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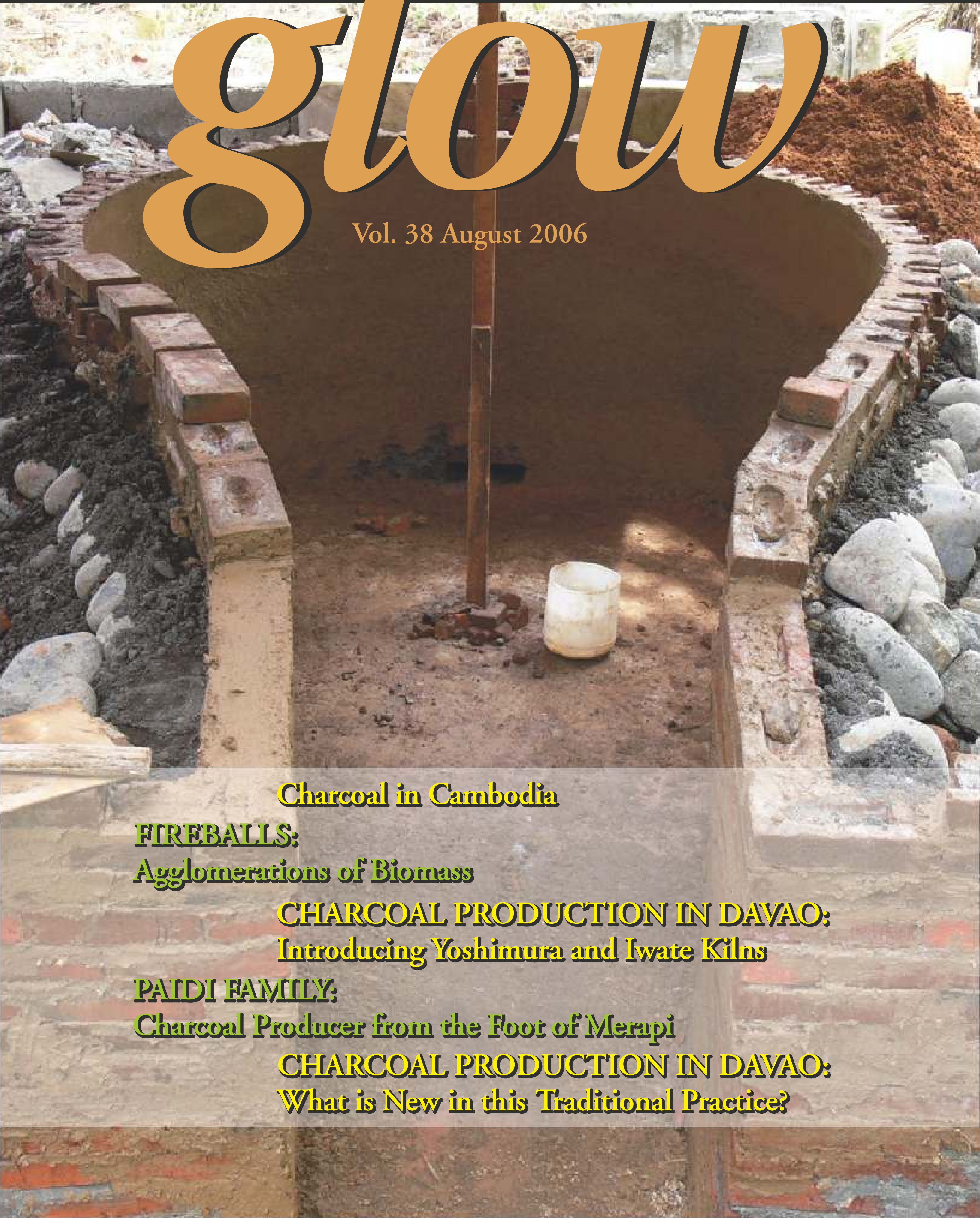

Charcoal in Cambodia

FIREBALLS: Agglomerations of Biomass

CHARCOAL PRODUCTION IN DAVAO: Introducing Yoshimura and Iwate Kilns

PAIDI FAMILY: Charcoal Producer from the Foot of Merapi

CHARCOAL PRODUCTION IN DAVAO: What is New in this Traditional Practice?

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The Asia Regional Cookstove Program (ARECOP) 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.

DEAR READER,

Charcoal is the primary fuel source in many regions throughout Asia, and is most commonly produced using traditional practices. This issue of Glow looks at methods of charcoal production, the problems they incur, and the innovations being developed.

As a result of the high demand for charcoal from urban families in Cambodia, deforestation around the Cardamon Mountain Range has become a major problem. Recent studies by GERES look at reasons why the price of charcoal remains so low compared with other fuel sources. Based on this research, GERES introduced an improved cookstove to reduce charcoal consumption, and "green charcoal," a new method of sustainable charcoal production. These approaches were found to reduce charcoal pressure on natural forests of Cambodia by 24%.

Jeff Davis explains techniques for making charcoal dust agglomerations (also know as "fireballs") which are suitable for gassifiers that can power internal combustion engines and heat devices. Dust from grass, leaves, sawdust, or leftover fine particles from wood charcoal production are used to make the fireballs.

In the Mindanao islands of the Philippines, charcoal is widely produced using the traditional ground-pit method. The ARECOP team reports on a training workshop where two new methods were introduced for producing higher quality charcoal products. Workshop participants learned how to build Iwate and Yoshimura above-ground kilns. Benefits of these kilns include production of commercial-grade charcoal and the by-product of wood vinegar.

A report about Mr. Paidi, a charcoal producer who lives at the foot of Mt. Merapi in Yogyakarta, provides insight about the charcoal industry from a producer's point of view. Mr. Paidi has independently explored several methods of charcoal production in search of the highest quality results. He now faces the growing challenge of finding enough wood.

In Davao, Philipines, the source of charcoal production has changed in the past decade from a coconut to wood-based source. Producers use a variety of traditional techniques, including earth pits and drum kilns. The high demand for charcoal fuel and the opportunities it presents to small-scale businesses has created a flourishing market for improved cookstoves in Davao. What remains in question is the threat charcoal production presents to the environment.

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Charcoal in Cambodia

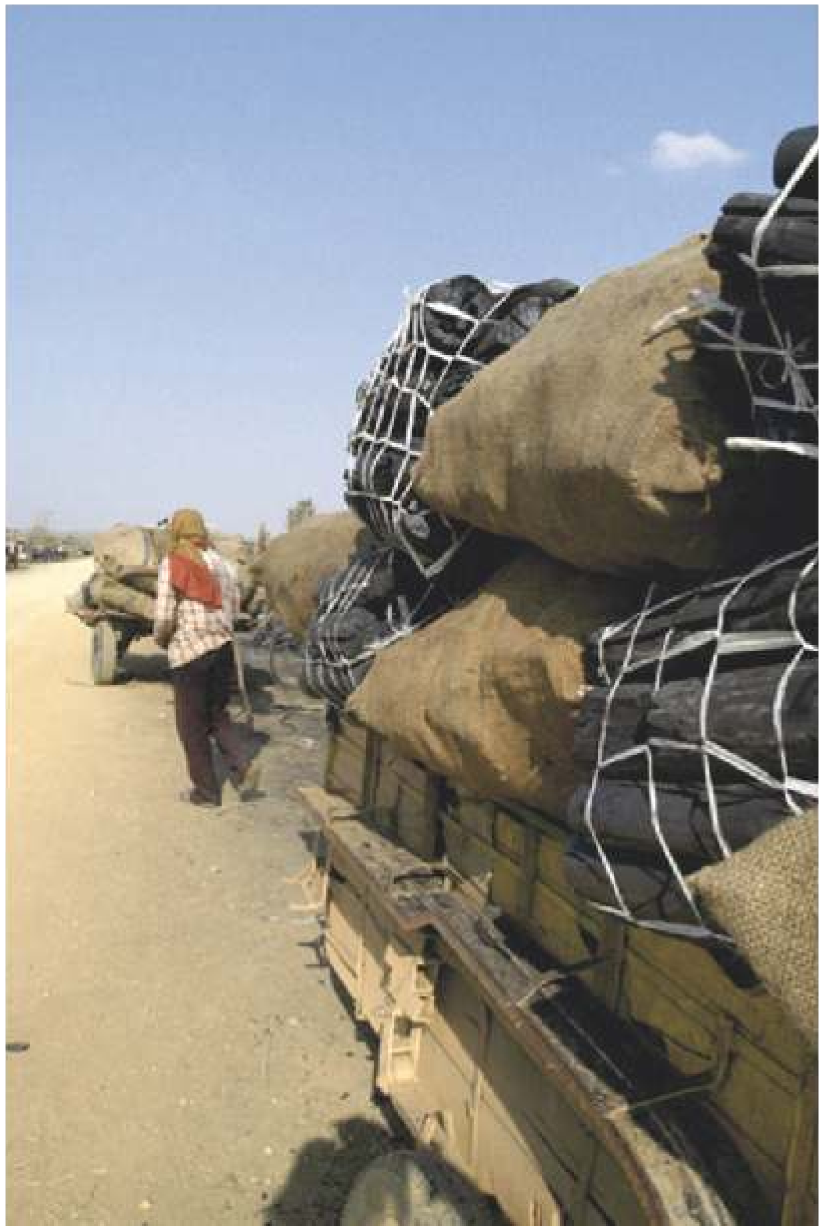
S. Yohanes Iwan Baskoro[1]

Introduction

About 90% of families in Cambodia rely on biomass based cooking fuel. Families in rural areas are mostly burning fuelwood and urban families are mostly burning charcoal. Recent study made by GERES in 2006 *(Wood Energy Baseline Study for Clean Development Mechanism)* found that charcoal flow to Phnom Penh is about 90,000 ton per year.

That amount of charcoal is produced by charcoal producers around Cardamom Mountain Range. Part of wood for charcoal is obtained from land use change; from forest land to agriculture land. The other part of the wood is cut intentionally for charcoal production.

Royal Government of Cambodia has tried to solve the problem of deforestation due to charcoal production through many ways. A number of NGOs are also involved actively in reducing forest cutting by destroying charcoal kilns. However, the efforts did not give significant result. Demand on charcoal (as well as fuelwood) remains high due to some competitive advantages of charcoals compare to other cooking fuels (kerosene, LPG, electricity).



Charcoal pool on the road to Aural Wildlife Sanctuary

1. *GERES Country Director, Cambodia*
2. *Khmer Riels, Cambodian currency*

Considering high demand of charcoal for cooking, GERES introduced improved cook stove that can reduce the consumption of charcoal. Furthermore, GERES moved upstream to improve charcoal production to be more efficient and supply of its raw material become sustainable.

Price of Charcoal

Since the year of 1996, charcoal price in Phnom Penh remains 500 KHR[2]/kg., but by the beginning of 2006, charcoal price in the markets of Phnom Penh increased to 600 KHR and some retailers sell by 700 KHR/kg (1 USD about 4,000 KHR). Table 1 shows average prices of charcoal in 5 provinces taken from in 26 observation spots (updated by May 2006), where the average price of charcoal is 560 KHR/kg see table 1. Charcoal in Phnom Penh is mainly supplied from the nearest province of those six, Kampong Speu province.

The increase of charcoal price in the market of Phnom Penh is mainly influenced by the increases of transportation cost, the fuel (Gasoline is 1 USD/liter; Diesel is 0.8 USD/liter). Though the price of charcoal is increased, in fact the price of other cooking fuel is also increased; Kerosene is 0.72 USD/liter (from USD 0.46/kg in Nov 2003); LPG is 1.34USD/kg (from USD 0.62/kg in Nov 2003).

Table 2 shows that the cost of fuelwood (for the utilized heat in MJ/kg) is the lowest among other cooking fuels. Though the efficiency of the devices used (the stove) for other cooking fuel (kerosene and LPG stove) are much higher than the wood or charcoal stove.

The price of cooking fuel is the

Table 1 *Average price of charcoal in 5 provinces*

Provinces	Price per kg in KHR	Number of observation spots
Kampong Cham	550	3
Kampong Speu	408	2
Svay Rieng	630	5
Kandal	583	6
Takeo	550	10
Average	562	26

Table 2 Cost of cooking energy for each useful energy (cost/MJ/kg)

Type of cooking fuel	Price/kg	Calorific value	Device efficiency	Cost of useful energy mj/kg
	in KHR	in MU	in percent	in KHR
Fuelwood	230	16.5	19	73.4
	230	16.5	25*	55.8
Charcoal	560	26	25	86.2
	560	26	30*	71.8
Kerosene	2,960	43.5	45	151.2
LPG	5,500	45.5	57	212.1

) efficiency of the improved cook stove

Common design of traditional kiln in Cambodia main reason for most people to keep burning fuelwood and charcoal. Choice of kerosene and LPG as cooking fuel is limited only to families who can afford kerosene and LPG stove.

Traditional charcoal production

How the price of charcoal so low compare to other fuel? There are several aspects that keep charcoal price remain low; it is informal activity, marginal, subsistence and almost no rule of the game.

Most charcoal producers are farmers who cannot cultivate anything due to unavailability of irrigation in their land during dry season. To survive they cut trees from the nearby forest or any land clearing areas to get wood and make it into charcoal. The cutting is neither controlled nor with proper management due to some limitation within forestry authority of the Royal Government of Cambodia. Current wood harvest for charcoal is absolutely unsustainable.

Many conservationists put charcoal producers at the same "level of fault" as illegal logging; they call charcoal produced by traditional way as "illegal charcoal". However, shops and stalls selling "illegal charcoal" and the users of "illegal charcoal" are liberated from "illegal" accusation. Somehow it is unfair at all.

The most common traditional kilns to produce charcoal in all parts of Cambodia are quite similar in design; it is a combination of ground pit kiln and beehive kiln.

A kiln commonly accommodates about 3 ton of fresh wood (raw material for charcoal), while fuel needed to make fire is 290 kg (in average). Totally, one cycle of traditional charcoal production needs about 3.3 ton of wood. From that quantity of wood, gives only 530 kg of charcoal (calorific value 26.4 MJ) and another 290 kg of uncarbonized wood (wood that does not turn into charcoal, remain as wood). Therefore, the ratio of wood to charcoal in traditional kiln is 6.54 which mean to produce 1 kg of charcoal, needs 6.54 kg of fresh wood.

The most common wood species in traditional charcoal production are Xylopia vielana, Albizia myriophylla, Levingia malayana, Lagerstroemia floribunda, Cratoxylum formosum, Xylia dolabriformis, Sindora cochinchinensis, Hopea recopei. Those species are hard wood that bear market value as timber.

A production cycle of traditional charcoal kiln needs twenty working days involving two people. A cycle of production is including loading the wood, firing, carbonization and unloading the charcoal.

From the kilns, charcoal is pooled on an access road before it goes to urban areas by a fleet of moto-remorque and then sold in retail door-to-door or in bulk to shops.

Improved charcoal production

Considering crucial situation with charcoal demand, charcoal production and supply of wood, GERES intervened by introducing improved cook stove (New Lao Stove) that might reduce charcoal consumption by 22% (real cooking test[3]). Current dissemination rate of New Lao Stove has reached 9,000 units per month[4].

This "weapon" is not sufficiently "kills" the "monster" of uncontrolled forest cutting for charcoal production. Recent studies by GERES (2006) found that annual demand of charcoal for Phnom Penh is about 90,000 ton that means this annual supply

Arranging the wood into the Yoshimura kiln

3. *CFSP Real cooking test in urban & rural areas, during rainy and dry season of 2003 & 2004*
4. *Market monitoring data of July/August 2006*

Forest management is to control over harvestry branches and twigs, which use for charcoal production in suistainable way

requires about 589,000 ton of fresh wood annually.

Second "weapon" is introducing charcoal briquette made of agricultural wastes (corn cob, sugar cane trash, coconut husk, peanut shell, etc…). Strategy to switch the dependency on solid charcoal to briquette is running quite well in Northern provinces of Cambodia; however it is in an initial stage with current sales of briquette of 2 ton per month.

Third "weapon" is introducing sustainable charcoal production, which we call it as "green charcoal". This strategy is a bit complex as it involves new kiln technology and sustainable forest management.

Pilot production of green charcoal applies Yoshimura kiln with similar volume capacity of common traditional kiln but require less wood, only 2.35 ton of fresh wood obtained from pruning and singling on community forest of Acacia sp. and Eucalyptus sp. To produce charcoal it needs only 10 days including loading the wood, carbonization, cooling and unloading the charcoal involving two people.

The improved kiln needs only 170 kg of fuel to make fire, instead of 290 kg as in traditional kiln. Weight yield of the improved kiln is 545 kg of charcoal (calorific value 30.5 MJ[5]), and no uncarbonized wood. So, the ratio of wood to charcoal in the improved kiln is 4.58 which mean to produce 1 kg of charcoal needs 4.58 of fresh wood.

Energy conversion by improved kiln is much more efficient than the traditional kiln. For example, for 1 ton of fresh wood, traditional kiln produce only 153 kg of charcoal with calorific value of 26.4 MJ latent energy is 4,033 MJ; improved kiln can produce 218 kg of charcoal with calorific value of 30.5 MJ latent energy is 6,658 MJ.

Theoretically, from one ton of wood, the improved kiln can produce charcoal with 65% higher latent energy than charcoal made by the traditional kiln. Practically, due to transport loss and other things, 50% more latent energy is very sure. That means improved charcoal kiln can supply 50% more energy than the traditional kiln.

Strategies being developed

The most important component in the strategy of "green charcoal" is proper and sustainable management of forest and it is "not-negotiable".

Sustainable forest management would be the back-bone of charcoal production, and improved kiln technology will be a means to achieve high energy conversion efficiency. In fact, Cambodia has had large areas of well managed forest, called community forests. These forests are managed by a committee that responsible on

5. Test done by LUACOB IUT Tarbes, France daily management of the forest including daily patrol, harvesting plan, replanting plan and other issues related to the utilization of the forests.

In 2003 GERES Cambodia introduced an alternative use of forest management excess for charcoal production to community forestry in the province of Takeo, Cambodia. Those excess are branches and twigs obtained from pruning, singling and thinning. Under supervision from a community forestry expert (Mr. Shambu Dangal of CONCERN Wordwide), the community forestry in Takeo identified the quantity of excess per hectare of Acacia forest. The identification gives result of 15 m3 of branches and twigs (and some small trunks) from a hectare. However, the expert suggested the pruning, singling and thinning to be done in a cycle o five years.

This baseline data becomes a benchmark to develop a plan on green charcoal production in Takeo over the existing 270 hectares of Acacia. Baseline data and forest availability permit only 5 units of improved charcoal kiln to be installed in order to produce charcoal in sustainable way. Those 5 kilns can produce about 6.8 ton of charcoal per month without destroying the forest.

Green Charcoal will only suitable if it is attached to properly managed forests or plantation, where planning and control over harvesting are practicable.

Scenario of sustainable charcoal in Cambodia

"Green Charcoal" pilot production running with 2 units of improved charcoal kiln in Takeo has entered its third year and proven to be OK in term of economic and sustainability of the forest.

Table 3 Comparison of Cooking Energy Cost Green Charcoal, Kerosene & LPG

Type of cooking fuel	Price/kg	Calorific value	Device efficiency	Cost of useful energy mj/kg
	in KHR	in MU	in percent	in KHR
Green Charcoal	1,100	30.5	25*	144.3
	1,100	30.5	30**	120.2
Kerosene	2,960	43.5	45	151.2
LPG	5,500	45.5	57	212.1

*) Traditional Cook Stove **) Improved Cook Stove

Recently, a delegation lead by the Director of Forestry Administration (FA) of the Royal Government of Cambodia (RGC) visited the pilot site in Takeo. In the discussion, the Director of FA agreed to adopt and to disseminate the strategy other areas in Cambodia where charcoal production is concentrated.

The adoption is mainly based on the availability of community forests in Cambodia (55,000 ha), which can contribute about 15,000 ton of charcoal per year, and the acceleration of improved cook stove adoption by the users (7,000 units per month when the visit was made).

Those two approaches - GREEN CHARCOAL and IMPROVED COOK STOVE can create synergy to reduce charcoal dependency (pressure) on natural forest of Cambodia by 24%. It does mean that Cambodia needs 220,000 hectares of manageable forest and about 1,000 units of improved charcoal kiln.

Economically, Green Charcoal should be valued in higher price than the currently available charcoal (made by traditional kiln). Based on the figure of cooking energy cost as in the Table 3, the price of Green Charcoal might increase up to 1,100 KHR/kg, instead of 600 KHR/kg. Charcoal price in this level is still competitive than kerosene and LPG, especially when it is burned in improved cook stove. glow

Fireballs

Agglomerations of Biomass

Jeff Davis

In the early 80's I converted a truck to run on woodgas. My main problem was the fuel used hence my motivation for researching other forms of gasifier fuels. The goal is to find a high quality renewable biomass fuel that is suitable for a gasifier that will power internal combustion engines and heat devices. This method should unify many odd fuels such as switchgrass, algae, sawdust, waste paper, crop waste, etc.

I learned of charcoal dust agglomerations, affectionately referred to as fireballs, from the REPP list called stoves [1]. According to Tom Reed, John Tatom (and S.C. Bhattacharya) pioneered the fireball concept. Furthermore my understanding is that the coal fireball was produced before this. For example Helifuel (McDowell & Wellman) converted high sulfur coal into clean fuel. It was a mixture of ground coal and limestone, pelletized in a disc agglomerator, followed by carbonizing in a grate type sinter machine to produce hard, smokeless agglomerations of low ash and sulfur content for combustion or gasification [2].

This has been a stimulating learning experience that I hope to share with you but please understand that this is just the beginning of my personal research. The only information that I had to start with was that John Tatom used a rotating drum with charcoal dust placed inside the drum with a water/starch binder.

People tend to interchange words that describe the art and science of consolidating particulate solids so I will start by defining a few terms that will be used in this article.

Agglomeration: Collected into a mass by means of agitation and or collision alone, thus without mechanical pressure in any kind of mold.

Balling: Producing rounded agglomerations

Binder: In order for agglomerations to stick together they need a binder. There are many binders for example starch, resins, tar, sewage mud [3], fish waste [3] algae [3], clay, cement, waste liquors [4], etc. A binder has been defined as something (such as tar or cement) that produces or promotes cohesion in loosely assembled substance [2]. There is some agreement that four binder classifications exist, 1 matrix type such as asphalt, 2 film type such as starch, chemical type such as lime plus molasses and 4 lubricant type such as oil and water [4]. I have my doubts that we would have a use for number 4.

Fireball: A charcoal and or biomass fuel that has been formed in a balling agglomerator.

Pellet: An agglomeration made in a balling agglomerator.

The danger in using charcoal as a fuel is the possibility of wasted wood. On an average one is fortunate if 30% of the heat value can be carried over to the charcoal , that was in the feedstock wood. This can contribute to deforestation. Ideally when producing charcoal one should find a use for the waste heat and or off gases. For example a dual mode gas producer was mainly used to produce charcoal and the producer gas was a byproduct that was used to fuel a 1000 kW dual fuel-diesel engine for thirty years. (Delacott System) [5].

One of the features of the charcoal fireball is the need for dust or fines as the feedstock. It is difficult to grind wood charcoal into dust but other biomass sources of charcoal or char are easier to reduce into fines. For example grass, leaves, sawdust etc. I have used switchgrass (Panicum virgatum) as a source for char. If wood charcoal is being produced the left over fines could be used for the production of fireballs.

Three balling agglomerators are described below:

Drum Agglomerator: This looks much like a rotating drum whose axis is inclined at a small angle to the horizontal. The entire feedstock bed moves forward in a plug flow fashion. Like the pan agglomerator the drum has many variations from axis tilt toward the inlet, tilt toward outlet, level axis, paddles inside the drum, etc. One of the most interesting variation on the drum is the falling-curtain agglomerator (O'Brien). Inside the drum is a rod-cage that resembles a squirrel cage blower. This rod-cage produces a curtain of dry fines that remain at a constant thickness thus preventing the sprayed liquid/binder coming in contact with the drum wall, as with all agglomerators it is best not to allow the surface to become too wet. Furthermore this curtain which preferentially agglomerates only the small particals lifted with the rod-cage. The falling-curtain also employees a ribbon or auger like device, fastened to the inside diameter, that returns the smaller particals to the inlet end.

Pan Agglomerator: Looks much like a shallow disc set on an angle between 40 and 60 degrees. The largest particles move on the top of the bed and discharge over the rim as more feedstock is added. The growth of the agglomerations can be controlled by the relative position of binder/liquid and feedstock. For example if the binder/liquid is introduced at 3 o'clock and dry feedstock is supplied at the 5 o'clock position the powder feedstock will stick to the wetted agglomerations and cause them to enlarge. Other positions will have different affects. Other factors are angle tilt, rim height, speed of rotation and amount of binder/liquid plus feedstock. Other forms of the pan agglomerator will have stepped pans that allow a separate re-roll area. This will aid in producing a more rounded, smooth and densified balled agglomeration. There is also the deep pan agglomerator.

Cone Agglomerator: This it a compromise between the pan and drum balling agglomerator. The cone angle and rotation speed control the pellet size. In order to provide a good surface for balling this agglomerator has a stationary and moving cutter bars. The axis angle can also be adjusted.

The list of balling agglomerators goes on and on. It seems to be more of an art than science, although the science has been greatly improved, hence one can dream up just about any form of balling agglomerator and make improvement until it works sufficiently for your needs. Or at least that is my impression of this method of pelleting.

I choose to employ a cement mixer for my experimental balling agglomerator. First the paddles need to be removed. Next add the char/charcoal fines, see picture 1. Now comes the difficult part of adding the liquid/binder. If the cement mixer is turning before the addition of liquid/binder you will have a severe dust problem. Ideally it would be beneficial to have a device that would spray the liquid/binder, I did not. So just before the cement mixer starts to rotate, the spray would begin, hence a form of dust control. In an experimental fashion, I have found that I could wet the dust lightly then start the cement mixer and continue to add the liquid/binder. I have made many mistakes and still have been able to produce some kind of balled agglomerations. Picture 2 shows the cement mixer in kind of a drum agglomerator mode and picture 3 shows it in more of a pan mode.

My most embarrassing mistake was not knowing that the starch water solution (liquid/binder) needs to be boiled first! I used about 6% starch to water. I have also added too much liquid/binder in the past. This will create a condition that causes the bed to lose traction with the drum and stop circulating. The material will also stop agglomerating and develop into one large clump. If you end up with a large clump, simply break it up with a stick and start over. My solution was to add more dry fines to the mix thus allowing formation

Picture 1

Picture 2

Picture 3

of nuclei and next growth. The amount of moisture seems to be paramount.

Other fines can be blended with the charcoal fines such as sawdust.

I did measure the density of one batch of charcoal/sawdust fireballs. It was about 500 g/mL. This was not a 100% charcoal feedstock but had about 20% sawdust. How fine the feedstock is reduced and the amount of dwell time in the agglomerator has an influence on the density.

At this point I am concentrating my efforts in the direction of the inverted down-draft gasifier. This gasifier produces gas from the volatiles in biomass and as a by-product charcoal or char is made. This is the reason for favoring the fibrillated bio-fiber fireball over the charcoal fireball. Examples of this species is the paper and switchgrass fireball. Picture 4 shows a paper/switchgrass (chopped), paper, and charcoal fireball from left to right respectively. Picture 5 shows three 100% switchgrass fireballs. They where made by hand, simulating the action of an agglomerator. This classification of fireball is binderless hence hydrogen bonding. Producing them in an agglomerator is a completely different procedure than making fireballs from dust feedstock. With the fiber fireball pulp is made out of the biomass first.

Picture 4

Picture 5

My best laboratory investment to date is the Woodgas Stove [6], a Tom Reed design. Picture 6 shows the stove loaded with paper fireballs. Picture 7 shows the stove gasifing/burning paper fireballs and picture 8 shows the charcoal produced. Simply put, what better way to test your fuel! The plan is to oven dry the fireballs, weigh the sample, then load the Woodgas Stove with them. Ignite the stove and place a measured quantity of water, in a pan, on top. Time the burn and measure how much of the water has been boiled away and measure how much charcoal was produced in the stove.

The charcoal, from the inverted down draft gasifier, will be used as a soil enrichment hence Terra Preta [7], this stands out among the opportunities for sustainable soil management. Basically it is a black soil found in parts of the world that had carbon added. This is a vary fertile environment for plants to flourish in. glow

Picture 6

Picture 7

Picture 8

INFORMATION

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