Simple techniques for basic bio-fuels

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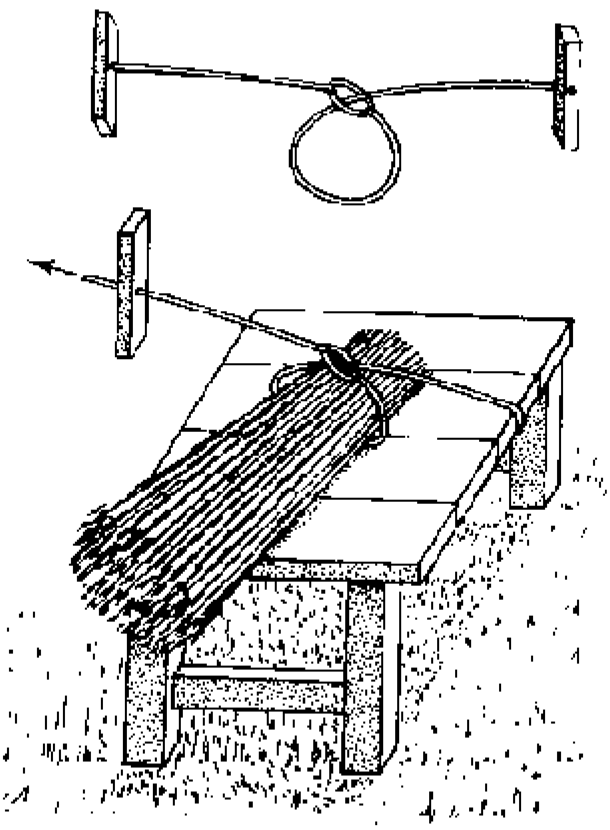
All kinds of familiar agricultural fuels will burn much more efficiently with proper processing. The methods are elementary and the costs are small.

1. Adding a piece of wood helps combustion

2. Tying the bundle



3. Forming the bundle

Simple fuel technologies for developing countries are based on available resources and the "do it yourself" principle. While the tools for processing fuel may be manufactured locally, what is needed is a well-organized demonstration and training programme covering large areas of these countries.

Although simple processing increases the heat value of big-residues considerably, every kind of fuel calls for a specific type of stove or furnace to provide optimal combustion. The term "fuel" means a substance which, during chemical reaction with oxygen, produces a heat or exothermical reaction. Most of the oxygen in the reaction derives from the air, which consists of 21 percent oxygen by volume and 79 percent nitrogen. Fuel can be divided into two main parts: the combustible part, which includes volatiles and solids; and the non-combustible part, including ash and moisture.

[4. Easily constructed hand-press]

[4a. Compressing the bundle]

[5. Another type of simple hand-press]

To achieve the optimal use of fuels it is necessary to control the speed of combustion from one piece of fuel to another. This is achieved by the controlled introduction of air into the combustion chamber. The most important factor determining good combustion is the complete consumption of the fuel used. Agricultural waste usually has poor combustion, but it can be improved by agglomeration, densification or drying.

Moisture decreases the heat value of fuel because evaporation of water consumes heat. For example, the evaporation of 1 litre of water consumes *5.5* times more heat than heating this water from ambient to boiling temperature. In the case of firewood, the differences in heat value between green and seasoned wood are considerable, as is shown in Table 1.

Processing of bio-fuel

Firewood. Twigs, straw, hay and dry leaves are often the only fuels available to rural people. Round firewood is often either too expensive or simply not available. But the material that is available burns so rapidly that it is difficult to maintain a steady fire for cooking.

Given these constraints, the easiest method of improving combustion is by pressing the material into bundles, i.e., by "agglomerating" and "densifying" the biomass volume. This restricts the access of air and thus slows down combustion. Well-pressed bundles should contain a mixture of twigs, biomass (cellulose) materials and, if possible, a piece of wood in the middle. The bundles may be compressed by simple presses (Figures 3, 4, 4a and *5).* They should be fastened by a band of straw, home-made cord or wire (Figure 2). Wire is best because it is fire-resistant. Before being used, the bundles should be dried for a long time in a well-ventilated place protected from the rain.

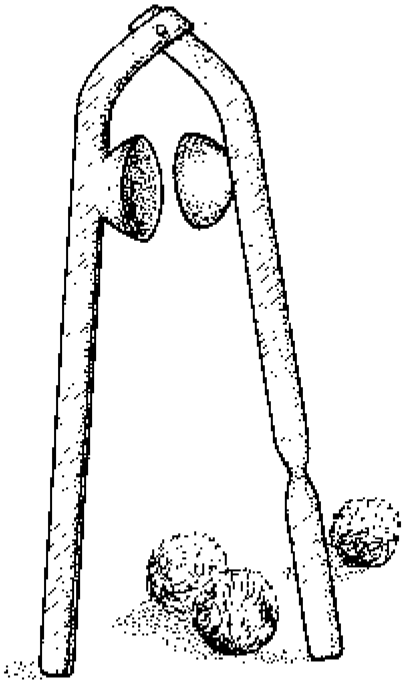
The bundles can be made by hand, but to increase pressure and thereby heat value a number of implements can be used. Those illustrated in Figures I through *5* can be made at home at practically no cost or manufactured by local smiths.

Briquetting. Neither wood nor agricultural wastes such as wood dust, sawdust and coffee husks can be burned directly in domestic stoves. They burn with difficulty, produce considerable smoke and are unsuitable for cooking. The same is true of charcoal dust.

One of the best methods of handling such residues is by the agglomeration of small particles into briquettes. There are two principal methods of briquetting, with or without a binder. Doing without the binder is more convenient, but it requires sophisticated and costly presses and drying equipment, and is energy-intensive.

Briquetting with a binder such as tar, pitch or asphalt calls for high-pressure industrial processes to produce briquettes from hard coal, coke dust and, to a lesser extent, coal dust.

6. Simple briquetting press



[7. Another simple hand-press for making briquettes]

Such processes are also sophisticated and expensive, and while they are not appropriate for villages they might be very useful for central or local government projects, especially in countries having an abundance of wood and agricultural waste.

For rural populations the most suitable briquetting methods are those which are based on available waste and building materials. The manufacturing should be done in locally made hand-operated presses. The hand-made briquette is held together mainly by the binding material. Depending upon local availability, the most suitable organic combustible materials for binding are resin, tar, animal manure, sewage mud (sludge) and fish waste.

If combustible binding materials are not available or the waste needs a stronger binding material as, for instance, in the case of charcoal dust, then it is necessary to apply noncombustible binders such as slime, clay or mud.

Although the non-combustible binder lowers the heat value of the briquette and increases the ash content, it does make possible the use of materials which otherwise would be valueless as fuel.

Presses, Design varies from the simplest, technologically primitive home-made hand-presses to very advanced automatic units. Among the illustrations is a simple hand-press (Figure 6) which can be manufactured by any village smith. The lower arm of the press is fixed to a wooden board. The pressure ranges from about 50 to 100 kg per briquette, or 5 to 15 kg/cm^2. The briquettes produced are spherically shaped, preventing the fracture of edges which is a weak point in home-made briquettes.

The materials used are soaked newspaper or any waste paper. The addition of wood ash makes the balls harder and prolongs combustion. The briquettes are pressed into balls of about 5-cm diameter, and the weight of a dry briquette is about 30 g. The size of a briquette may vary, but larger balls are more difficult to press. The cost of making one press would entail 3-4 man-hours and 1-2 kg of iron. The working time can be considerably reduced if a number of presses are manufactured together and work is well organized.

Another illustration is of a simple metal briquetting press (Figure 7). It produces a pressure of 200 kg per briquette or about 3 kg/cm^2. The square form is fixed to the base by the hinge, which makes it mobile and facilitates removal of the briquette. The press can be modified by stronger construction and a longer lever. The base should be kept above the ground. Underneath the container there should be an opening with a metal cover: this plate is opened and the finished briquette is removed by means of the hand lever.

Another press which has been developed and tested consists of a square container in which waste is pressed by a screw similar to that in a wine press. Pressure is up to 2 tons per briquette or about 40 kg/cm^2. The rate of production, however, is slower than with the lever press.

Good results have been obtained by adapting these presses for bricks or earth blocks. They are now well known in developing countries under such names as "Cinva-Ram", "Terstaram" and "Combustaram" (Figure 8). To produce briquettes it is necessary to insert moulds of the required forms (Figure 9).

In Europe during World War I screw-type briquette presses worked on the same principle as meat-cutting machines. They produced a continuous briquette mass for cutting into sections. The screw press has much lower pressure than the piston press and consequently has limited application for waste which is easily convertible into briquettes resistant to crumbling.

Table 1. IGNITION TEMPERATURES OF SOLID MATERIALS

Material	Ignition temperature (°C)
Lignite dust	150-170
Hard coal dust	150-220
Coke from lignite coal	300-400
Coke from hard coal	350-700
Graphite	700-850
Charcoal (soft)	250-300
Charcoal (hard)	300-450
Peat	200-450
Paper	300
Wood dust	315-460

Source: Author's measurements.

Table 2 NET HEAT VALUE OF FIREWOODS

	Heat value		Specific weight of dry wood
	Seasoned	Green	
	kcal/kg		*kg/dm³*
Pine *(Pinus)*	4658	3870	0.49
Weymouth pine *(Pinus strobus)*	4 876	4 055	0.37
Birch *(Betula)*	4 658	3 869	0.61
Spruce *(Picea)*	4622	3 589	0.43
Larch *(Larix)*	4 597	3 818	0.55
Fir *(Abies)*	4 559	3 785	0.41
Locust *(Robinia)*	4 527	3 760	0.73
Beech *(Fagus)*	4478	3 705	0.69
Linden *(Tilia)*	4 474	3 713	0.49
Elm *(Ulmus)*	4 419	3 810	0.64
Oak *(Quercus)*	4329	3742	0.65
Ash *(Fraxinus)*	4329	3593	0.68
Alder *(Alnus)*	4 288	3 555	0.49
Sycamore *(Acer pseudoplatanus)*	4 245	3 845	0.59
Black poplar *(Populus nigra)*	4 205	3 518	0.41

Source: T. Wojciechowski, **Nauka o drewnie**, PWRIL, Warsaw, 1961.

Table 3. MATERIALS USED FOR THE MANUFACTURE OF BRIQUETTES

Paper waste
Municipal waste
Wood waste
Coconut fibre
Peat
Tundra dust
Cotton waste
Sawdust Straw
Groundnut shells
Hazelnut shells
Olive-oil residue
Sugar cane
Bark
Rice husks
Sunflower husks
Leather waste
Hemp
Manure
Used motor-oil (as an additive to solids)
Hay
Shrubs
Fish waste
Food-processing waste

Advanced industrial presses for wood and agricultural waste exert much higher pressures, ranging from 1000 to 1200 kg/cm^2. At these pressures the temperature is very high. Both high temperature and high pressure destroy the elasticity of the wood, making it possible to form the briquettes without a binder.

An example of an advanced piston press is one manufactured by Fred

Hausman Ltd. of Basel, Switzerland (Figure 10). Its capacity ranges from 100 to 3 000 kg/in. The materials for use in such a press include wood waste, bagasse, tree bark, olive residue, leather waste, nutshells, waste paper, peat, the husks of rice or sunflower seeds and other agricultural waste material. The briquette press is only one of the elements of production, which include a grinder, a suspension drier, a press, and a packaging machine. Also illustrated is a production line design (Figure 11) for making briquettes from wood waste.

An installation similar to this is used in the Polish timber industry with wood bark as the source of material. The basic equipment includes a grinder, a suspension dryer and a briquetting press.

Waste preparation. The first operation, common to all briquette-making processes, is the chopping and/or grinding of combustible waste. In simple village technology, where the materials to be prepared are branches, twigs and straw, the best tool for chopping is a hatchet or broad axe. For production on a large scale, different tools are required such as the straw chopper commonly used by European farmers.

The second operation is the drying of the main combustible ingredients. In a simple technology, drying should be performed without the use of fuel. The only real option, therefore, is natural drying in well-ventilated places protected from rain. Such drying takes a long time, so the basic ingredients for briquetting should be prepared well in advance.

Third comes the mixing of various kinds of waste and binding materials in order to produce the optimum consistency and heat value. If used motor-oil is available it may be added to the waste, but, although it increases the heat value of the briquettes, it makes them crumbly.

8. Lever press adapted for making briquettes, with mould inserted

9. Mould for briquettes

The fourth operation is compressing the briquettes, and the fifth is drying them in open air, under shelter. Depending upon the binding material and drying conditions, it will take between a few and several months to produce dry briquettes. Drying significantly increases the heat value of the briquettes and thus saves fuel. They should therefore be produced well in advance of intended use.

New types of fuel

Experience has shown that the successful implementation of new technical projects depends on socio-cultural, historical and economic factors as well as on purely technical ones. Many projects involving obvious technical improvements have failed because the non-technical factors were neglected.

When starting a new project, preliminary work on organization and research is essential before proceeding with technical design. The most effective way of achieving success is to assess the situation from several viewpoints, namely those of forestry administrations, women's associations, contractors and technicians. These groups should be invited to express their views regarding the availability of combustible waste, the social climate, the attitudes of local people to innovation, and economic and other relevant factors.

On the basis of this inquiry, targets for the promotion of new fuels should be established. Costly and time-consuming surveys are not necessary. The environmental aspects should also be taken into consideration because the combustion of biomass waste in stoves eliminates one of the important elements in the ecological chain. Under normal conditions biomass waste is recirculated to the soil.

If this delicate equilibrium is broken, the consequences may be observed in decreasing productivity of the soil and, in extreme conditions, in its desertification.

Owing to the interdependence of fuel and stoves, it is recommended that stove and fuel improvement programmes be undertaken concurrently. A combined programme might consist of improvements to existing stove designs and fuel types to suit local cooking practices, and the design and construction of new stove models, together with the introduction of new types of fuel.

10. Piston press can produce up to 3 000 kg/in

11. Production line for waste-fuelwood briquettes

1. Conveyor - 2. Grinder - 3. Fan - 4 Cyclone - 5. Bin (wet material) - 6. Bin discharge - 7. Furnace - 8. Fan - 9. Suspension dryer - 10. Insulation - 11. Cyclone - 12. Briquetting press - 13. Cooling line - 14. Ground wet material - 15. Hot air.

New briquettes should be laboratory tested. This is the only way to collect and compare the technical data of the various options available locally. Testing equipment is not too costly, about US$5000, and it can often be found in the laboratories of universities and technical schools. It is important to develop a comprehensive test procedure, especially concerning measurement of net heat value, humidity and ash content. The fuel should be tested both in the laboratory and in everyday cooking.

Table 4. COMPARISON OF SAMPLE BID-FUELS

Composition	**Gross heat value**	**Humidity**	**Ash**	**Net**	**Comment**
	kcal/kg	***Percent***		***kcal/kg***	
Dry beech wood	4 554	8,0	0,3	4 224	Type of wood rarely available in poor rural areas
Green birch wood	3 308	42,9	0,25	2 889	Type of wood commonly found in poor rural areas of developing countries
Waster-paper balls (made from soaked newspaper)	4 143	6,9	2,9	3 825	Made by hand; burn better if wood ash is added
Briquettes made of 30-45% charcoal dust 30-45% chopped twigs 15-20% manure	4626	2,4	32,2	4 408	Comparable to medium-quality hard coal: high ash content probably from sand
Briquettes made of 25% charcoal dust 25% straw 30% chopped twigs 20% manure	3 397	7,2	13,7	3 109	Lower percentage of charcoal dust reduces heat output

Briquettes made of 50% straw 50% cow manure	3 898	5,4	9,5	3 599	Feasible everywhere, but has high manure content - and manure is better used for fertilizer
Briquettes made of 40% straw 40% sawdust 20% manure	3 561	9,2	14,0	3 266	Needs careful drying because of sawdust
Briquettes made from charcoal dust with clay as binder	1 064	-	73,0	975	High mineral content lowers heat value and creates much ash

Field testing should also be applied, both to develop or improve new fuels and to analyse their heat values. Groups of people from different backgrounds could be organized to investigate, promote, and later use the fuels in their households on an experimental basis. They should be invited to carry out further investigation on the composition of locally available biomass waste for briquetting and binding materials.

In most developing countries there are considerable quantities of biomass waste which could be processed by means of agglomeration and densification. The best results are usually achieved if several kinds of material are mixed with a binder. The heat value of well-dried, compressed biofuel waste is similar to that of fuelwood. However, the uncontrolled use of biomass waste could have adverse ecological consequences on the soil, such as reduced fertility. Careful evaluation of how much and which biomass can be used as fuel in specific regions should be undertaken and monitored by competent officials.

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