Sustainable Energy Handbook

Module 4.4
Clean Cooking Systems

Published in February 2016

1 General Introduction

Total primary energy consumption of biomass reached approximately 57 Exajoule (EJ)[1] in 2013 of which almost 60% was traditional biomass used mainly at the household level for cooking and heating (IRENA, Global Status Report (GSR) 2014). The use of traditional biomass for cooking and heating is associated with very high energy losses (i.e. only a small part of the energy embedded in the biomass is eventually used to provide the desired energy service – see figure below). The high dependence on wood fuels contributes to deforestation, desertification and smoke-related health risks and negative environmental and social consequences.

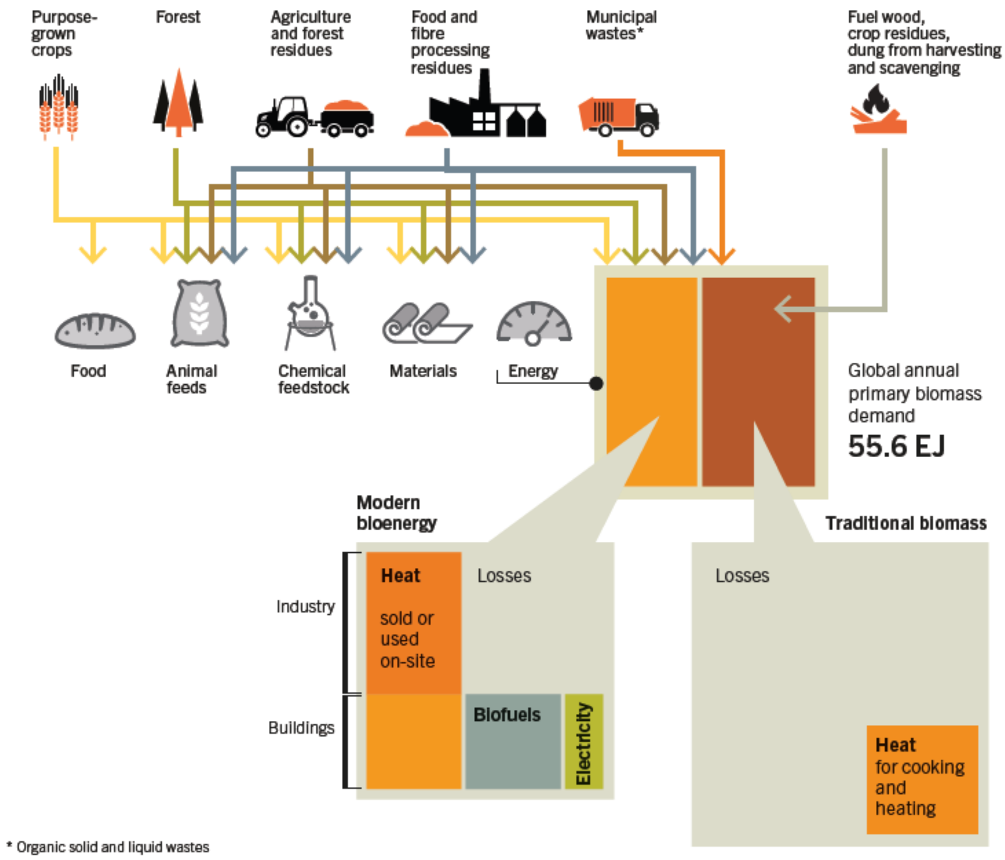

Figure – Global biomass demand, its uses and losses, both as modern and traditional bioenergy

Source: REN21, Renewables 2014 Global Status Report

In certain regions of the developing world, the dependence on traditional wood fuels has resulted in a massive depletion of local forests with devastating economic, social and health consequences for the rural populations. About 3.4 million hectares are deforested annually in Africa and wood fuels for cooking are a major driver of deforestation and, even more importantly, of forest degradation (UNEP, 2014). This is associated with the release of large amounts of CO_2, contributing to climate

[1] 1 Exajoule is equivalent to 10^18 J (1 billion of billion Joule)

change. Indoor pollution from traditional biomass fuels kills about 1.5 million people per year (FAO, 2012).

Depleted forests oblige the poor rural population to increasing difficulties to gather or afford wood and charcoal and to cover much longer distances to collect the required wood, while the penetration of modern energy services (biogas, LPG, bioethanol to be used in improved stoves) is still low.

Leveraging on the traditional and inefficient use of biomass in developing countries can significantly **reduce health diseases and improve gender implications**. Thousands of people die from respiratory diseases due to kitchen smoke, while children and women spend a great amount of time collecting firewood for daily subsistence at the detriment of education or other rewarding activities. At the same time it can:

- **Improve natural resource management.** Biomass collection to be used in the household is a major cause of forest degradation with severe local consequences in many sub-Saharan, Asian and South-East Asian countries.
- **Contribute to climate change mitigation.** Bioenergy can reduce CO_2 emissions if compared to fossil fuels. The combustion of biomass release harmful emissions, but not as much as fossil fuels. For example, biomass combustion does not produce sulphurous compounds that cause acid rain. When burned, biomass does release CO2 but in equal amounts as what is absorbed during its growth.

China, India, Indonesia, Ethiopia and Pakistan combined account for 50% of greenhouse gas(GHG) emissions from global household wood fuel use (Climate Focus, 2014).

The use of fuel-wood and charcoal in these countries have very important impacts especially on women wellbeing and the time spent for collecting fuel wood (according to recent surveys, the average in sub-Saharan Africa is of 1.5 hours per day and Niger and Ethiopia have the highest rates with a record of4 and 3 hours per day respectively).

2 General principles

Bioenergy can be used for cooking and provision of heat at household level. Usually solid biomass is burned to this end, mainly wood fuels collected from forests (which include charcoal and fuel wood) but can also be in the form of biogas which can be produced easily and cheaply at the household, thus providing a reliable and cheap energy source to be used in improved cooking stoves.

In fact, although the majority of traditional biomass is burned in solid form, use of modern bioenergy such as biogas in improved cookstoves has expanded considerably and there is also some use of refined liquid fuels (e.g. ethanol, gels and briquettes) for cooking. Liquefied petroleum gas (LPG) is also a common alternative to inefficient wood fuel use, and this fossil fuel is often promoted as a way to displace unsustainable wood use and to protect the environment thus providing immediate benefits.

However modern bioenergy can, additionally to what LPG could do, transform the agricultural sector by providing additional roles to the existing ones, being the guarantor of resource use efficiency and the basis of rural livelihoods.

The bioenergy feedstock used at household level is **usually biomass harvested from natural resources**. It includes forest, woodland, grassland, aquatic resources and animal dung. Some areas might have the potential to harvest naturally growing biomass for local needs; however, the local potential is often low and generally not able to supply large populations. Wood is the most common form of biomass and has been burned for thousands of years for cooking and water heating. The term 'wood' includes products such as wood, sawdust and bark that has not been chemically treated

or finished. It can be obtained from a number of sources such as forestry, saw mills and timber merchants. When buying wood for fuel, the physical forms it can be bought in are logs, sawdust, woodchips, wood pellets and briquettes. Wood can also be converted into charcoal, thus improving its characteristics. The lower the moisture content the better the calorific value of the wood product as a fuel.

Also **residues** can be used to provide heat at the household. These do not directly compete with food production for land, water or inputs, or with biodiversity and carbon sinks for land use, and can provide significant GHG savings, as long as they are collected and used in a sustainable manner. Waste/residues are suited for direct conversion into heat, or into biogas. However it is important to determine the proper balance of residues that should remain in the field or in the forest to maintain soil fertility and soil carbon content, and improve soil conservation.

3 Technology overview

Feedstock	Conversion process	Energy vector	End use	Typical scale range
Woody biomass / Crop residues / Agro-processing residues	Combustion in improved cooking stoves	Heat	domestic / community	1-10 kW_{th}
	Torrefaction / carbonisation	Solid biofuels (heat)	domestic / community	2,000-200,000 GJ/year
Animal waste / digestible organic residues / wastewater	Anaerobic digestion and production of biogas	Heat	farms or domestic (but also industry)	1-1,000 kW_{th}
		Electricity		5-5,000 kW
		Mechanical power		5-100 kW

Table: Relevant bioenergy technologies at the household level

Fuel type	Net calorific value (MJ/kg)	Lower	Upper
Wood/Wood waste	15.6	7.90	31.0
Other primary solid biomass	11.6	5.90	23.0
Charcoal	29.5	14.9	58.0
Biogas	50.4	25.4	100
LPG	47.3	44.8	52.2

Table: Net calorific values and lower and upper limits of selected cooking fuels

Source: IPCC, 2006

Improved cooking stoves

Improved Cooking Stoves (ICS) refer to a range of cooking stoves that offer higher fuel economy and less indoor air pollution in comparison to traditional cooking practices. They comprise closed stoves with chimneys, as well as open stoves or fires with chimneys or hoods, but exclude open stoves or fires with no chimney or hood. ICS usually have an energy efficiency value greater than 20-30% and their flue gases are released distant from their users (GBEP, 2011).

From a technology point of view, improved cookstoves have an energy efficiency value greater than 20-30% and are capable of wood savings of 60% or more. As their flue gases are released distant from their users they do not negatively affect the health of the users and the environment. The International Standards Organisation (ISO) identified four performance tiers for cookstoves depending on their efficiency, environmental and health impacts. The World Bank's Africa Clean

Cooking Energy Solutions Initiative (ACCESS) project[2] has adopted a classification of performance of different cookstoves which includes also health impacts criteria.

Proposed ISO Tier	**Tier 0**	**Tier 1**	**Tier 2**	**Tier 3**	**Tier 4**
Illustrative stove type	3-stone fire	ICS	Rocket stove	Forced draft	LPG / advanced biomass
Efficiency	<15%	>15%	>25%	>35%	>45%
Energy savings relative to Tier 0	0%	23%	>40%	>57%	>67%
					

Table – Cookstove efficiency ratings for proposed ISO Tiers

Source: World Bank ACCES project

The feedstock for ICS is similar to that for traditional stoves: fuel wood, charcoal, briquettes and crop residues.

Advantages

- ICS are typically very economic because of their limited cost and high cooking fuel saving potential
- Reduced fuel consumption leading to a reduction of deforestation and time spent on collecting fuel wood
- Reduction of indoor air pollution

Disadvantages

- In contrast to traditional 3-stone-fire stoves, ICS have to be bought
- Acceptance of ICS is hampered by cultural factors in cooking

Household energy forms a substantial part of total energy consumption. Energy efficiency in this sector can lead to enormous reduction in wood fuel demand. The health effects of ICS are important due to the high potential of indoor air pollution reduction.

Charcoal production

Charcoal is the product of slow pyrolysis (or carbonisation), an exothermal thermochemical conversion process that takes place in the absence of oxygen. During carbonisation, biomass is converted into char and a variety of condensable vapours and gases. Charcoal is widely used as a domestic fuel for cooking, particularly in urban areas. Traditionally it is produced in rural areas from where it is transported to urban areas.

[2] More information on the World Bank's Africa Clean Cooking Energy Solutions Initiative (ACCESS) are available at http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/AFRICAEXT/EXTAFRREGTOPENERGY/0,,contentMDK:23310007~pagePK:34004173~piPK:34003707~theSitePK:717306,00.html

There are several production processes for charcoal, including:

- Traditional methods, whereby biomass is stacked, lit and covered to shut it off from air. Vapours and gases escape into the open air. Efficiency is typically in the range of 10-20%.
- Low tech improved methods, whereby the process takes place in small kilns. Vapours and gases are often channelled away and combusted. Efficiency is typically in the order of 20-30%
- Industrial systems, typically (semi) continuous, where the vapours and gases are combusted outside the kiln, whereby the heat is used for sustaining the process. Efficiency is high (typically above 30%)

Figure – Traditional (left), improved (center) and industrial (right) charcoal production

The feedstock for charcoal production is usually dry lignocellulose biomass with low ash content (wood, bagasse, stalks, peanut shell).

Advantages

- Charcoal is a relatively high value product with a high energy density (lower transportation costs) and clean combustion
- "Modern" charcoal replaces traditional charcoal which is often produced unsustainably, consuming large quantities of wood and leading to large greenhouse gas emissions
- Can be produced at small scale (low tech, low output) and at industrial scale

Disadvantages

- Sometimes difficult to compete with traditional charcoal
- Better performing fuels are usually more costly, which hinder their market penetration
- Unless used in improved cooking stoves, it can lead to indoor air pollution

Charcoal is an important source of domestic energy. The demand and use of charcoal is a major contributor to deforestation. Charcoal from sources other than wood (e.g. crop residues, agro-processing residues) could substitute traditional charcoal with little or no adaption at the end user, and thus reducing the pressure on forest resources.

Briquettes and pellets production

Biomass briquettes and pellets are high density agglomerates of dry biomass particles, which are produced by compressing biomass together. Both fuels are primarily intended as domestic fuel; briquettes can be used directly as a fuel wood replacement, pellets are best used in dedicated stoves.

Briquettes are larger, log-like agglomerates with typical dimensions of Ø50-100 mm[3] and length of up to 30 cm. They can be produced with mechanised (screw or piston) presses or with different type of manual presses. Pellets are smaller, typically 6-8mm in diameter and up to 30 mm in length, and are produced by mechanised presses. Depending on the type of feedstock, a binding agent (e.g. animal dung) and/or heating during compression may be required for binding the particles together.

Usually the biomass feedstock is sawdust and shavings from wood industries or dry biomass residues.

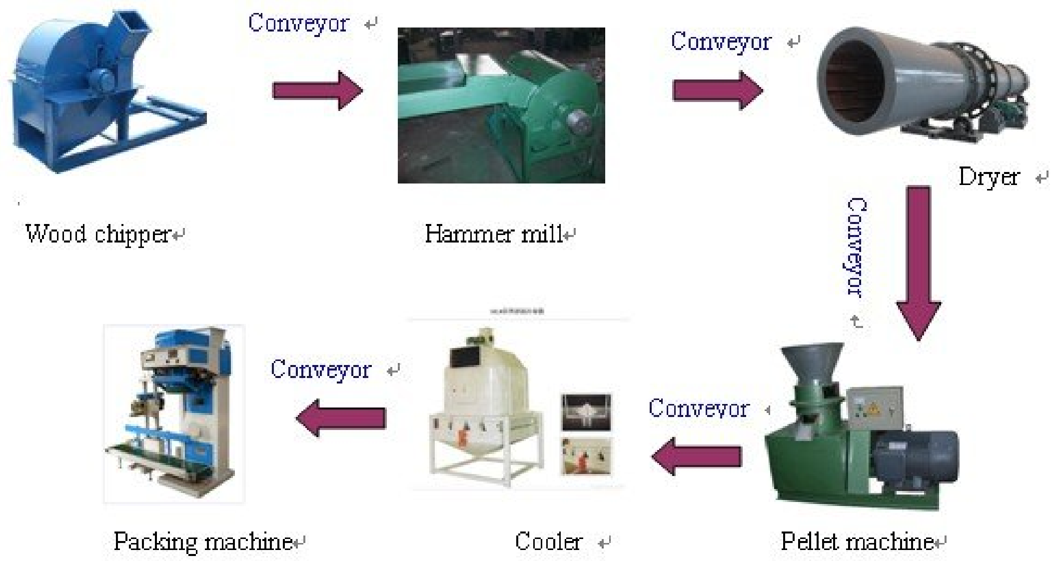

Figure – Pellet production process from wood

Advantages

- As an alternative for traditional biomass, it limits deforestation
- In combination with improved cooking stove, it improves indoor air quality
- Use of residues that may have no alternative use (waste)
- Low-tech briquetting systems can introduce income generation opportunities for virtually everyone

Disadvantages

- Pellets and briquettes are processed fuels; although the feedstock is often available at little or no cost, the production costs and logistics give them a cost disadvantage to traditional fuel wood.
- Considerable investments required for (mechanised) production
- Unless used in improved cooking stoves, it can lead to indoor air pollution

Small-scale biogas

Small biogas refers to production of biogas for cooking and lighting, at household and institutional level. It typically concerns biogas systems at a scale of 4-12 m³ digester volume, producing some 1-3 m³ of biogas per day for domestic use; and 50-500 m³ digester volume, producing some 10-100 m³ of

[3] http://www.biomassenergycentre.org.uk/portal/page?_pageid=75,18519&_dad=portal&_schema=PORTAL

biogas per day for institutional use. Most prevalent technologies are fixed dome (brick) and floating dome although PE and PVC systems are gradually gaining ground. These systems are not heated or agitated, and therefore operate at ambient temperatures.

In most cases, the feedstock is cow dung that is produced by the livestock owned by the family itself. Normally, some 3-10 heads of (zero grazing, i.e. stationary) livestock are required to produce 1-3 m^3 of biogas per day (which is more than enough to run an average household including its electricity demand). For institutional systems, night soil from latrines are the most used feedstock, sometimes together with kitchen waste. In situations where invasive plants must be contained, they can be used as feedstock for the biogas digester.

Advantages

- Reduces indoor air pollution
- Frees up time otherwise spent on firewood collection
- Reduces deforestation
- Production of digestate, which allows nutrient recycling
- Creates an economic sector for construction and servicing of biogas systems
- Elimination of wastes and residues, creating a cleaner and healthier environment

Disadvantages

- System costs surpass the investment capacity of most households, making it dependent on subsidies
- Relatively simple technology that is however relatively complicated to construct, requiring high construction skills (although PVC/PE systems offer alternatives)
- Building a sustainable sector takes a large effort (training technicians, developing market, building confidence)

Biogas is one of few non-fossil fuel solutions for reducing pressure on land and forests. It provides modern household energy, eliminating indoor air pollution and freeing up time spent by women and children on fuel wood collection. It enables the utilization of household and agricultural waste, and produces a good and cheap alternative to chemical fertiliser. It enhances the environment with reduced methane emission.

Ethanol and gelfuel

Liquid biofuels for households refer specifically to ethanol-based fuels for cooking. Ethanol with a purity of >50% can be used in different types of burners / stoves (pressurised and non-pressurised). An alternative is to gellify ethanol (gelfuel, typically with a purity of some 80%), and use it in a non-pressurised stove / burner. Production costs make ethanol-based fuels specifically relevant for high-end markets (i.e. as an alternative to LPG).

The ethanol can be produced using conventional or second-generation technologies, using sugars, starches or cellulose feedstocks. Using a lower purity ethanol (typically, ethanol is produced at a purity levels of approx. 96%) may result in production cost advantages.

Most common feedstocks are sugars and starches (conventional fermentation / distillation techniques); second generation techniques use cellulose feedstocks.

Advantages

- Ethanol fuels burn clean, and are a good measure against indoor air pollution.

- As a replacement of traditional biomass fuels, it reduces deforestation

Disadvantages

- Ethanol production costs are relatively high unless produced on a large scale and/or using waste streams (e.g. sugar molasses, cassava peels)
- Gelfuel is relatively expensive to produce because of the gellification agent, which may make it uncompetitive with other fuels and/or with alternative ethanol markets
- Safety: especially liquid ethanol is highly volatile, which may create dangerous situations in case of leaks or spillages.

Gelfuel can directly replace wood fuels for cooking, thus reducing deforestation and forest degradation.

Liquid biofuels can also be used for cooking and heating at the household level. A number of experiences have been reported in FAO, 2009. Technologies associated with liquid biofuel production are covered under the 'Biofuel production' module.

4 Technology Benchmarks

The four tables below summarize the current costs of the main bioenergy technologies, associated and depending on their characteristics.

Technology	Typical characteristics	Capital costs (USD/kW)	Typical energy costs (LCOE – US cents / kWh_{th})
Domestic pellet heater	Plant size: 5–100 kW_{th} Capacity factor: 15–30% Conversion efficiency: 80–95%	360–1,400	6.5–36
Biogas digester	Digester size: 6–8 m^3	500-1,000 (unit cost)	Highly variable

Table - Status of the main bioenergy technologies applicable at household level: characteristics and costs (adapted from REN21, 2015)

Biogas system by size of fermenter	3 m^3	6 m^3	12 m^3
Required number of cows (cross breed, zero grazing)	2-3	4-6	8-12
Manure feed (litres/day)	50	100	200
Water feed (litres/day)	25	50	100
Biogas production (m^3)	1	2	4
Daily cooking hours (using a two burner stove)	1.5-2	3-5	6-12
Slurry production (litres/day)	75	250	300

Table –Typical performance of small scale biogas systems (Source: www.simgas.com)

To the extent possible, costs provided are indicative economic costs, levelised, and exclusive of subsidies or policy incentives. Several components determine the levelised costs of energy (LCOE), including: resource quality, equipment cost and performance, balance of system/project costs (including labour), operations and maintenance costs, biomass costs, the cost of capital, and productive lifetime of the project.

5 Economic and environmental impact

The displacement of traditional wood fuels used inefficiently in the household, brings important positive impacts as it directly reduces the demand for fuels sold in informal wood fuel (mainly

charcoal) markets. Informal biomass trade and wood fuel collection is an important phenomenon in several developing countries. It is difficult to assess its scale in each country; however, FAO calculated that it is responsible for more than three quarters of all removed wood from forests (FAO, 2010).

Recent studies assessed the amount of renewable and **non-renewable biomass fraction** removed by traditional wood fuel demand, based on GIS. They demonstrate that about 27 to 34 percent of wood fuel harvested worldwide would be considered "unsustainable" (Bailis et al. 2014). According to the assessment, "sustainability" is based on whether or not annual harvesting exceeds incremental re-growth. The study identifies a set of "hotspots" where the majority of wood extraction exceeds sustainable yields. These hotspot regions, located mainly in South Asia and East Africa, support about 275 million people who are reliant on wood fuels. However, even within a given country the situation varies a great deal with areas over-exploited while others are still totally untouched. A better understanding of the relationship between supply and demand requires a spatial approach to clarify e.g. what the impacts of different policies will be.

Illegal wood removal is at the same time an economic, environmental and health problem. It is directly responsible for deforestation and forest degradation in several countries (globally around 13 million hectares of forest were lost each year between 2000 and 2010) and is commercialized at a price that does not take into account the ecosystem loss that it causes. Moreover, charcoal, which is in high demand especially in urban areas, comes predominantly from felled trees, while the wood collected by rural women for their own use is mainly dead wood taken from trees (therefore more sustainable, as they wish to conserve the tree for the future). It is important to move to cleaner fuels for cooking but at the same time the transition should be smooth, and the new fuel (and stoves) should be made economically competitive with the traditional ones. Successful experiences exist where traded charcoal was taxed and at the same time the cleaner fuel (i.e. LPG) was subsidized.

As mentioned before, one critical issue is the health impact of pollution by **black carbon**[4]through biomass combustion in traditional biomass stoves. This is a major health problem in many developing countries, and has a considerable regional and global climate impact (UNEP, 2011). Without significant improvements in the efficiency of biomass cookstoves, over 1.5 million people could die every year by 2030 from the effects of indoor smoke (IEA, 2011). These health implications underline the importance of deploying advanced stoves and cooking fuels (e.g. equipped with chimney or forced ventilation systems).

In addition, modernisation would lead to more efficient use of biomass resulting in fuel cost savings, and would reduce the time people spend on gathering wood that they could use for other productive, learning or recreational activities. Employment opportunities in the stove manufacturing and distribution chain are another important socio-economic benefit (IEA 2012).

The positive environmental impacts of moving from traditional biomass to alternative and modern sources includes reduced **GHG emissions**. Wood fuel use is responsible for around 800 MtCO2 per year, or 2% of global GHG emissions. This is equivalent to the entire annual GHG emissions from the aviation sector and for many countries in Sub-Saharan Africa, wood fuel GHG emissions are roughly half the size of nationally reported GHG emissions (Climate Focus, 2014).

[4] Black carbon is a component of fine particulate matter and is formed through the incomplete combustion of fossil fuels, biofuel, and biomassand causes human morbidity and premature mortality. It is emitted in both anthropogenic and naturally occurring soot. Black carbon is also a climate forcing agent.

Country	Woodfuel GHG emissions ($ktCO_2$/yr)
Rwanda	4,879
Kenya	25,833
Burkina Faso	6,402
Eritrea	2,150
Haiti	5,013
Burundi	3,296
Uganda	25,179
Ethiopia	65,081
Nigeria	34,100
Senegal	3,551

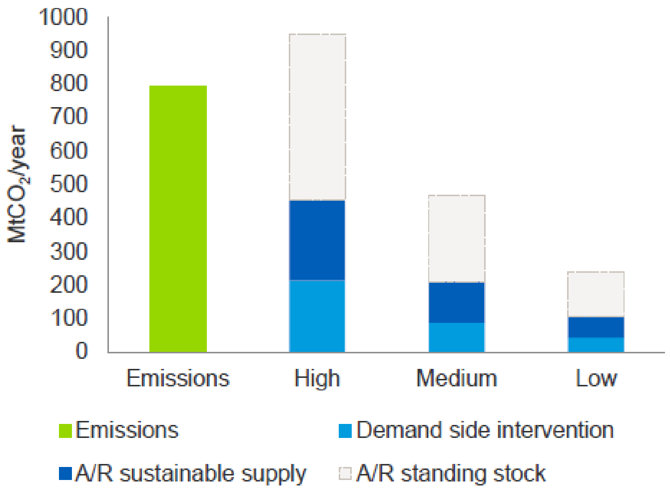

Table – Household non-renewable biomass GHG emissions of selected countries (left) and emission reduction potential from replacement cookstoves and afforestation/reforestation according to different adoption scenarios in these countries (Source: Climate Focus, 2014)

The deployment of 100 million improved cookstoves could reduce this by 11 to 17 percent. These reductions would be worth more than USD 1 billion per year in avoided greenhouse gas emissions if black carbon were integrated into carbon markets (Science daily 2015). Adoption of clean cooking technologies are expected to reduce GHG emissions by as much as 214 MtCO2 per year, and dedicated wood fuel plantations would reduce GHG emissions by a further 734 MtCO2 per year (Climate Focus, 2014).

The mitigation potential at stake is enormous, as annual GHG emissions from wood fuel consumption are equivalent to roughly a quarter of gross GHG emissions from deforestation in the tropics, and GHG emissions from wood fuel use in some countries are up to nine times greater than reported GHG emissions from deforestation (Climate Focus, 2014).

LPG promotion policy in Senegal: The role of alternative energy subsidies (Enda Energie UN-HABITAT, 2013)

The LPG promotion policy in Senegal aimed at reducing the consumption of wood which puts pressure on the forest cover with all its adverse effects on health and the environment, especially with the acceleration of desertification processes. This long-term policy, with the sequential application of measures, was based on: i) A good choice of appropriate cooking equipment (bottles of 2.75 kg and 6 kg); ii) a subsidy targeting only bottles of 2.75 kg and 6 kg considered as more popular; iii) removal of LPG subsidy between 1999-2009. The consumption increases annually between 10 and 12% on average from 1974 to 2010.

A recent study on the impact of the removal of the subsidy in the region of Dakar shows a decline in both the percentage of households using LPG and the rank of LPG in the domestic cooking fuels mix. The overall LPG usage rate has decreased from 97% to 85%, with charcoal and firewood usage increasing from 78% to 90% and 13% to 17%, respectively. This reflects a return to charcoal and firewood at the household level. In the four departments that were part of the survey, LPG was the main cooking fuel for more than 90% of households before the removal of the subsidy. After the removal of the subsidy, only 70% of households use it as main energy for cooking. This decline is linked to the abandonment of LPG as main cooking fuel by 22% of the households surveyed.

The major challenges for tackling unsustainable fuel use for household activities in a development context revolve around the following issues:

- The need to articulate the supply side and demand side for bioenergy for the sustainable supply of different (domestic) energy sources to the population. Experiences show the relevance of an approach combining both: the offer in terms of production of bioenergy (reforestation, participatory forest management) e.g. to enhance the availability of wood in rural and urban areas and, on the other hand, the demand by diversifying alternative fuels to reduce dependence on wood or kerosene through the dissemination of biogas, biodiesel, ethanol and LPG.
- The development of markets for new bioenergy products and the establishment of new regulation or a mechanism that facilitates access to equipment and fuel to reach a larger number of end-users, especially at the base of the pyramid. Depending on the country context, it could be more effective to concentrate efforts on the improvements of cooking stoves and the charcoal production process and the use of biogas from anaerobic digestion from agricultural residues.
- Quantification of the actual GHG emission reduction compared with the business-as-usual (the use of fossil fuels) from a life-cycle perspective, in order to attract international climate mitigation support to finance a transition towards cleaner energy services.

6 What are the key questions?

- What is the local level of awareness and knowledge among final users, private actors and governments of bioenergy solutions?
- What is the amount of biomass resources which can be made practically and economically available?
- Are there fossil fuel or other subsidies that make traditional energy sources artificially cheap or their alternatives artificially expensive?
- Which sustainability requirements should the bioenergy produced comply with and what is the associated compliance cost?
- Which funding or financing sources are locally available?
- Is there any public support available?
- What is the amount of GHGs that could be saved as a result of interventions targeting cooking fuels?

7 Useful information

Sustainable bioenergy tools

FAO BEFS Rapid Appraisal Tools:

- Country Status: http://www.fao.org/energy/befs/86186/en/
- Natural Resources - Biomass Potential Assessment (including Land Suitability Maps): http://www.fao.org/energy/befs/86187/en/
- Energy End-use Options - Techno-economic and Socio-economic Analyses: http://www.fao.org/energy/befs/86188/en/

GBEP, 2011. The Global Bioenergy Partnership Sustainability Indicators for Bioenergy, First edition. http://www.globalbioenergy.org/fileadmin/user_upload/gbep/docs/Indicators/The_GBEP_Sustainability_Indicators_for_Bioenergy_FINAL.pdf

References on cookstove standards: http://cleancookstoves.org/technology-and-fuels/standards/index.html

The FAO Support Package to Decision-Making for Sustainable Bioenergy: http://www.fao.org/energy/82318/en/ including: the Decision Support Tool for Sustainable Bioenergy (DST), Bioenergy and Food Security (BEFS) Approach, the Bioenergy Environmental Impact Assessment Framework (BIAS), the GEF biofuels project screening toolkit, the BEFS Operator Level Tool.

Small scale biogas solutions providers

SimGas (Netherlands) – www.simgas.com

Further Reading

Bailis R., Drigo R., Ghilardi A., Masera O., 2014. The carbon footprint of traditional wood fuels. http://www.nature.com/nclimate/journal/v5/n3/full/nclimate2491.html

BIOS BIOENERGIESYSTEME Website:http://www.bios-bioenergy.at

Charcoal Project: http://www.charcoalproject.org/

Cooking Energy Compendium - Cooking with Wood fuels: https://energypedia.info/wiki/Cooking_with_Woodfuels_(Firewood_and_Charcoal)

Climate Focus, 2014. Cookstoves and REDD+. Understanding wood fuel's impact on tropical forests. Briefing note. http://cleancookstoves.org/binary-data/RESOURCE/file/000/000/345-1.pdf

ClimateTechWiki. Charcoal Heating and Cooking.http://climatetechwiki.org/technology/charcoal-heating-and-cooking

Cooking Energy Compendium - Charcoal Production and Cooking with Charcoal: https://energypedia.info/wiki/Charcoal_Production andhttps://energypedia.info/wiki/Cooking_with_Charcoal

Enda Energie /UN-Habitat, 2013. Impacts of the removal of LPG subsidy on households and small production/services units in urban areas of Senegal: The Case of Dakar

FAO Wood Energy Website: http://www.fao.org/forestry/energy/en

FAO, 2014. State of World's Forests 2014

FAO, 2010. Global forest resources assessment – Key findings

FAO, 2009. Small Scale Bioenergy Initiatives - Brief description and preliminary lessons on livelihood impacts from case studies in Asia, Latin America and Africa. ftp://ftp.fao.org/docrep/fao/012/i1273e/i1273e.pdf

GIZ, 2014. Wood Energy - Renewable, profitable and modern. http://tinyurl.com/wood-energy-talking-cards

Global Alliance for Clean Cookstoves: http://www.cleancookstoves.org

Household Energy Development Organizations' Network Website: http://www.hedon.info/

IEA, 2012. Technology Roadmap – Bioenergy for Heat and Power

IEA, 2011. World Energy Outlook 2011

IPCC, 2006. IPCC Guidelines for National Greenhouse Gas Inventories – Chapter 1

ODOE: Bioenergy in Oregon Website:
http://www.oregon.gov/energy/RENEW/Biomass/Pages/index.aspx

PREDAS, 2004. Aménagement Participatif et Gestion Décentralisée des Forêts Naturelles pour la production de bois-énergie: Capitalisation de l'expérience nigérienne

REN21, 2015. Renewables 2015 Global Status Report

REN21, 2014. Renewables 2014 Global Status Report

Science daily, 2015. Surprising insights into effects of wood fuel burning.
http://www.sciencedaily.com/releases/2015/01/150122154849.htm

Thematic fiches prepared by the EU Energy Facility on improved cooking systems:
http://energyfacilitymonitoring.eu/images/stories/publications/thematicfiches/thematic_fiche_4.0_stoves.pdf

UNEP, 2014. The Environmental Crime Crisis. http://www.unep.org/unea/docs/RRAcrimecrisis.pdf

UNEP, 2011. Integrated Assessment of Black Carbon and Tropospheric Ozone. Summary for decision makers.www.unep.org/dewa/Portals/67/pdf/BlackCarbon_SDM.pdf

WRI, 2015. Avoiding Bioenergy Competition for Food Crops and Land