Small Scale Urban Waste Management For Energy Production. Phase 2

SOLID FUEL BLOCK OUT OF WASTE BIOMASS. THE CUBA CASE

Consolidated Report
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Cuba's Consolidated Report

SMALL SCALE URBAN WASTE MANAGEMENT FOR ENERGY PRODUCTION. PHASE 2

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1. Introduction

Various building materials, such as quicklime and fired clay bricks, are manufactured by burning firewood as fuel. The lack of alternatives to solid fuels such as firewood is severely affecting the small-scale building materials production in Cuba.

The Sugar Industry and the railroad depleted most of Cuba's tropical forests at the beginning of the XXth Century. The remaining forests are subject to severe protection by the government, and the areas where firewood sourcing is still allowed are too far from the main urban centers, and transportation costs therefore are significantly increased.

However, there are huge amounts of waste biomass resulting from the agriculture, or the industries, that do not have yet a proper disposal and a productive use. Among those are the rice husks produced in industrial rice mills, most of the sugar cane straw produced at the sugar factories pre-processing plants, and the sawdust produced in the carpentry workshops.

These are rather clean streams of waste, which are relatively close to urban centers. CIDEM (*Centro de Investigación y Desarrollo de Estructuras y Materiales*) has started a program to manufacture alternatives fuels, to be use directly in the manufacture of building materials. The Solid Fuel Block (SFB) is the main target of this program.

This consolidated report pretends to illustrate the work done by CIDEM in launching the SFB technology and setting up its first pilot plant in Santa Clara city. The main idea of this second phase in the project consist of setting up a pilot workshop which will allow us to suit the chosen technology in practical conditions after the experimental phase is completed and before a further wide spreading is implemented.

2. An alternative fuel: the Solid Fuel Block

2.1 The Solid Fuel Block

The SFB is simply densified biomass whereas clay is used as a binder. Densification is done at a very small scale, with simple machinery, as a labor-intensive activity. The resulting fuel has reasonably good burning properties, and the ash resulting from it is potentially pozzolanic.

The selection and screening of the biomass depends on its properties of each residue. The screened material is then shredded to fragmenting it into small pieces that could be easily bonded. This process is done in shredder machines of simple operation and reasonably high productivity that are available in the market.

The most important step is the densification of the biomass. It seeks to optimize fuel disposal by increasing density. This project intends to use the existing stock of hand presses, formerly used to manufacture earth pressed blocks to shaping the SFB.

These machines attain low compacting pressure, which implies the need of a binder. Clay will be used as binder. The idea of the SFB considers both binding properties of clays. Before combustion, the clay acts as the binder that helps compacting the biomass; when the SFB is burnt, the clay present in it is thermally activated, thus becoming a reactive pozzolana that is suitable to be used for the manufacture of lime-pozzolana binders.

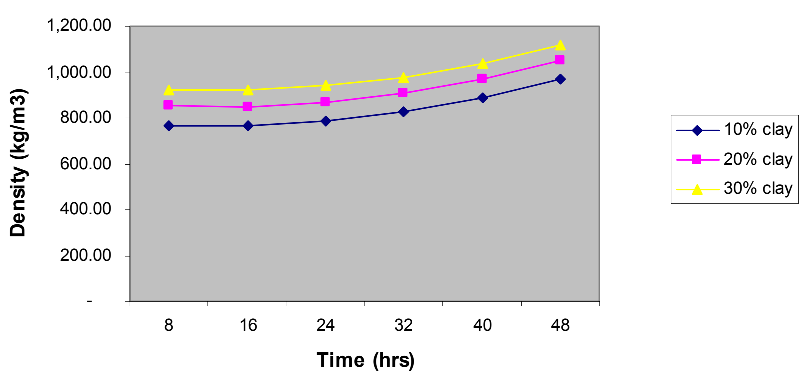
The resulting SFB is composed approximately of 20%-30% binder, for a moisture content (maximum) of 20%. The combustion residues account for 25-35% of the initial weight, depending on the moisture content (water). As thumb rule, the specific heat potentially generated by the active part of the fuel (biomass) is approximately half the heat produced by the same weight of coal.

2.2 Technical requirements

The development and further transfer of technology includes several aspects that have been studied as part of the work presented in this report. Among them:

Target density vs. clay content: As a fuel, the density of block cannot exceed a certain limit, beyond which proper burning could not be accomplished. The attained density depends on the compacting energy, the clay content, the moisture content of the densified mass, and the specific properties of the densified biomass.

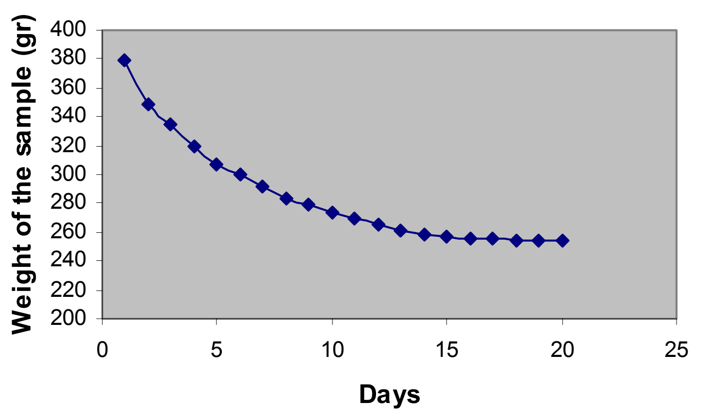
Fig 1: Relationship between clay content & density



At wet densities below 500 kg/m^3 the block disintegrates, while at wet densities over 1200 kg/m^3 the target dry-density could not likely be accomplished. As it dries, the block slightly increases its density because of the shrinkage caused by the evacuation of water, but soon it falls to approximately 40% of the wet density. Fig. 1 presents the analysis of the relationship between clay content and density in a SFB made in the laboratory with clay content ranging between 10-30% of the biomass weight. Measured were taken up to 48 hours, the time at which shrinkage due to evaporation of water is supposedly stopped. The greatest density, as expected is obtained with the highest clay content. Clay contents beyond 30% could significantly influence burning properties of the fuel, therefore it is recommended as the upper limit for the clay content.

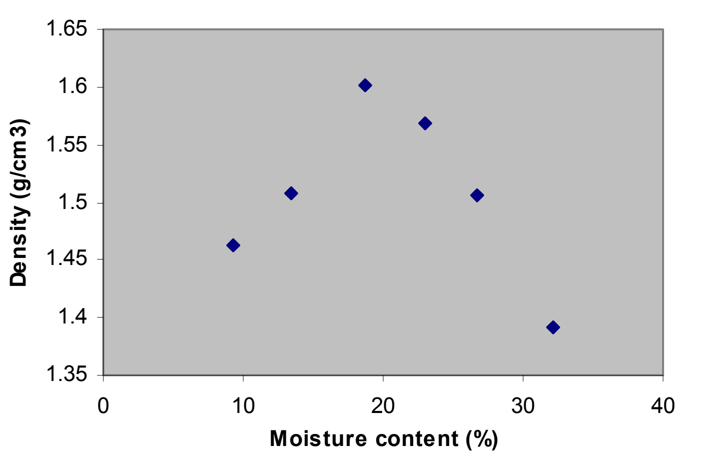
Drying process: The block has to be dried out. This is determined by continuously assessing the change in weight in the block, until the changes between one measurement and the next are smaller than 3%. The block can be sun-dried or dried aided by driers in case there is some source of cheap energy for drying. Research has proved that a laboratory-made block with dry density around 600-800 kg/m^3 dried in the shadow at temperatures between 25-30 Celsius achieves constant weight after approximately 12 days of drying. Further field tests have proven that this process cut be cut to approximately half the time when the blocks are sun-dried. The form of the blocks also influences the drying pattern: the thicker the block, the longer the drying time, because it will be harder to evacuate the water from the inner layers of the block. In this regard, blocks shaped as a fired clay brick (size 24 x 13 x 8 cm) are most desired because they provide the best drying conditions.

Fig 2: Drying Curves Solid Fuel Block



Compacting energy: The compacting energy is one of the most demanding requirements of this technology. It is essential for the devising of the machinery with which the compaction will be undertaken. Fig. 3 shows the results of a Proctor standard test[1] performed to a SFB made of shredded biomass and 30% clay per weight approximately. Compacting was done using the energy requirements of the Proctor standard testing (in the range of 6 kg/cm2/cm3). Results show that the optimal density can be attained at a moisture content of approximately 20% of the SFB weight (wet block). At this moisture content/energy, a wet density of 1.6 g/cm^3 can be attained, which falls slightly beyond the wet-density limit demanded for the block. However, even at this high density, as soon as the block dries out the density is lowered to acceptable ranges. For compacting energies lower than that of Proctor standard testing referred above, the curve moisture vs. density simply does not fall and the density depends almost linearly of the moisture content. To attain the minimal aspired density the compacting energy should be at least 50% of that of Proctor standard testing. Besides, the water to clay ratio should be kept within the limits w/c = 1 – 2.5 (the higher the compacting energy, the lower the w/c ratio).

Fig 3: Wet density vs. Moisture content



Machinery: The machine used for the densification of the block must comply with the following requirements:

a) Easy to operate

[1] Test performed to assess to optimal moisture content in soils for road construction

b) Mechanical operation, without electrical power
c) Productive
d) Relatively cheap
e) Lightweight

Initially, the authors considered the possibility of using the CINVA-RAM press designed for the manufacture of the Earth Compress Block (ECB), which is a rather popular model in development projects. Further testing showed that the energy of the machine, as well as the size of the block produced did not suit the conditions required for the SFB. Being the energy too little and the size of the block too large, the resulting block had a low density, and it most of the times disintegrated.

Fig. 4: a) Hand press used for the SFB manufacture, b)
Discarded CINVA-RAM press

After this experience, it was decided to launch a new model of hand press, this time using a hand driven screw press. This machine consists of (see fig. 4) a frame that holds a rectangular form 24 x 13 x 10 cm size. There is a lever, which holds the bottom of the form, and pushes it up after the block has been molded. A piston driven by a screw applies the pressure to the wet mass in the form to the final molding. This hand operated screw press can produce a pressure between 8-12 MPa, depending on the strength of who applies the force at the driving levers tied to the end of the screw. Field-testing performed by the authors has proven that this machine provides the necessary energy for the compaction of the SFB.

The machine has an average productivity of 150-180 blocks 1-1.5 kg each approximately per 8h journey. The cost of this machine ranges around $US 200. It is estimated that a normal production at a workshop demands for a minimum of two machines. CIDEM is launching a new design of the machine, which over performs the former machine, mainly in compacting energy and operation. It is more productive and easier to operate, thus making it gender-sensible.

Optionally a workshop could be equipped with a simple biomass shredder, which could eventually shred the waste biomass source in large fibers. There are many practical prototypes in the market, out of which the authors chose one, known as “hammer mill”. This machine, still in a testing stage can shred the biomass fiber to a desired fiber size.

2.3 Production process

The production of the SFB involves a series of aspects ranging from the preparation of raw materials, the production itself, the drying and final storage and transportation of the product. These processes will be explained below:

- Biomass processing: the waste biomass used for the manufacture of the SFB has to be shredded to a fiber size not exceeding 5 mm. There are types of biomass like pulverized sawdust, which do not need shredding but normal sieving. However other types of biomass, such as roots and leaves of crops have to be pre-processed before mixing with clay.

- Clay processing: The clay has to undergo a process of moisturizing, which could last some 2-4 days before it is ready for mixing. This allows breaking the clay structure and dissolving it into small grains. As the clay is kept in water for this relative long period of time, it becomes low viscosity sludge. The water / clay proportion for this sludge should be kept within 1 and 2.5 per weight. For relatively large production facilities similar to those of fired clay bricks workshops for clay processing are recommended.

- Mixing of raw materials: mixing is done manually in most cases, except when a drum mixer is available. The sludge is poured into the dry biomass. Both are mixed until homogeneity is accomplished.

- Pressing: before pouring the mixture in the form, a flat wooden piece must be laid on the bottom of the form. The formed block will rest on the wooden piece until it is hard enough to be removed. The wet mixture must be fed into the press. Then it must be pressed for some 15-20 seconds, until the extra water is leaked. Finally a lever pushes up the already formed block, which rests on the wooden piece. Then it is ready for handling.

- Wet storage and drying: The wet block resting on the wooden piece has to be laid in flat position for initial drying. After 24 hours the block must be moved to up-right position (see fig. 5), in order to remove the wooden piece. The block must rest in this position for at least 5 days before it is moved to final storage position. Completion of drying must be assessed directly on site. However drying must be completed before the second week after manufacture.

- Transport: For transports, heaps of 160 blocks (8 x 4 x 5) of blocks should be stocked and most desirably wrapped with some tissue or paper in order to prevent disintegration. Each stock must be conveniently tied and packed for transport. The packages can be smaller, depending on the clients demand.

- Final storage: The blocks can be piled up in heaps having less than 10 rows of blocks to avoid crushing. The blocks must be preferably stored in cover areas indoors, to prevent them from getting wet.

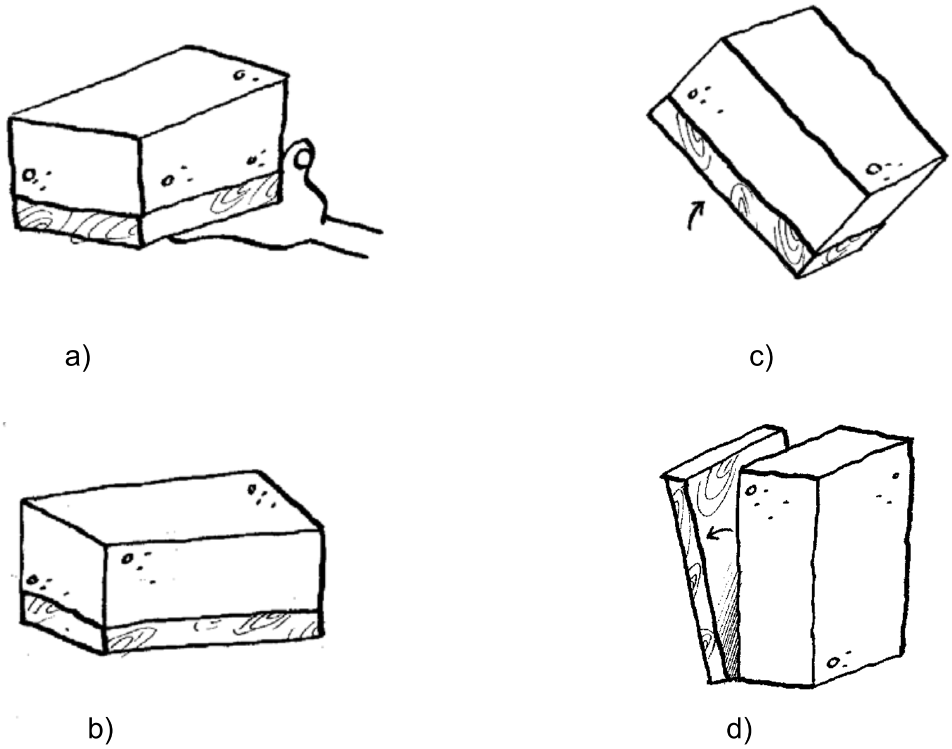


Fig. 5: Block handling after manufacture: a) The block just after pressing, b) The block should be laid for the first 24 hours, c) After 24 hrs. the block should be folded, and d) The wooden piece should be then removed

3. Organization of SFB production, Stakeholders

3.1 Biomass availability

Only in Villa Clara province there are 16 carpentry workshops, most them in urban areas of the 14 municipalities. The estimates for monthly production in the province are 39 tons coarse sawdust, and 6 tons of fin sawdust. Santa Clara city takes the greatest share, with a monthly production of approximately 8 tons of coarse sawdust and 2 tons of fine sawdust per month.

This does not consider other entities not related to IL which also have carpentry workshops. There is an important sawmill in Santa Clara city, whose wastes have not yet a proper disposal. So, a safe estimate could be to start with a production of, say, approximately 6 tons of sawdust per month, with would imply processing of approximately 300 kg of sawdust per day at the new workshop.

3.2 Infrastructure for production

The project aims at producing the SFB basically from sawdust. This waste is produced in all the network of carpentry workshops operated by TEDIS in Santa Clara.

TEDIS is one of the various enterprises managed by the holding "*Industrias Locales*" in the province Villa Clara. Fig. 6 shows the flow chart of this enterprise, which has three main divisions located in difference places within the province. Each division controls a series of workshops, whose production is done on independent basis, that is, they manage their own cost-profit schemes. For strategic decisions, each enterprise consults the municipality here it is located.

TEDIS' labor includes 317 persons; most of them handicapped persons who through this enterprise find a way to integrate themselves in society. These people are represented by ANSOC (National Association of Deaf and Hipo-acustic), ANCI (National Association of Blind and Vision-weakened persons) and ACLIFIM (Cuban Association of Physico-handicapped persons). Normally these people work in small workshops related to craftsmanship work.

TEDIS is thus inserted in the scheme for the holding of Local Industries in Villa Clara province, presented in fig. 2 in this report. Technically, it would be another area of influence for the IL holding, which eventually would receive the wastes produced by the various carpentry and craftsmanship workshops in operation.

Fig. 7 shows the specific areas where the project will be active at its first stage. A first workshop will be set in operation in January 2002 in Santa Clara city, operated by TEDIS. This workshop will basically process sawdust coming from two carpentry workshops located in Santa Clara city, and will produce SFB to be used mainly for the manufacture of quicklime in Remedios, and for brick firing in Placetas.

3.3 The workshop

Negotiations with the Local Industries Holding (LIH), which took place within December 2001 and January 2002 ended up in a concrete proposal to set up the pilot workshop in the Santa Clara city. This workshop is supposed to collect most of the available waste sawdust produced by the wood mills situated in the outskirts of the city.

The outcome of the negotiations with LIH allowed setting up the production in a workshop located in Santa Clara city. The workshop will have only two people as labor force. Both are disable (one of them is deaf and the other is weak-sighted) whose involvement is coordinated by disable people organizations in Cuba.

The workshop consist of an approximately 85 m^2 total area, out of which 25 m^2 is indoors covered area, equipped with a water pond to wet-process the clay before mixing it with the biomass previous to the forming of the Solid Fuel Block. Besides there is an approximately 60 m^2 outdoors area, paved with a concrete slab, where the blocks will be set to drying and further storing. There are various pictures of the workshop enclosed as annex.

The process of setting up the workshop was divided into several stages listed below:

1. <u>Discussion with administration on the conditions where production is to be launched</u>. This was done between mid December 2001 and early January 2002.

Fig.6: Flow chart of the enterprise "Producciones varias" in the province Villa Clara, Cuba

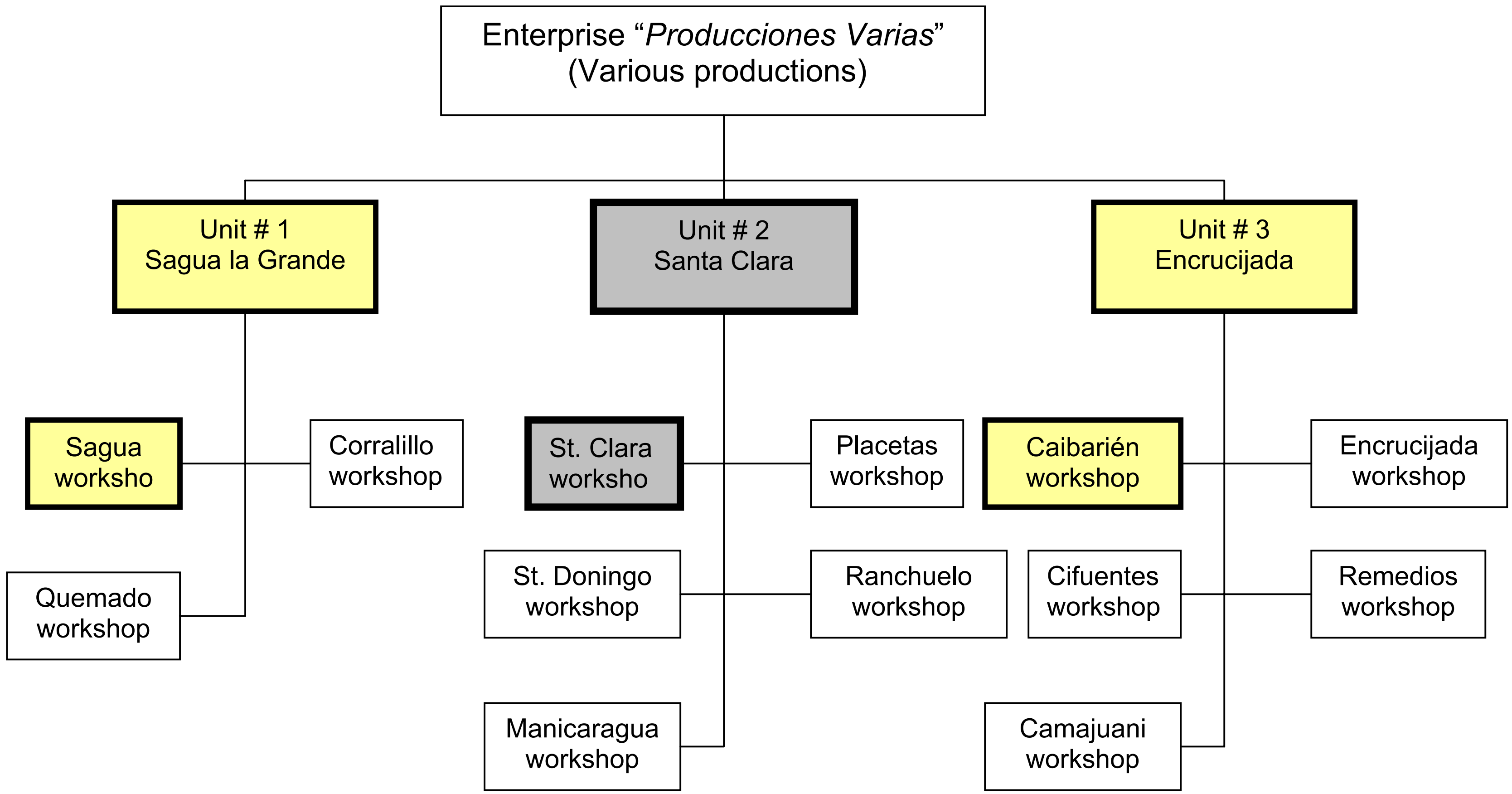
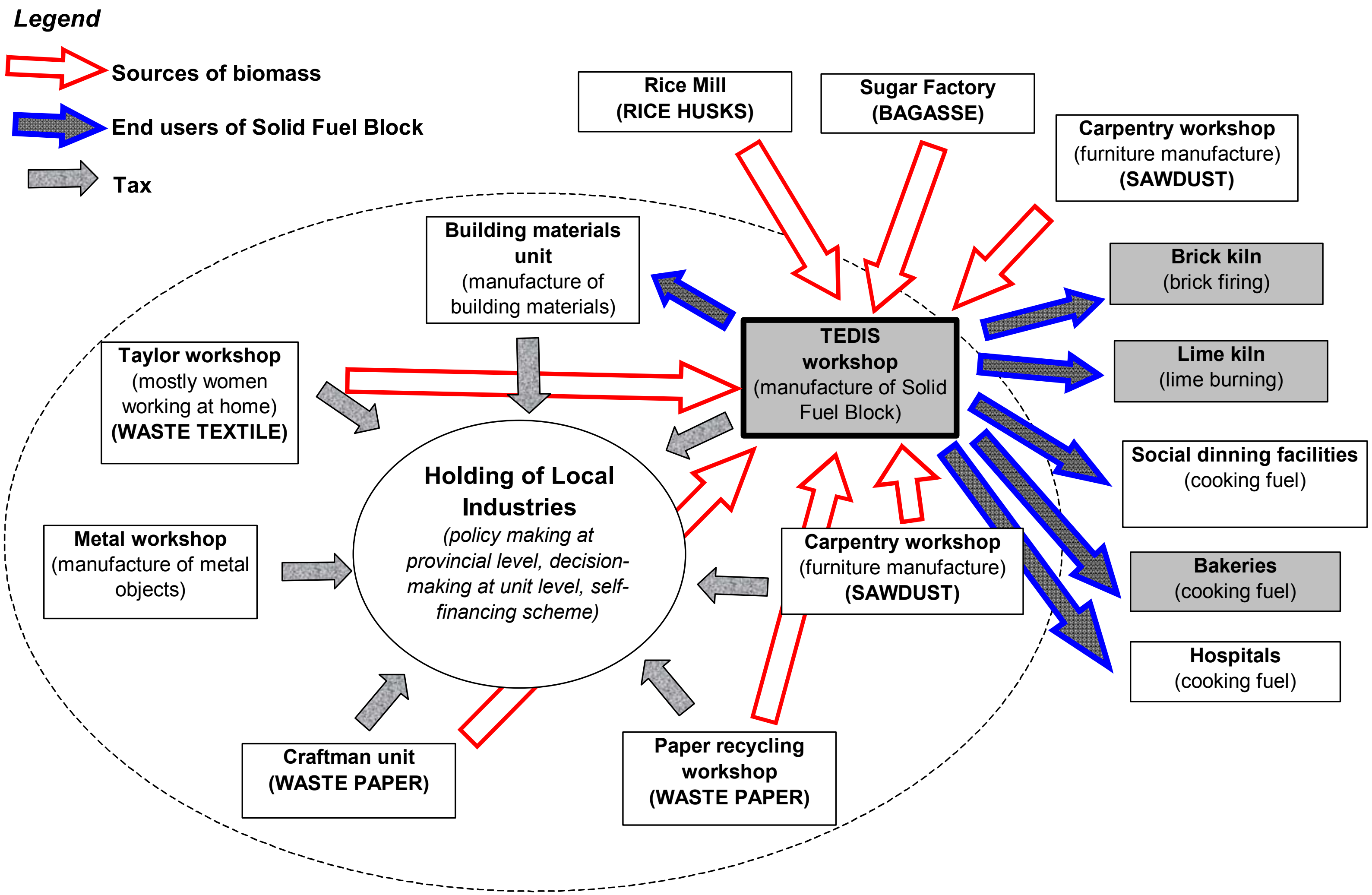


Fig. 7: Organizational scheme of the Local Industries holding in the province Villa Clara, Cuba



2. Workshop with the producers to present the main features of the technology. This was done on the 29.01.2002, and the signatures of the participants as a sign of agreement with the proposed working conditions were collected (enclosed in the annex). The technology was widely explained aided by VCR pictures of experimental productions. Because of the complexity of the communication with the workers involved, an interpreter had to be sought in order to make sure that the (deaf) worker could fully understand what we were presenting. This working session was also filmed and photographed. The workers showed their agreement with the proposed methods for the manufacture of the SFB.
3. Creating conditions at the workshop: this included the replacement of part of the roof that was removed by recent hurricane "Michelle", also the fencing of the working area, which is close to carpentry facilities within the LIH facilities.
4. Supply of raw materials: the sawdust was sourced aided by tri-cycle carriers owned by private owners. Everyday production demands approximately of 30 bags of sawdust weighing between 10-12 kg each. The waste sawdust was pre-stored in plastic bags to facilitate handling and transport. Besides, the selected clay was brought from a quarry located 20 km away from Santa Clara city. It is estimated that the continuous production demands less than 5 m^3 of clay per month.
5. Initial demonstration: the technical team did it together with the workers. It aimed at organizing the initial production of SFB with the available biomass. The whole process was practically described to the attendants. Finally, as part of the demonstration production, 120 SFB units were manufactured and set to drying.
6. Further monitoring of the production: It consists of regular visits to the working site to verify that the production is kept under the technical regulations; also to assess further improvements to implement in the technology, based on the practical experiences in the manufacture.

4. Economy of SFB manufacture

4.1 SFB cost analysis

Before the start-up of the production, detailed cost analyses were performed. For the cost estimate, only local currency was considered, since hard currency expenses like diesel for transport, are not needed. The resulting data sheets are included in the Annex of this report.

The costs of production are described below:

1. Fixed production costs: basically include cost of indirect labor force, financial costs, transport, maintenance and other costs. As the production is very simply organized, financial costs are not considered in this analysis. The machines are paid up-front by TEDIS. Also, they use their own financial resources; therefore they do not need to go for bank loans. Fix production costs represent approximately 40% of the total production cost; most of their share (38.5%) taken by transport costs (sawdust collection with tri-wheeler cycles)
2. Variable production costs: basically include the cost of raw materials such as sawdust and clay, the cost of commodities like water and electricity, and finally the cost of direct labor force. All these costs have been set according to information provided by TEDIS. Variable costs represent 60% of the production costs.

3. Profitability margin: they usually assume it as of 20% profit. This is relatively easy to achieve, since they have been momentarily released from the production and sales taxes, as a means to stimulate production of this environmentally friendly product.

The minimal price established is \$CUP 0.09 /kg. This could be expressed in volume as \$CUP 39.06/m^3. The price of a piece would then be \$CUP 0.09. The alternative product traded in the market (firewood) is sold at approximately \$CUP 58.8/m^3. In this minimal profit scenario the SFB could be traded at prices approximately 34% lower than that of firewood. The break-even point for this minimal scenario is reached for 80% of sales approximately; this can be accomplished by maintaining 19 continuous working days in the month.

In a more profitable price scenario, the SFB could be traded at the same price as firewood. This would yield a price of \$CUP 0.13 apiece. The break-even point is reached after 14 days of continuous work. Table 1 summarizes the two analyzed scenarios.

Table 1: Economic analysis of SFB production in comparison with firewood.

Firewood Price x m3	**SFB optimal scenario**			**SFB minimal scenario**		
	Price x m3	Price x unit	Days for BEP	Price x m3	Price x unit	Days for BEP
58.80	58.80	0.13	14	39.06	0.09	18

Health problems

There are no major health problems associated with the manufacture of SFB at TEDIS workshop.

4. SFB fuel properties

The Solid Fuel Block is an attractive source of renewable fuel, therefore it is important to know the limits of its application. In this regard, a group of studies were implemented to assess the fuel properties of the SFB. The studies were done both in the laboratory and in the field. The results are presented below.

4.1 Laboratory studies

4.1.1 Heat of combustion

It was determined aided by the calorimetric pump. The calorific value was estimated for SFB made of three different sources of biomass (Rice Husks, Sugar Cane Bagasse and Sugar Cane Straw). The results obtained in these tests can be further extended to sawdust, since there are no significant differences in the composition of the materials evaluated.

The test included calibration of the Beckmann thermometer according to existing standards. A sample of the size of an aspirin pill is taken from the SFB. This sample is pressed in order to make it compact. The waste of the sample must be around 0.1 g. The sample is pressed together with an ignition wire. Then the sample is weighed and tied to the ends of the pump, while 5 ml of water are poured. Oxygen is added to vacate the air from the inside of the pump; finally O_2 at 30 atm remains in order to complete combustion. Then it is burnt out inside the calorimetric pump and results are obtained.

After the test is finished, the following parameter can be calculated according to 4.1:

$$H_0 = \frac{C * \Delta T - (Q_S + Q_N + Q_Z)}{P_A} \quad (4.1)$$

Being:

$\Delta T = T_2 - T_1$
$Q_S = 15.1(a + b - 20)$ Heat produced while H_2SO_4 is produced (J o kJ)
$Q_N = 6.0(20 - a)$ Heat produced while HNO_3 is produced (J o kJ)
$Q_Z = P_{AQ}$ * Combustion heat Fe (J o kJ)

The calorific value (CV) can be calculated according to 3.2:

$H_U = H_0 - 24.41 * F$ (4.2)

Being:

ΔT = Temperature difference. (K)
C = Caloric capacity of the calorimetric system. (J/K)
F = Water produced in the experimental analysis (Wt. - %)
m_B = Weight of benzoic acid. (g)
H_{0B} = Combustion heat of benzoic acid. (J/g o kJ/kg)
H_0 = Combustion heat of the sample. (J/g o kJ/kg)
H_U = Calorific value of the sample. (J/g o kJ/kg) .

Table 2 shows the results of the experiments carried out. The ratio between the calorific value of the SFB and that of the equivalent weight of pure biomass, in order to assess the losses of the CV produced by the presence of clay and moisture. As seen on table 2, the CV decreases in according to the amount of clay used in the SFB. Water evaporation takes approximately 10% of the calorific value of the SFB. This confirms the criteria referring to maximum clay content up to 30%, since otherwise the loss of CV would make senseless the use of the SFB as fuel.

Table 2: Results of the Calorific value testing

Used Biomass	% clay	Combustion Heat (H_0) (kJ/g)	Ratio Hg (SFB)/Hg (normal biomass)
Rice Husks	28%	10.96	60%
SC Bagasse	20%	13.85	75%
SC straw	25%	17.87	Not available

4.1.2 Immediate analysis of the fuel

This is one of the normal testing performed to evaluate fuels. A gravimetric method is used to separate the different components to be finally determined, for instance by evaporation or incineration. This test gives us the percentage of fixed carbon, the ash content and volatiles in the sample. The test was also applied to SFB samples made of the various sources of biomass (Rice Husks, Sugar Cane Bagasse and Sugar Cane Straw).

The test consists of weighing 1,000 g of the sample, which are further dried until constant weight at 125 ^{o}C - 130 ^{o}C. The weight difference is attributed to the moisture content of the SFB in equilibrium. The recipient is then dried at 850 ±10^{0}C for 7 min at an oven. After cooling the sample is again weighed and the weight difference corresponds to the presence of volatiles in the sample. Soon after, the sample is further subjected to incineration at 900^{0}C until constant weight (approximately 4 hours). Incineration takes place when the carbon is removed from the sample. Finally the sample is once more weighed and the weight difference is attributed to the presence of fixed carbon in the sample.

Table 3: Results of the immediate analysis of the SFB as fuel

Parameters	Rice Husk	Sugar Cane Straw	Sugar Cane Bagasse
% Moisture (% w)	7.14	6.03	5.48
% Volatiles (%Vr,Ih)	49.96	49.15	56.53
% Fixed carbon (C_f,Ih)	10.11	8.91	4.65
% Ash (A,Ih)	39.93	41.94	38.82

Table 3 presents the results of the tests. As seen, the moisture content in all cases is below 10%, and the fixed carbon is low enough as to qualify the materials as a good pozzolana. The ash content is high as expected, mainly because of the presence of clay and the ash produced by burning the biomass itself.

4.2 Field testing

As the production got started, some trials with the SFB were soon organized. The aim was to prove that the SFB fulfilled the expectancies created at the experimental part of the work.

Fig. 8: SFBs packed for transportation before the trial

Fig. 9: SFBs feeding in the burning chamber

The trial was organized in one of the social kitchens in operation in Santa Clara city. The stove burns on firewood sourced from the outskirts of the city. Normally this kitchen cooks food for the lunch of approximately 120 workers of the Local Industries Holding in Santa Clara.

Some 12 kg of SFB were used for the trial. The blocks were produced with sawdust as biomass, with approximately 30% clay content (wt.). The blocks were dried until constant weight for 12 days until they were ready for the trial. For transportation, the blocks were packed in a cardboard recycled box, as shown in fig 8.

The stoves were hot before feeding in the blocks, so it was just to stop feeding firewood and instead feeding the SFBs). Fig. 9 shows the process of manual feeding of the blocks into the stove. Fig. 3 shows the block after the initial burning, directly in the burning chamber.

There was an interesting outcome of the trials, described below:

1. Self-burning temperature: There was a violent process of auto combustion as soon as the block was fed into the burning chamber of the stove. Large flames could be seen, rising above the upper level of the stove. It is estimated that the temperature at the burning chamber was around 400 ^{o}C. This could be regularly assessed in all tested blocks.

Fig. 3: SFBs initial burning in a cooking stove

2. Block combustion: The combustion of the block was in all cases more consistent that that of the firewood pieces formerly burnt. At the start, a pyrolysis was visually assessed, and finally the block burnt itself out. Normally a 2 kg block took more than half an hour to be totally burnt out.
3. Smoke: to the technical team's surprise, the amount of smoke dramatically decreased in comparison with the firewood earlier used. As the stove is indoors, this is obviously an advantage, also seen by the workers who witness the trial .
4. Ash content: as expected, approximately 40% of the weight of the block was converted into ashes. However ash removal was not a problem for the continuous operation of the stove.

The trial lasted approximately 90 min, during which the 12 kg of SFBs were burnt out. Some of the workers at the kitchen were interviewed, and in all cases their impressions were very positive.

5. Conclusions

This study has shown that the SFB is a profitable and quite viable technology, which can be implemented at very small scale with minimal resources. This represents obviously an alternative to traditional fuels, specifically in Developing Countries.

ANNEX 1: RECORD OF THE MEETING HELD WITH THE SFB PRODUCERS

TALLER DE PRESENTACION DE LA TECNOLOGIA DE PRODUCCION DEL BLOQUE SOLIDO COMBUSTIBLE

Lugar: TALLER TEDIS   Fecha: 29.01.2002

ASISTENCIA

Nombre y Apellidos	Firma
Fernando Martiven	
Ivan Machado	
Ricardo Monzón	
Roberto Arabí Nabarro	
Amarilys González Cuello	

ANNEX 2: FEASIBILITY STUDY OF THE SFB PRODUCTION

FEASIBILITY OF THE MANUFACTURE OF SOLID FUEL BLOCK

DATA SHEET

I	***Generalidades***						
	Country	Cuba					
	Region	Villa Clara					
	City	Santa Clara					
	Address						
	Land area	120 m2					
	Developed area	90 m2					
II	***Production data***						
	Descripción	**u/m**		**Amount**			
	Days of production in month	dias		24			
	Days of production in year	dias		273			
	Daily production(loss included)	kg		377.3			
	Nominal daily production	kg		385			
	Monthly production	kg		9055.2			
	Yearly production	kg		103002.9			
	Loss in production	%		2%			
III	***Materias primas***						
	Description	**Daily consumption**		**Unit cost**		**Monthly cost**	
kg	Fine sawdust	269.5	$	0.010	$	64.68	
kg	Clay	115.5	$	0.005	$	13.86	
IV	***Commodities***						
	Descripción	**Daily consumption**		**Unit cost**		**Monthly cost**	
lts	Water	0.77	$	0.00	$	0.02	
kW	Electricity	0	$	0.09	$	-	
V	***Labor force (based on 8 hours journey)***						
	DIRCECT WORK FORCE						
	Description	**Unit wage**		**Daily wage**		**Monthly wage**	
	Specialized labor						
2	Worker	$ 6.15	$	12.30	$	295.20	
	Non-specialized labor						
	Assistant		$	-	$	-	
	'INDORECT WORK FORCE						
	Description	**Unit wage**		**Daily wage**		**Monthly wage**	

VI	*Machinery*			
	Description	**Unit cost**	**Intern. Transport**	**Total cost**
2	Hand press	$ 200.00	$ -	$ 400.00

VII	*Infraestructure*			
	Description	**Amount**	**Unit cost**	**Total cost**
m2	Storage area	70	$ 30.00	
m2	Production area	24	$ 40.00	
u	Water installation	1	$ 200.00	
u	Electricity installation	1	$ 300.00	

VIII	*Tools and maintenance*	
	Description	**Monthly cost**
	Various tools	$ 10.00
	Maintenance for machinery	$ 20.00

IX	*Transport*			
	Description	**Amount**	**Unit cost**	**Monthly cost**
u	Viaje de triciclo	24	$ 10.00	$ 240.00

X	*Other fixed costs*	
	Description	**Monthly cost**
	Machinery devaluation	$ 1.00
	Land rental	
	Sales commissions	

XI	*Cost of technical assistance*	
	Description	**Total cost**
	Know-how	
	Experts	

XII	*Financial aspects*	
	Interest rate	
	Infrastructure	
	Equipment	
	Working capital	
	Technical assistance	
	Tax (%)	0%
	Planned profit	20%
	Cost of hard currency	$ 1,000.00
	Initial working capital	$ 600.00

FEASIBILITY OF THE MANUFACTURE OF SOLID FUEL BLOCK

COSTS AND PRICE SHEET

COSTS					
Required external capital	**$**	**1,000.00**			
Investment	**$**	**400.00**			
Infrastructure	*$*	*-*			
Equipment	*$*	*400.00*			
Working capital	**$**	**600.00**			
technical assistance	**$**	**-**			

Description		Monthly cost		Unit Cost	%
Monthly fixed costs	**$**	**277.67**	**$**	**0.03**	**40%**
Indirect work force	*$*	*-*	$	-	*0.0%*
Financial costs	*$*	*6.67*	$	0.00	*1.1%*
Infrastructure	*$*	*-*	$	-	*0.0%*
Equipment	*$*	*6.67*	$	0.00	*1.1%*
Initial costs	*$*	*-*	$	-	*0.0%*
Working capital	$	-	$	-	*0.0%*
Tools & Maintenance	$	30.00	$	0.00	*0.4%*
Transport	*$*	*240.00*	$	0.03	*38.5%*
Other fixed costs	*$*	*1.00*	$	0.00	*0.2%*
Monthly variable costs	**$**	**373.76**	**$**	**0.04**	**59.9%**
Raw materials	$	79	$	0.01	*12.6%*
Labor force	$	295.20	$	0.03	*47.3%*
Non-specialized	$	-	$	-	*0.0%*
Specialized	$	295.20	$	0.03	*47.3%*
Commodities	$	0.02	$	0.00	*0.0%*
Total production costs	**$**	**651.43**	**$**	**0.07**	**100%**

SALES PRICE				
		Monthly		**Unit**
With planned profit	***$***	***781.71***	***$***	***0.09***
Variable costs	$	373.76	$	0.04
Fixed costs	$	277.67	$	0.03
Profit	$	130.29	$	0.01
Sale tax	$	-	$	-
Final sale's price	***$***	***781.71***	***$***	***0.09***