PRACTICAL ACTION
Technology challenging poverty

GASIFIER STOVES
ADVANCED BIOMASS STOVES

Advanced biomass stoves covers improvements developed over recent years for household cooking in developing countries. They are often referred to as gasifier stoves although not all of these stoves strictly gasify the fuel. These designs of stove incorporate "forced ventilation" through the use of a fan, which improves their performance.

Background
Traditional three-stone fires and traditional stoves are still used by millions of people around the world. There are very good reasons for this; they are free or very low cost, three-stone fires are portable, and traditional cooking methods can cook food quickly – particularly when skilled cooks use them. The temperature of these stoves can be 'turned up or down' by adding or withdrawing pieces of fuel. They will take all shapes and sizes of pots, and all shapes of fuel, from agricultural residues to big logs, and these attributes make them hard to replace successfully.

However, the health risks from using three-stone fires and rudimentary stoves are immense; nearly 2 million people a year die prematurely due to illnesses attributable to indoor air pollution from solid fuel use (2004 data). Among these deaths, 44% are due to pneumonia, 54% from chronic obstructive pulmonary disease (COPD), and 2% from lung cancer. There is also evidence of links between indoor air pollution and low birth weight, tuberculosis, heart disease, and other forms of cancer. In low-income countries it is responsible for around 4% of all days lost to illness (WHO).

Traditional stoves and three-stone fires are damaging to people's lives in other ways. People need to spend many hours each week gathering fuel – time that could be spent by adults (particularly women) in employment, and by children, when they should be at school. Alternatively, they spend money they can ill afford to buy fuel. Fuel, like food, is an essential part of life.

Inefficient burning of biomass increases the greenhouse gases and black carbon (soot) emitted from millions of small fires around the world. In February 2012, this was recognised in a new initiative by the US government (US State Department, 2012) to reduce black carbon, stating that it 'is emitted from a wide variety of sources that burn but do not fully combust fossil or plant-based fuels. Common sources include…inefficient cookstoves, among others.'

Advanced biomass stoves
For an advanced stove to be accepted and successful, it must be easy to light and use, like a three-stone fire, and at the same time burn much more cleanly and efficiently. The most important thing is that the cook must want to use it – or it is doing no good at all.

Many of the so-called 'improved' stoves reduce the amount of fuel used but fail to substantially reduce the health-damaging pollutants.

An 'advanced biomass stove' is not a particular technology, but rather, it is a stove that has the following characteristics:

- The stove must be **well-liked by the cook**, or she/he will not use it
- The stove must burn **cleanly**, **reducing the amount of indoor smoke** inhaled by the cook and her family sufficiently to have a positive health benefit
- The stove must burn **efficiently**, **reducing the quantity of fuel** that needs to be bought or gathered by the user, providing them with savings in both money and time.

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technical brief

How do they work?

This type of stove uses the principle of *forced ventilation*. The stoves are designed so that when the stove is lit, air is *blown* into the fuel. The hot air drives off the volatile components (gases and vapours) from the wood or other biomass. The gases can then be thoroughly mixed before combustion. Because of this more controlled process and greater mixing, the hot gas and air burns much more cleanly and thoroughly.

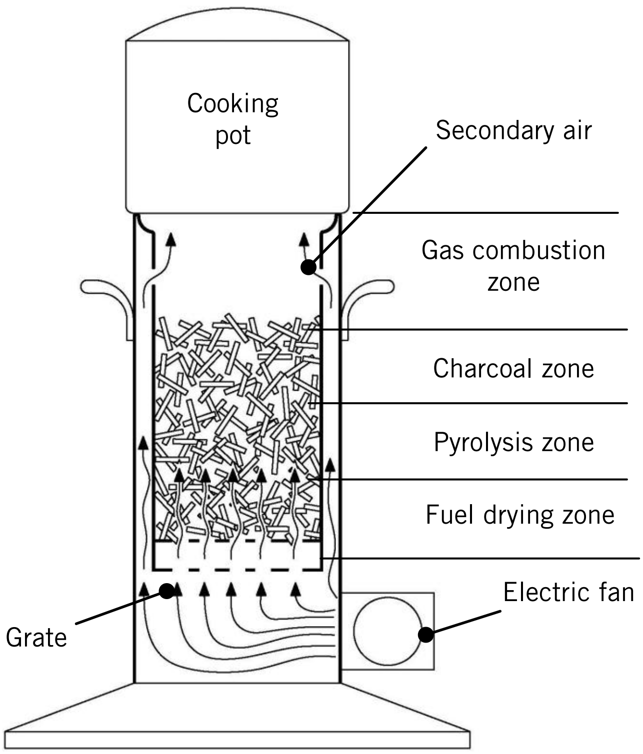

Figure 1: Diagramme of a basic forced ventilation non-continuous updraft stove. Illustration: Neil Noble / Practical Action.

The reduction reaction

The combustion process can be split into its various stages rather than happening all together.

Firstly, the wood or biomass is dried. Some of the heat is used to drive off any excess moisture.

Then pyrolysis takes place where the volatile components within the wood are driven off as gases from the solid biomass because of the biomass being heated.

The gases burn separately from the solid carbon part of the wood with secondary air added to ensure complete combustion. If burned thoroughly then the end products will be just water vapour, carbon dioxide and carbon.

Some stoves stop at this point, and the charcoal can be removed and used in a separate charcoal stove (or stored for other uses), whilst in others, if there is sufficient oxygen available, the charcoal is also allowed to burn. Although the carbon can be removed and used separately the charcoal is normally burned within the same stove.

Forced ventilation is achieved in a number of ways. A common approach is to use an electric fan, a small source of electric power is required which often comes from a battery. The battery may need to be replaced from time to time or sometimes the battery is recharged by the stove (see Philips Stove).

The configuration of the stove can also vary. Figure 1 shows a non-continuous updraft stove in which air travels from the bottom to the top. Other designs use a downdraft approach which allows fresh fuel to be added into the top of the stove. The fuel will then more downwards towards the combustion zone.

Some designs also incorporate a “gas wick” or “flame holder” in a similar way that a gas lamp has a mantel. This ensures that the combustion of the gas is contained in the most effective area.

Examples of advanced biomass stoves

This type of technology has only recently come into existence. Many of the stoves are still at the prototype stage, and are being tested, through NGOs, in various parts of the world, making sure that the stoves are appropriate to the type of cooking in a particular region. However, the Oorja stove and the Philips Woodstove are commercially available. The Biolite stove is at an advanced stage, and should become commercially available for household use by the end of 2012.

Figure 2: Advertisement for Oorja stove.

The Oorja stove

This stove has been developed in India by 'First Energy' http://www.firstenergy.in/. The stove is batch fed and uses fuel pellets which are made from agricultural residues (a mix of corn cobs, coffee beans and sugar cane residues), thus saving fuelwood, and is commercially available. A big advantage of this stove over many stoves is that you can control the heat, as with a gas stove, by turning it up and down. It is distributed in both Karnataka and Maharashtra States. A commercial model is available for restaurants and tea-shops.

The Oorja stove is highly commercialised, with a distribution network of around 300 women trained to sell these products. There is strong and entertaining print and TV advertising (see http://www.firstenergy.in/media-2/ads.html and http://www.firstenergy.in/media-2/video.html) making it 'desirable' and comparable to other fuels, and thus more 'modern' to the consumer. http://www.pigtailpundits.com/clients/oorja/wp-content/uploads/oorja_print_1.jpg

The Philips Woodstove

In this forced ventilation stove, air is forced into a combustion chamber at the top and bottom of the chamber. Intense heat at the bottom vaporises the fuel (small chips of wood, or wood pellets) and the injected air burns the vapour as a combustible gas. The flame is smokeless once the stove is running, and because the fuel burns so efficiently, the stove uses far less fuel than a conventional fire. To contain the extreme heat, high-tech materials are used. These materials absorb less energy, so it reaches cooking temperature very fast. It is very well insulated, so less heat is lost to the surroundings, and more of the heat is available for cooking. The regulated airflow makes the heat output stable and controllable.


Figure 3: The Philips woodstove. Photo: Philips

A field trial in India showed that, when used properly, the woodstove typically reduces fuel consumption to a third of that used by traditional, three-stone fires. It reduces pollution from smoke to a tenth of the level of traditional, three-stone cooking fires. The stove burns the fuel completely and inside a portable container, which saves the time and effort of cleaning up afterwards.

The African Clean Energy Company, ACE Pty Ltd http://www.ace.co.ls/ in Maseru, Lesotho manufactures the stoves.

The Biolite stove
http://biolitestove.com/
With the Biolite Homestove, the electrical power for the fan comes directly from the stove itself, using a technology that produces electricity from the temperature differential between the hot stove and its surroundings. In this case, the remaining electricity can be used to charge up the battery for next time and to power a light or charge a mobile stove.


Figure 4: Biolite HomeStove being used in Ghana. Photo: Biolite.

The Biolite Homestove has been tested in India, Ghana, Kenya and Uganda, and has had modifications made to it in order to cook particular types of staple food in each of these countries. This stove uses small pieces of wood as fuel. It is available as both domestic stove and a camping stove. The stove itself produces the electricity needed to drive the fan. Sales of the camping stove are currently helping to support the one-time market establishment costs for the HomeStove. Tests show that it reduces smoke by around 94%, as well as producing small-scale electricity.

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The Turbococina stove
The Turbococina uses a slightly different process. It is a highly efficient wood stove developed in El Salvador. It produces virtually no smoke and reduces greenhouse gas emissions by 95%. The stove was developed and patented by the Salvadoran engineer René Núñez Suárez. This technology results in a massive decrease in consumption of firewood (reductions of 95% are quoted). A whole meal can be cooked on a Turbococina or "Turbostove", using around five small pieces of wood. This reduction in fuel use means that the fuel that would normally last a day will last a complete month (Ayala, June 2012).

The stove comprises a stainless steel cylinder fitted with 10 air injectors, an internal fan that runs on electricity, and a steel plate that regulates the amount of air entering or leaving. Where the combustion takes place, the temperature is extremely high; typically greater than 1500ºC.

Despite its many merits, the Turbococina faces a major obstacle in terms of widespread use in poor rural areas. As with other forced ventilation stoves, it requires electricity to operate an internal fan, which moves air into the combustion chamber.

Availability
The Turbococina is not sold commercially as the inventor is currently seeking the best mechanism to distribute the stoves free of charge to El Salvador's poorest families and communities. He plans to distribute 100,000 Turbococinas in this way, alongside a promotion campaign to explain the benefits. In El Salvador, the Ministry of Education has purchased 1,050 of the stoves and distributed them to 800 schools as part of a program that provides students with a free snack every day.

SCORE Stove
The SCORE stove is an experimental thermo-acoustic design that can generate electricity from the heat of the stove via a chamber that converts heat into sound waves that then can be converted into electricity. The electricity generated is still quite limited but it is hoped that the amount can be increased through further development.

The heat causes thin metal sheets with tiny holes to vibrate 70 times a second that produce air waves. These travel along specially shaped pipes into a flexible cone and alternator (like a loud speaker in reverse) which in turn generates electricity.

Although the sound inside the pipe is intense, it creates no more than an external hum

There SCORE stove has been developed by the University of Nottingham and its Malaysian while Practical Action has been working with rural people to evaluate the stoves and ensure the most suitable design with universities such as BUET and Kathmandu University modifying the stoves to ensure they are suitable for local cooking needs. More information can be found at http://www.score.uk.com/.

Figure 5: SCORE Stove being used in Kenya. Photo: Practical Action.

Benefits of advanced biomass stoves

Attractiveness to the user
With a flame that 'cooks just like gas', stoves such as these are recognised as modern and highly desirable. A further advantage is that the quantity of fuel required to cook a meal is reduced, as the fuel is burnt very efficiently. Importantly, this means that the cook and her family do not have to spend as much time collecting fuel, and/or can save money in buying less.

Health benefits
It is now widely accepted that reducing the amount of smoke reduces the burden of ill-health associated with it (WHO). However, recent evidence from a major study with chimney stoves (~ 50% reduction) suggests a need for 'stove or fuel interventions producing lower average exposures than these chimney stoves to substantially reduce pneumonia in populations heavily exposed to biomass fuel air pollution' (Smith et al, 2011). Thus, the majority of biomass stoves, although benefiting households in other ways, are not yet sufficiently advanced to reach levels that impact on the main health risk to infants. The advanced biomass stoves discussed in this Technical Brief achieve very substantial reductions in pollutants and meet this requirement.

Environmental benefits
Environmentally, advanced biomass stoves can reduce local pressures on woodland and forestry areas. They can reduce to a fraction the amount of fuel that is needed, and allow twigs and small branches to be gathered locally. In countries such as Brazil, Indonesia and Sudan, where deforestation is currently thousands of square miles per annum, there is an urgent need to reduce reliance on woodfuel.

The use of advanced biomass stoves reduces greenhouse gases in two ways; firstly because less fuel is used so it can be harvested more sustainably; secondly, the quantity of greenhouse gases per stove is reduced with cleaner combustion. However, unless very large numbers of stoves are disseminated, this is a small effect, and it will require political will for cleaner stoves to have a substantial impact on global warming.

Additional considerations
This type of stove works best using evenly-sized small pieces of wood or twigs, or wood pellets, and if twigs/small branches are not locally available, the cook may have to cut large pieces of wood to size.

The size of the pot is dictated by the size of the burner, as in a conventional gas stove. This may be problematic where households use very large pots for making animal feed, brewing beer, and heating washing water.

Many 'improved' stoves can be made by local artisans, providing them with an income, keeping the price of the stove affordable, providing some of the benefits, and ensuring that they are appropriate for local use. By contrast, for households where the bread-winner may earn just one or two dollars a day, an advanced biomass stove may be unaffordable unless the capital cost can be paid off over several months using some type of loan.

Further information

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