kaliurang Km.7, Gg. Jurugsari IV/19, PO BOX 19 YKBS, Yogyakarta 55281, Indonesia
Or e mailed to: arecop@yogya.wasantara.net.id
Please put on the subject line "Glow article"

The ARECOP Secretariat is providing US$100 remuneration for every thematic article published in Glow and US$50 for non thematic article.

Local Inputs to Improved Stove Development

DO DUCK KHOI*

From 1998 to 2000, Population and Development International (PDI) – in partnership with the Vietnam Women's Union – implemented the project, the Integrated Family Health and Food Security. *The project targeted 3 mountainous communes of Quy Hop district in Nghe An Province, in which there are high concentrations of Thai ethnic minorities. The principal objectives of the project were to improve the health of women and children in this area, as well as to raise awareness with regard to the importance of environmental conservation. Cross-sector activities of this project related to the project objectives included the introduction of fuel-efficient, smokeless stoves. Implementation of this activity clearly demonstrated that successful introduction of new cookstove technologies among Thai minorities in Quy Hop district required the active participation of target populations during the design and construction phase.*

When the project began in 1998, the vast majority of people living in the three target communes were using traditional cooking techniques, suitable perhaps to the migrant life style of upland groups in the past. As these groups have settled in more permanent landholdings and as fuel resources have become increasingly scarce, their cooking techniques are no longer appropriate. However, early efforts to introduce new cooking techniques, have been unsuccessful.

In the early stages of implementation, the *Integrated Family Health and Food Security* project supported the costs of bringing national cookstove experts to the project sites in an effort to transfer basic knowledge on cookstoves to target beneficiaries. However, initial stove models introduced did not interest the villagers. Many complained that the costs were too high and that the stoves were too heavy for typical wooden stilt houses that the Thai ethnic groups build. In addition, the new stoves did not take into consideration many traditional uses of fire in the household such as for keeping warm in the winter and for drying and preserving agriculture products. Further, the stoves did not take into consideration the types of cooking utensils, pots and pans used by the target group. In the end, we found that there was better acceptance of the new stove technology among those Thai ethnic groups closely assimilated to the Kinh (Vietnam's major ethnic group) lifestyle, much more so than groups living in more traditional Thai cultural settings.

As a follow-up to the first cookstove training course and dissemination activities, the project supported a participatory learning and action (PLA) process for local project staff. The stated objective of this activity was to overcome target groups' resistance to new cookstove technologies. This process led to the development of a diverse set of cookstoves designs that employed not only theories on efficient cookstove design but also took into consideration local needs and customs. The majority of design adaptations took place through stove building workshops involving target beneficiaries and facilitated by experts and local builders. Adaptations made can be summarised as follows:

1. **Decreased Costs –** Typically through the use of local materials (i.e. iron, brick, sandy soil, soil mixed with lime) the local builders made significant cuts in costs with no significant cut in fuel efficiency. Cost is perhaps the main reason for the resistance in Quy Hop due to high levels of poverty among Thai ethnic minorities.

2. **Improved Suitability –** Local builders developed a number of different configurations of the stove based on individual demands. For in-

AN IMPROVED COOKSTOVE RESULTED FROM THE PARTICIPATORY DESIGN PROCESS

stance, the builders developed stoves with funnel-shaped potholes, to enable the use of pots and pans of different sizes. Similarly, the designers experimented with smoke outlet designs such that villagers could make use of the smoke when preserving foods. Another adaptation is to vary the height of the stove depending on the size of fuel wood used. Additionally, builders developed a variety of stoves of different shapes and sizes, including those lighter stoves that could be moved about easily.

3. Improved Efficiency – There were adaptations made to raise the fuel closer to the pothole.

In addition to building techniques, project staff also learned that cookstove acceptance can improve when one considers common needs. For instance, increasing disposable income to purchase blankets at a minimal cost can decrease a family's need to burn fires throughout the day and night during the winter months. Or, adding additional pillars to the house structure can provide the support necessary for a cookstove.

Project staff members also recognised the importance of social marketing aspects in cookstove introduction. To create a demand, target beneficiaries must clearly understand the net benefit of fuel savings (time and money). It is equally important to ensure adequate locally supplied building materials and skilled artisans.

By December 2000, the project had supported the construction of 660 fuel efficient, smokeless cookstoves for the poorest of target beneficiary households, with the project supporting the costs of cement, iron, and smokestacks. Beneficiaries receiving such support provided labour, sand and other building materials. We also observed that at least 150 other households in target areas have already built or were building similarly designed cookstoves without project support. It also appears that other communes in the district have taken an interest in the activity and have arranged for local artisans to share their designs.

The direct impact of improved cookstoves is difficult to measure. Based on our findings from the project's participatory assessment in 1998, wood is the principal source of fuel in these Thai ethnic villages. 80 – 90% of the wood gathered was used for cooking. Efficiency improvements vary from 30% - 50% with improved cookstoves, which may translate into significant reductions in wood extracted from the forest. One should also consider the savings in time and hassle in collecting wood or perhaps the economic opportunity villagers have, for example through selling excess fuel.

Regardless of how one calculates the net benefit, beneficiaries have provided extremely favourable feedback on the project's cookstove activities. It could be generally assumed that locals will adapt the improved stoves and that such stoves will gradually replace traditional cooking methods in the three communes within three to five years time.

Such achievements would not have been possible without the use of participatory processes that involved target beneficiaries in the design and construction of cookstoves. g

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CALL FOR CONTRIBUTIONS TO GLOW

VOL. 26, DECEMBER 2001: INDIGENEOUS KNOWLEDGE

In this volume of Glow, we are requesting articles on indigenous knowledge in industrial/institutional as well as in household stoves and in fuel conserving practices.

Indigenous knowledge to be covered could be classified as follows:

- Knowledge regarding stove materials and/or on specific applications of material/s
- Knowledge on specific design/construction of stove or stove parts
- Knowledge on stove building methods
- Knowledge on fuel conservation practices or other beneficial fuel management practices

Publications

Ecologically Sound Integrated Regional Energy Planning

Y.V. Ramachandra (Indian Institute of Science). 2000. 348 pp. ISBN 1-56072-876-0. Price US$95.

The main objective of this book is to develop an "Ecologically Sound Integrated Energy Plan" at district level to arrive at an optimal mix of energy sources that can meet the energy demand in a region by keeping in view development priorities of the region. This books presents a conceptual design for energy systems which could meet demand of all sectors in a region. The proposed design in principle, supplies enough energy for sustainable development of a region. The plan proposed is based on Decision Support System approach (DSS) and is flexible, adaptable and ecologically sound.

Contact : **Nova Science Publishers**
227 Main Street, Suite 100, Huntington, NY 11743-6907
Tel : 631-424-6682, Fax: 631-424-4666
E. mail: Novascience@Earthlink.net
http://www.nexusworld.com/nova

Commercial production of energy-efficient biomass stoves for the commercial and institutional sector. Manual for producers, promoters and users

Energy for Sustainable Development Limited. 1999. 42 pp

Drawing experiences from several East African countries, the manual presents an overview of an approach in conducting institutional and industrial stove commercialization programs. The manual guides readers on what activities should be undertaken, why and how the activities should be conducted and which stakeholders should be involved.

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Fax: +44 1225 812103
Download it for free in PDF format from:
http://www.esd.co.uk

Measuring Successes and Setbacks – How to Monitor and Evaluate Household Energy Projects.

HEP (Household Energy Programme), ITDG (Intermediate Technology Development Group), FWD (Foundation for Woodstove Dissemination). 1996, 56 pp.

Based on experiences from 12 projects in Asia, Africa and Central America, HEP, ITDG and FWD, developed the manual for monitoring and evaluation (M&E) of household energy programs. The main aim of this book is to provide ideas and advice on how to go about monitoring household energy programs. The handbook is divided into two distinct sections; the first, a general guideline on planning monitoring and evaluation; the next on how to conduct monitoring and evaluation activities.

Contact :
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C/o: Peter Young
Myson House, Railway Terrace, Rugby, CV21 3HT
United Kingdom
Phone: 0788-560631, Fax: 0788-5402 70

Internet Resources

Journey to Forever

http://journeytoforever.org/at_woodfire.html (verified 1st June, 2001).

This web site contains many useful and interesting links to web sites and documents related to improved stoves and biomass energy.

Biomass Cooking Stoves

http://www.ikweb.com/enuff/public_html/Stoves.html (Verified 1st June, 2001).

This page exists to help people involved in the development of a better stove for cooking with biomass fuels in developing regions. It has links to archive on stove mailing list, a mailing list which facilitates discussions on stoves and issues through internet. The site also contains papers written by members of the stove mailing list. Some of the documents can be downloaded.

Event

International Conference on Energy and Quality of Life – Policy directions for the Millenium 29 November-1 December 2001.

TOPICS AND SUBTHEMES

- Energy end uses, lifestyle, standard of living and quality of life
- Fuels, kitchen design, health, indoor and outdoor air quality
- Renewable energy generation and use, technologies and impact on natural resources
- Energy, housing, environment and sustainable development
- Energy and gender issues
- Energy and technologies for lighting, in residential and non-residential buildings
- Energy auditing and retrofits
- Energy education for sustainable development
- Policy directions and global actions.

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