WBA fact sheet

CLEAN AND EFFICIENT BIOENERGY COOKSTOVES

SUMMARY

Globally, more than 3 billion people rely on traditional use of biomass for cooking and inefficient use of fuel is leading to over 4 million deaths per year. There is an urgent need for developing clean and efficient cookstoves and fuels. Currently, the cookstoves sector is growing rapidly with a 50% increase in annual sales during 2003 – 2013. The growth is expected to continue further.

Clean and efficient cookstoves are an important development for improvement of both the environment and public health. Use of such cookstoves leads to better combustion of fuel and improved heat transfer leading to reduction in fuel demand, improved health of women and children and lower costs of cooking.

Cookstoves vary greatly in terms of performance across different models and designs. A set of interim international guidelines for stove performance was developed under the International Standards Organization International Workshop Agreement process. This framework provides categories to measure and classify performance including efficiency, emissions and safety. There are also a broad range of other factors such as affordability, accessibility, and livelihood impacts that are critical factors to consider.

An integrated systems approach involving all actors is essential. Factors such as efficient forest management, replacing traditional fuels like charcoal with modern and renewable fuels like pellets, ethanol, electricity etc., and proper awareness are crucial in protecting the environment and public health.

The objective of the World Bioenergy Association is to support increased production and use of sustainable bioenergy and hence, this fact sheet specifically focuses on biomass based fuel sources and associated stove technologies.

INTRODUCTION

Worldwide, approx. 3 billion people are burning solid fuel, including biomass, agricultural residues and charcoal, for their daily cooking (1). This is a challenge as inefficient systems of cooking have a major impact on health, environment and economy (2). Hazardous emissions released during the process of inefficient cooking are one of the world's major public health challenges, and result in many premature deaths (3). Inefficient fuel use drives up demand and thereby increases the negative effect on the environment. Furthermore, fuel gathering can be dangerous as it leaves women exposed to threats of violence, and cooking on traditional stoves is time consuming, preventing women taking on income generating work and often meaning children do not attend school (4).

For World Bioenergy Association (WBA), the objective is to support clean and efficient stoves and increased production and use of sustainable bioenergy for cooking. Increased and improved production of biomass also leads to local job creation through supply chain development. This factsheet presents an overview of biomass based cookstoves and renewable fuels currently available. WBA does not promote the use of fossil fuels. Even if fossil fuels like Liquefied Petroleum Gas (LPG) and Kerosene are widely used for cooking, they will not be covered in this factsheet.

With this background, it is evident that introduction of efficient and clean-burning cookstoves have a great potential for contributing to improvement in both the society and the environment. The UN´s initiative, Sustainable Energy for All (SE4All), has 'Universal Adoption of Clean Cooking Solutions', including both cookstoves and fuels, on its agenda, emphasising the high impact opportunity of improved cooking systems for building shared prosperity (5). For successful adoption, one important aspect, besides high quality technology, is to include users in the stove design and selection (6).

Photo: UN SE4All

Figure 1. A mother preparing her meal on a traditional three stone fire (Location: India)

An important player in the cookstove market is GACC. The Global Alliance for Clean Cookstoves (GACC) is a public-private partnership hosted by the UN Foundation and is working with its over 1500 partners towards a goal of 100 million households adopting clean and efficient cookstoves and fuels by 2020. (7).

BASIC COOKSTOVES

The most conventional traditional stove is the three stone fire (Figure 1). It is a simple construction where three stones are arranged in a triangle on the ground in order to position a cooking pot over the fire that is lit between the stones (8).

The traditional three stone cookstove has low heat-transfer and combustion efficiency. Hence, the heat is not concentrated on the pot but is mostly lost to the surrounding, resulting in high firewood consumption. Furthermore, the use of inefficient stoves is also linked to high emissions of methane, carbon monoxide, nitrous oxides, and black carbon that are released due to a low combustion temperature (9). To counter these negative effects of cooking, a number of initiatives for clean and efficient cooking systems are recognised at a global level.

COOKSTOVE STANDARDS

The overall purpose of a clean and efficient cookstove is to improve combustion efficiency and transfer the heat to the cooking device more efficiently and to reduce emissions. This reduces the use of energy in comparison to traditional stoves (Figure 2) (10). There is not yet a standard measurement of cookstove performance accepted worldwide, but to enable a comparison between different stoves, this factsheet will reference IWA tier based framework. It determines the performance of the stove using four indicators of stove performance using efficiency, indoor emissions, total emissions and safety, each along 5 Tier (0: lowest performing and 4: highest) (11). Each of the four indicators provide quantitative values determining the Tiers as shown in Table 1. Cookstoves are tested in lab settings to determine the Tier performance.

In the next section, a brief explanation of the most common types of cookstoves and fuels will be introduced.

SOLID FUEL COOKSTOVES

- Solid fuel cookstoves are constructed considering design principles such as: adding insulation and shielding around fire and pot, using a grate under the fire and ensuring a good draft through the fuel and pot.
- The aim is to reduce overall costs of cooking, reduce time in acquiring fuel and reduce household air pollution.

Photo: R C Pal, The Energy and Resources Institute (TERI), India

Figure 2: A woman preparing a meal using an improved cookstove

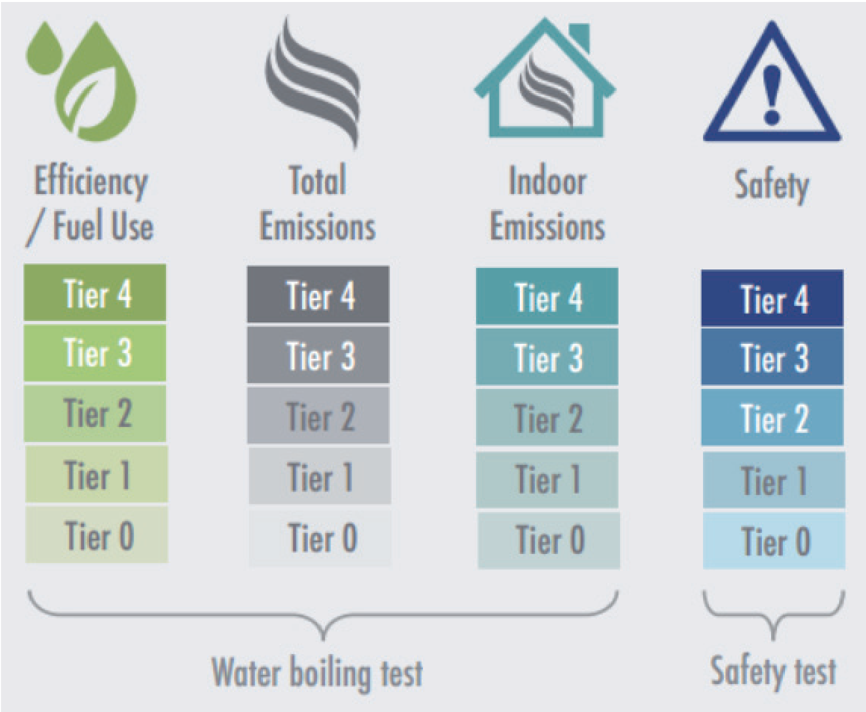

Photo: Global Alliance for Cookstoves (GACC)

Figure 3: The IWA framework rates cookstoves on four indicators: efficiency, indoor emissions, total emissions, and safety. The tier boundaries for each indicator are defined by quantitative values from lab testing.

Photo: Awamu Biomass Energy

Figure 4. A top lit updraft gasifier stove using solid fuel in an efficient manner, developed by Awamu.

Many types of technologies can be considered improved cookstoves, such as rocket stoves (12, 13) and gasifiers. These types correspond to an improved efficiency and ISO Tier 1-2 on the scale for efficiency (14). Some cookstoves rely on a fan to circulate air through the burning chamber as the air improves combustion. Others rely on the shape of the stove and combustion chamber to promote air circulation; these are known as natural draft cookstoves. On the other hand, gasifier stove models with a fan create jets of air that lead to favourable mixing of flame, gas, and smoke for clean combustion (15). This category reaches Tier 3 for emissions reduction and Tier 3-4 for efficiency.

For e.g., the Awamu stove in Uganda (Figure 4), Belonio rice husk stoves in Philippines and the Oorja stove design in India are representing this cookstove technology (Figure 5).

Photo: Oorja, First Energy

Figure 5: Oorja K30 DLX pellet cookstove, based on efficient gasification technology

TABLE 1: TIER PERFORMANCE SCALE

	Emissions CO Sub-tiers		Emissions PM2.5 Sub-tiers		Indoor emissions Sub-tiers		Efficiency/fuel use Sub-tiers		Safety
	High power CO (g/MJd)*	Low power CO (g/min/L)	High power PM2.5 (mg/MJd)*	Low power PM2.5 (mg/min/L)	Indoor emissions CO (g/min)	Indoor emissions PM2.5 (mg/min)	High power thermal efficiency (%)	Low power specific consumption (MJ/min/L)	Scale of 0 – 100
Tier 0	> 16	> 0.20	> 979	> 8	> 0.97	> 40	> 15	> 0.05	> 45
Tier 1	≤ 16	≤ 0.20	≤ 979	≤ 8	≤ 0.97	≤ 40	≥ 15	≤ 0.05	≥ 45
Tier 2	≤ 11	≤ 0.13	≤ 386	≤ 4	≤ 0.62	≤ 17	≥ 25	≤ 0.039	≥ 75
Tier 3	≤ 9	≤ 0.10	≤ 168	≤ 2	≤ 0.49	≤ 8	≥ 35	≤ 0.028	≥ 88
Tier 4	≤ 8	≤ 0.09	≤ 41	≤ 1	≤ 0.42	≤ 2	≥ 45	≤ 0.017	≥ 95

Source: Global Alliance for Cookstoves (GACC)

*g/MJd - grams per megajoule delivered to the pot. mg/MJd - milligrams per megajoule delivered to the pot
High power - Stove operating at maximum rate of energy use. Low power - Stove operating at minimum rate of energy use

Fuel

Locally sourced (either collected or sold) firewood and charcoal are commonly used fuels in many developing countries. Charcoal is produced from locally procured wood in a process where the moisture and volatile components are lost. The wood is transformed into a lightweight and energy-dense material. The disadvantage is the energy loss in the conversion process from wood to charcoal to energy, where 75 % or more of the original energy in the wood is wasted (17). Other solid fuels are easily made in low-resource situations by use of high or low pressure briquette technology and the resulting densified fuel can be used in a biomass stove (16).

Photo: Project Gaia

Figure 6. CleanCook, a front edge stove within the alcohol-fuel category produced by CleanCook and promoted by Project Gaia

LIQUID FUEL COOKSTOVES

• Liquid-fuelled cookstoves are designed around a small container where the liquid fuel is held and above which the fuel vapour burns.

• When absorbed in a canister, fuel is vapourized to burn as a gas.

Common liquid fuel cookstoves are alcohol cookstoves that are designed so that the vaporising alcohol burns in controlled jets underneath the pot. The heat can be regulated by adjustments of open surface and alcohol evaporation. Compared to the biomass solid fuel cookstoves, alcohol cookstoves burn without constant tending, allowing the cook to reduce the time spent on adjusting the fuel (18). Furthermore, the property of alcohol fuel is that it burns controllably, cleanly and completely, making it one of the cleanest and safest cookstove fuel options available (19) In tests, alcohol stoves often perform at a Tier 3-4 on efficiency and slighly better on emissions and safety, depending on model (Table 1, Figure 6) (13). The CleanCook stove is a Tier 4 in all categories.

Fuel

Fuels include ethanol and methanol, produced from a wide range of resources such as sugar, starch, agri wastes and cellulosic feedstock. The process comprises several steps such as grinding, fermentation, distillation etc. Alcohol fuels can be found in hydrous and anhydrous form and can be processed into gel or liquid form, depending on user preferences (20). A key benefit is that ethanol production is scalable and can be done by small communities or large commercial entities.

BIOGAS FUEL COOKSTOVES

• Biogas cookstoves use the fuel produced usually via anaerobic digestion of organic matter

• The gas is directly fed into the cookstoves from the digester

The biogas cookstove is constructed so that a pipeline from the biogas digesters is connected directly to the stove in the kitchen. When in use, the gas is lit and the temperature is easy to adjust on the stove, allowing users to cook efficiently and with a clean burning flame (21).

There are also systems by which a householder without a digester can provide manure to a community digester and carry home a day's biogas in a lightweight gas-tight bag. The efficiency and emissions of gas cookstoves is commonly reaching a Tier 3-4 on the scale (13). Biogas is utilized by millions of households around the world, with most of them in Asia, Africa and Central America. A household that has access to about 25 kg a day of manure, two to four cows or five to ten pigs, or even less of putrescible wastes like food scraps, can generate enough biogas for the cooking needs of a family. Improved utilisation of effluent and manure from farming, particularly when they are near cities, has great potential to provide clean and efficient cooking fuel (21).

Fuel

Biogas is usually used directly from the container, where the mix of putrescible waste like food scraps and agricultural waste is placed. Water and manure is added to the mix and starts a decay process that produces the biogas. The biogas is separated and a gasholder system provides the cookstove with biogas. The decomposed organic matter can in turn be used as fertiliser. Biogas is a source with great potential as it uses many kinds of waste materials. It is also improving sanitation, reducing time spent on collecting fuel and cooking. (21).

SOLAR COOKSTOVES

Solar cookstoves are another cookstove technology. As they are a sustainable and renewable alternative, they are briefly mentioned in this factsheet.

Solar cookstoves work on the main principle to capture and convert the energy from the sun to heat.

Light from the sun is reflected from a mirrored surface and transferred to a cooking container where it is absorbed as heat. There are many different types of solar cookstoves, for e.g.: a box construction where the pot is placed. Another type is curved concentrating reflectors that have a parabolic design and where the pot is placed in the middle (at the focal point). Finally, panel cookers that have the reflectors on bottom, and its three surrounding walls – incorporating the box and parabolic design. The panel cookers are usually most cost efficient. The temperatures for household solar cookstoves range from 65 °C up to 400 °C, depending on the model. For efficient absorption, cooking devices should be matte black and lids should be used at all times. An example is the CooKit which is an inexpensive and easily adaptable.

As solar cookstove is fuel and smoke free, it benefits the household economy as well as the users health. (22) In emissions, it reaches 4 on the Tier scale. However, the efficiency differs between models. (13) Also, solar cooking often increases cooking times and significantly diverges in the process from traditional cooking. Since it is demanding a change of cooking habits for the customer, information and education about the stove is therefore essential for the adoption process. (23) As solar cookers do not work during cloudy days, in strong winds or at night, an additional cookstove using other available fuels is required for complementary use at times (22).

Solar cookstoves are successful in many contexts, having a small but increasing market share (23). An example is the kitchen at Saibaba Ashram in Shiridi, Maharashtra State, India that cooks 50 000 meals a day with 73 parabolic dishes (24).

COMBINED BIOENERGY AND SOLAR COOKSTOVES

An option for the future is to combine different fuel sources to create a more efficient stove. One such stove is the stove which The Energy and Resource Institute (TERI) and African Centre for Technology Studies (ACTS) have been piloting (Figure 7) that uses solar and biomass to produce multiple outputs.

A solar panel is connected to a power pack / charge controller producing electricity that runs the fan and can also be used for mobile phone charging or illuminating a light, making it ideal to be used in rural villages with no grid connection while biomass from fuel wood or agricultural residues can be used for cooking.

FIGURES AND STATISTICS

Over 40 % of the world's population is still using solid fuels to cook and the level is predicted to persist with over 3 billion still using solid fuels by 2020. Additionally, more than two-third of households that rely on solid fuels use traditional stoves (typically in Sub Saharan Africa and Asia as shown in Figure 9), hence, the market potential for cookstoves is extensive (25).

The cookstove sector is growing where sales have increased by 50 % annually between 2003-2013, 3.6 million cookstoves sold in 2011 and 14.3 million in 2013, respectively (25). In 2014, this number increased to 14.8 million stoves sold, of which 0.3 million were Ethanol/Alcohol based, 7.1 million constructed for Biogas/Gas/LPG and 4.8 were unclassified (26).

Photo: The Energy and Resources Institute (TERI)

Figure 7: A TERI cookstove with an integrated solar panel

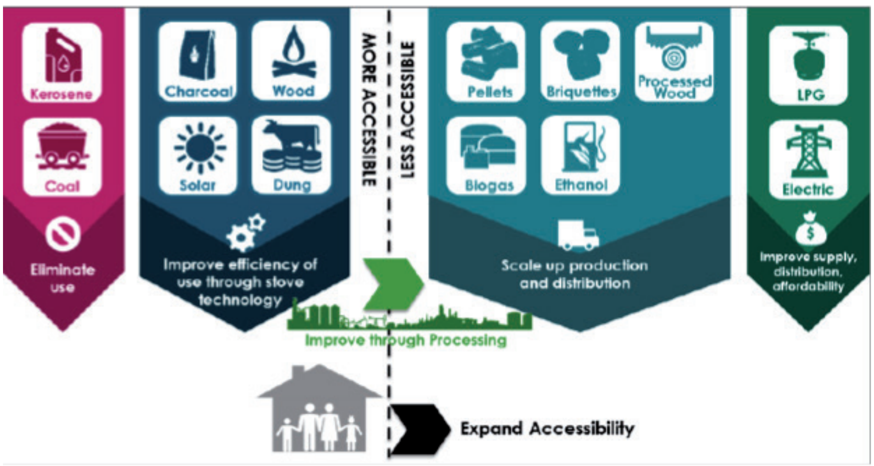

Photo: Global Alliance for Clean Cookstoves (GACC)

Figure 8: The Global Alliance's strategy is to use available fuel more efficiently and increase the access to cleaner fuels.

The growth is expected to continue and the Global Alliance for Clean Cookstoves' (GACC) goal is that 100 million homes should have adopted clean and efficient cookstoves by 2020 (17). It is important to note that this data is self reported and limited to the base of the pyramid. However, the statistics demonstrate momentum and promising trends in the sector, but the estimates are still a limited representation of the growth in the fuels sector.

It is estimated that household air pollution from cooking contributes to 4.3 million deaths per year and it is associated with many more diseases, including lung cancer, tuberculosis and lower respiratory infections. (27) Furthermore, in average, a woman who does not use efficient cooking systems spends 1.3 hours to collect firewood and 2-4 hours is spent cooking every day preventing her to perform income generating activities (24). GACC calculates that more efficient cookstoves can save 61 % of fuel costs for families and significantly reduce emissions (28).

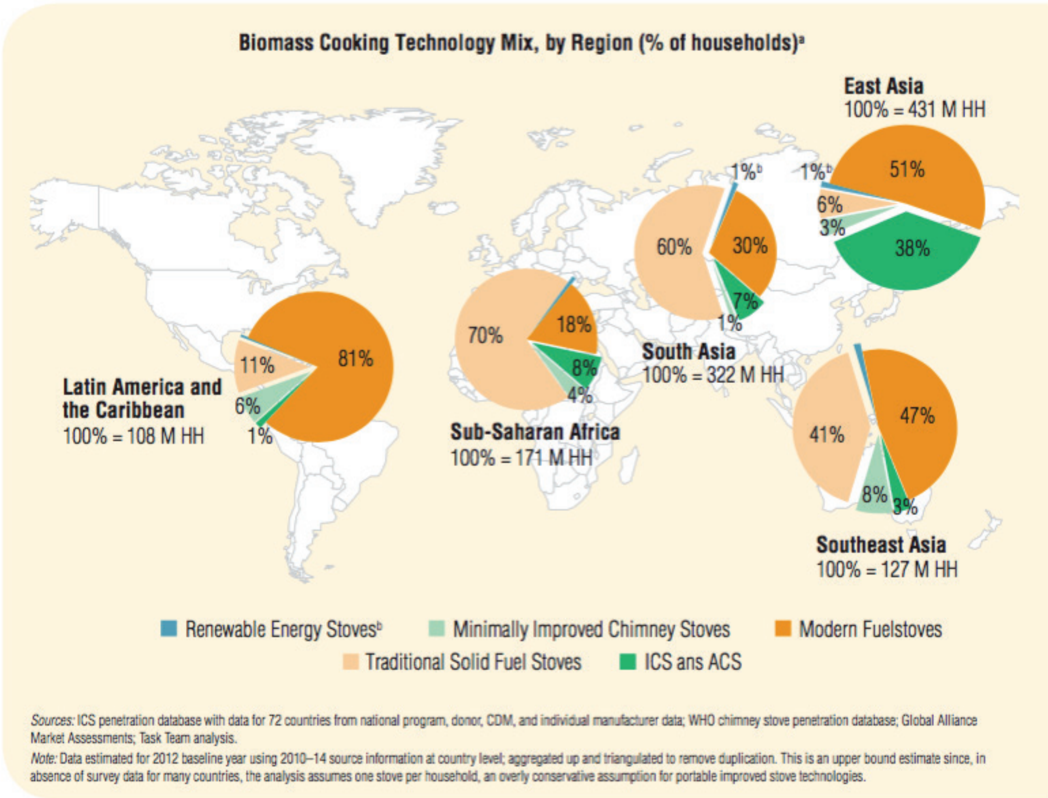

Photo: ESMAP and GACC

Figure 9: Illustration on the biomass mix used for cooking, in percentage divided in regions

OPINION OF WBA

The main challenge with inefficient cookstoves is the health risks due to indoor air pollution and emissions. The introduction of fossil fuels in the market for cooking is extremely costly, creates new dependencies and increases global emissions. Finally, lack of capital and the lack of an integrated strategy to solve the cooking issue are hindering the development of improved cookstoves and the development of liquid and gaseous biofuels.

WBA's opinion is that clean, renewable and sustainable energy for cooking should be the major focus for development organizations and for government's policy formulations. The financial support for modern cooking solutions including rural electrification (from renewable sources) should be increased substantially for countries in Africa, Asia and Latin America.

A systems approach including efficient forest management, replacing charcoal/fuelwood with modern bioenergy like pellets, biogas, ethanol, solar cooking, electricity etc., the use of organic wastes for energy production, and proper information dissemination is needed. Finally, in the cookstove market, a combination of two approaches hold promise for the future of clean cooking; innovative cookstove designs that vastly improve efficient combustion of solid biomass fuels and modern cookstoves that burn cleanly liquid and gas fuels.

The World Bioenergy Association sees potential for development of improvements in cooking fuel technology and sustainable fuel supply chains. Improvement in these areas can truly contribute to better living standards for households around the world.

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