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"Clean" Cooking Energy in Uganda – technologies, impacts, and key barriers and enablers to market acceleration

Roz Price
Institute of Development Studies
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Question

Provide a scan of the available evidence on "clean" cooking energy alternatives in Uganda, focusing on the different technologies, their impacts and the key barriers and enablers to market acceleration.

Contents

1. Overview

The cooking energy mix in Uganda is dominated by unprocessed biomass, with charcoal the next most utilised fuel. "Clean" alternatives either relate to improved biomass cookstoves or switching to "clean" fuels such as liquefied petroleum gas (LPG), biogas and ethanol. However, access by poorer and rural communities to modern, clean fuel is currently limited by relatively high prices, low demand and unreliable supply; this is of particular importance in Uganda as the main supplies of LPG are imported. Changing to "clean" alternatives can have potential impacts on social and environmental factors, including limiting rates of deforestation, improving health, reducing the costs of cooking, time savings, and cleaner kitchens and cooking vessels. However, empirical evidence of the impact of such technologies, especially on health, remains limited and inconclusive, and is primarily focused on improved biomass stoves. If clean alternatives are to produce impacts they must be used correctly and consistently, and critically, they must come to displace the use of traditional stoves, without 'stacking' of polluting and improved technologies.

Rehfuess et al (2014) in their comprehensive mixed-method systematic review identified 31 factors within 7 domains capable of acting as enablers or barriers to the uptake of improved cookstoves in middle and lower country environments. They found that all domains matter and jointly influence the adoption and sustained use of improved cookstoves. Some factors appear to be critical for success, but none can guarantee either adoption or sustained use. Integration between factors primarily acting at the household/community level and factors acting primarily at the programme/societal level is critical if programmes are to reach their intended populations and be successful at scale and over extended periods of time. In a systematic review on available evidence of adoption and sustained use of clean fuels, Puzzolo et al (2016:231) found that the evidence suggests that in practice the reported factors influencing uptake and use of clean fuels tend to operate on a spectrum. If factors are present or satisfactory they act as enablers; conversely, if absent or unsatisfactory, they act as barriers. None of the factors identified necessary for success (e.g. higher income levels, fuel savings, appropriate financing and governmental support) are sufficient on their own to ensure adoption. Hence, all of these considerations need attention in planning, implementation and evaluation of initiatives to introduce and scale-up clean fuels, and they will differ depending on the country’s context and technology being considered. Key barriers and enablers to market acceleration in Uganda include skills, community engagement, marketing, quality, financing, governmental support, and design.

Gender considerations are also important for cooking interventions in Uganda. As the primary energy consumers and beneficiaries of improved cookstoves, women are well-versed in understanding the challenges of adoption and continued use, and are therefore integral to any consumer awareness and education campaign. Women can also play central roles in microenterprise and as leaders, networkers, and promoters for improved cookstoves in their region. It will be key to effectively engage women in ways that accommodate or help overcome existing constraints while building intrinsic and extrinsic supports for their successful involvement.

There was an array of literature on this subject matter. The evidence was relatively strong, particularly related to Uganda and improved cookstoves. However, there was disagreement on the impacts of interventions especially in the field. A number of gaps exist for further and future research including but not limited to: more comprehensive knowledge of the market in Uganda, consumer behaviour, rural segments on less than USD3, switching to cleaner fuels, urban firewood users and the extent of use of improved cookstoves in Ugandan households.

2. Types of “Clean” Cooking Energy Alternatives

The main cleaner alternatives to traditional cooking methods with solids fuels and inefficient cookstoves are (Brooks et al, 2016):

(a) improved efficiency biomass stoves (i.e. improved cookstoves) or

(b) stoves that rely on modern fuels or alternative energy sources (e.g. Liquefied Petroleum Gas (LPG), electric, or solar)

There are a number of international standards and guidelines that are relevant to “clean” cooking energy. World Health Organisation (WHO) Indoor Air Quality Guidelines were developed in 2014. The International Standards Organisation (ISO) is in the process of developing international standards for cookstoves, there are currently interim international guidelines (IWA Tiers of Performance) in place for stove performance as a first step towards formal standards (Fresh Air Uganda et al, 2015). In 2012, recognition by the United Nations that energy access is critical for achieving the Millennium Development Goals led to the launch of the Sustainable Energy for All (Se4All) Initiative, with ambitious targets for universal access to electricity and modern cooking energy systems by 2030. Se4All and other initiatives envisage a mix of interventions. In favourable settings, where biomass fuels are already purchased and/or households possess the necessary economic means, a relatively rapid shift to clean fuels is feasible. At the same time, households unable to afford and/or access modern fuels in the short- to medium-term must have access to solid fuel stoves that are as clean and safe as possible (Rehfuess et al, 2014).

Current characteristics of Uganda cooking energy sector

In Uganda, a large portion of the population uses unprocessed biomass to cook. Eighty-seven percent of the population lives in rural areas and 13 percent in urban areas. One-third of households are headed by women (GACC, 2017). Global Alliance for Clean Cookstoves (GACC) (2017) estimates that of cooking fuels in Uganda: unprocessed biomass makes up the majority with over 85 percent; charcoal is used by 13 percent of the population, mainly in urban and peri-urban areas; LPG and kerosene are used in small portions, less than 0.5 percent each; the remaining 0.8 percent is a mix of fuels produced from small enterprises and possibly some electricity. In 2014, SNV, the Netherlands Development agency, commissioned a market intelligence study of cooking techniques in Uganda. Despite more than three decades of interventions in the renewable energy sector in Uganda, SNV (2014) estimates that approximately only 10 percent of the population is accessing clean energy for cooking. They reported that Uganda’s energy consumption matrix stands at: about 90 percent biomass; 7 percent petroleum products; and 2 percent of electricity produced from hydro and thermal power plants. Only 12 percent of the total population is estimated to have access to electricity of which only 1 percent comprises the rural population.

General cooking energy characteristics in Uganda include (GACC, 2017; GVEP International, 2012b; SNV, 2014):

- The majority of rural households use firewood for cooking whilst in urban areas households use both firewood and charcoal.
- Rural households mostly cook on three-stone fires, often in enclosed spaces. Three-stone fireplaces have very low efficiencies (10 percent-17 percent).
- Many households in rural areas can collect firewood for free although it is becoming increasingly unavailable.
- Uganda has had more than a 2 percent decrease in forest land per year over recent years, and only 15 to 26 percent of Uganda’s land area is covered by forest.
- Nearly 22 percent of the rural population live in areas with woody biomass shortfalls.
- The price of fuel is higher in urban centres and is subject to seasonal fluctuations.
- The type of fuel used can vary depending on the time of day and meal being cooked.
- LPG usage is low and restricted mainly to urban, higher income families. It is often perceived as a dangerous fuel and availability outside urban centres is low.
- Kerosene is used by a small percent of the population; mainly smaller, urban families.
- Government subsidies are available for kerosene, but not for LPG.

- In 2012, the government removed subsidies on electricity; very few households can afford to cook with this fuel.
- Recycled biomass briquettes have been introduced but awareness and uptake is low.
- Production of charcoal in the country is not regulated.

Improved cookstoves

Despite significant heterogeneity in cost, quality, and materials, generally speaking improved cookstoves (ICS) are designed to reduce emissions by increasing combustive efficiency. In so doing, ICS are expected to yield health benefits, and also reduce the total amount of biomass required, easing stress on local forests and the global commons (through lowered climate-changing emissions). These benefits, however, depend on sustained use (Usmani et al, 2017). Stove designs include a wide variety of styles, materials, construction techniques and performances; ranging from very simple to well-engineered and sophisticated technologies (Puzzolo et al, 2015). According to the IWA Tiers of Performance, stoves can be classified as follows in Figure 1. For more detailed information on the different types of cookstoves (i.e. basic, solid fuel, solar, liquid fuel, biogas, combined solar and bioenergy) see this fact sheet by the World Bioenergy Association.

Figure 1: Classification of Stoves in the ISO Standards

Source: Taken from Puzzolo et al, 2015:46.

There are a number of biomass fuels that can be used in many ICS[1], including:

- *Charcoal briquettes from wood*: an energy-dense, light-weight, easy-to-handle, and convenient fuel, which burns without producing much smoke other than during lighting, making it a preferred fuel especially in urban areas. However, there can be significant energy losses and emissions during charcoal production processes. Charcoal may also be produced from bamboo, which is a fast growing and renewable feedstock choice.
- *Non carbonised briquettes from sawdust*: processed biomass material, which may be derived from sawdust.
- *Non carbonised briquettes from crop residues*: processed biomass material, which may be derived from crop residues, including straws, stems, leaves, husks, shells, peels, etc. Excess residues are increasingly being viewed as a valuable resource, and are an increasingly common fuel source in developing countries.
- *Wood pellets*: densified woody material, they are an increasingly common fuel source in developing countries.
- *Wood chips*: processed woody material, they are an increasingly common fuel source in developing countries.
- *Ethanol from sugarcane*: a clean liquid biofuel that can be made from a variety of feedstocks. Ethanol may be directly produced from sugarcane processing, or may be produced from molasses, a co-product of sugar production.
- *Ethanol from wood*: a clean liquid biofuel that can be made from a variety of feedstocks. Many new feedstocks are under development, such as ethanol from sawdust or from forest residues.
- *Biogas from dung*: a methane rich gas produced through the anaerobic digestion of organic wastes. It can be generated from animal and kitchen wastes, as well as some crop residues. For cooking, biogas can be used directly in conventional low-pressure gas burners.
- *Liquefied Petroleum Gas (LPG)*: a comparatively clean-burning, portable, sustainable, and efficient fuel. LPG is a co-product of natural gas and crude oil production and usually consists of a mixture of propane and butane for standard heating and cooking purposes. Its unique properties make it a versatile energy source – it is multi-purpose, is portable, and can be used virtually anywhere in the world.

Fuel-switching

The international development community continues to debate the optimal approach to supporting clean cooking. In recent years it has been argued that many clean cooking interventions, including ICS with biomass, are not effective enough at reducing exposure to key pollutants (fine particulate matter) to low enough levels to be in agreement with WHO indoor air quality guidelines (Bruce et al, 2017). Laboratory testing for some of the newer advanced stoves is promising, but the results cannot be consistently replicated in the field, and the reliability of fuel supply for processed biomass presents another challenge. Van Leeuwen et al (2017) argue that

[1] The fuel definitions are taken from GACC, 2017 FACIT Toolkit http://cleancookstoves.org/technology-and-fuels/facit/index.html

where possible, the focus needs to shift to “BLEN” fuels (biofuels, LPG, electricity, and piped natural gas) – fuels that are truly clean at point of use.

However, access by poorer and rural communities to modern, clean fuels (among which LPG is the most widely available) is currently limited by relatively high prices, low demand and unreliable supply. The benefits in terms of low emissions, speed, controllability and convenience are substantial however, and parallel efforts need to be made to overcome these barriers (Puzzolo et al, 2015). Some in the development community dislike LPG because it is non-renewable. But others argue that as it is an unavoidable by-product of oil and natural gas production and oil refining, a global LPG surplus exists (Van Leeuwen et al, 2017). Production of renewable (i.e. non-fossil fuel derived) LPG is also underway and holds promise for further expansion. Bio-LPG, as a product, is identical to fossil fuel-derived propane and is produced from renewable feedstocks such as vegetable oil, animal fat, waste oils or other cellulosic waste material (Bruce et al, 2017). Although LPG prices and reliable delivery pose a challenge in many countries, the multiple benefits brought by the transition to clean fuels should be pursued (Puzzolo et al, 2015). Low-income countries in Africa are trying to learn from the large-scale adoption of LPG for clean cooking in Indonesia, India, and other parts of the world, and to demonstrate its affordability when the right supports are in place. Uganda has set a LPG penetration target of 1 million urban households by 2030 through its Se4All Action Agenda (Van Leeuwen et al, 2017).

3. Impacts of “Clean” Cooking Energy Alternatives

Impacts of fuel use in Uganda

GACC (2017 and 2016) undertook research to provide an understanding of trade-offs between fuel options and environmental impacts across the value chain in Uganda. This study evaluates various cooking fuels using life cycle assessment (LCA), a method for comprehensive, quantified evaluations on the environmental benefits and trade-offs for the entire life cycle of a product system, beginning with raw material extraction and continuing through the product’s end-of-life (GACC, 2017). Table 1 below gives the summary for Uganda for the different fuels. Further key observations from the report (GACC, 2017)[2] and its Annex (GACC, 2016) include:

- *Firewood*: is low cost; the firewood market is informal and fragmented and many people, especially in rural areas, collect it freely by hand. Time spent collecting firewood in Uganda takes an average of 3 hours per day for those living in urban areas and 6 hours per day for those living in rural areas. This time requirement will only increase with deforestation.
- *Charcoal briquettes*: have the greatest impact across the full fuel life cycle and are less affordable than firewood. Uganda’s declining forest area is expected to result in supply-related issues for both fuels. Due in part to the decreasing supply, the government has begun actively supporting producers of charcoal briquettes from wood with financial incentives, as cooking with charcoal briquettes is more efficient at the point of use compared to cooking with unprocessed firewood. Despite its higher energy content, the life cycle environmental impacts of charcoal briquettes are greater than wood because it requires a substantial amount of energy to produce. The price of charcoal made from

[2] For more detail on the methodology of this study and insights see the main report (GACC, 2017) and its Annex (GACC, 2016). Also visit the FACIT tool at http://cleancookstoves.org/technology-and-fuels/facit/index.html

wood is quite high compared to other fuels use. Alternative feedstocks to wood, such as bamboo, demonstrate slightly better environmental performance, further decrease pressure of forest resources, and provide a locally based business opportunity. Small charcoal briquette enterprises struggle to access traditional sources of financial assistance, and affordability issues may follow from high production costs being passed on to consumers. Also, a variety of taxes (value-added, employment etc.) disadvantage licensed producers of charcoal relative to their counterparts in the informal sector.

- *Wood chips, wood pellets and non-carbonised briquettes*: have mostly mid-range life-cycle impacts; however, these fuels are not widely used in the Ugandan cooking fuel market (e.g., non-carbonised briquette production is 5,000-7,000 tonnes annually, representing less than one percent of the national cooking fuel market). Due to their limited uptake, little information is available to evaluate cost and implementation. One encouraging sign is the adoption of non-carbonised briquettes at the commercial level. Although not used for cooking, briquettes made of crop residues and sawdust have begun to displace firewood and charcoal as the primary fuel source at some schools, hospitals etc. Pilot start-ups are at infant stages for the use of wood pellets, and non-carbonised briquettes from crop residues are available from small enterprises, some of which are owned by women. Non-wood charcoal briquettes represent an opportunity market for small- and medium-sized enterprises (SMEs).
- *Ethanol*: has one of the lowest environmental impacts, however, it is not currently used to any significant extent in Uganda. Insufficient information was available to assess cost and implementation issues of ethanol. Ethanol from sugarcane exhibits poor relative performance in total energy demand when compared to other African countries with the exception of Kenya. This is driven by the distribution phase within fuel processing as the model assumes this fuel needs to be imported.
- *Biogas*: has one of the lowest environmental impacts but is not currently used to any significant extent in Uganda. Biogas from dung can be used in rural areas where dung is readily available, but biogas systems are very uncommon due to the initial cost of the digester and unavailability of loans to purchase them. Affordability concerns and design issues might improve now that cooking with biogas is promoted through a National Biogas Program. A review of literature by Lwiza et al (2017) into dis-adoption of biogas showed that households that dis-adopted the technology, did so within a period of 4 years after its installation, yet the lifespan of using it is estimated at 25 years. Factors that contributed to dis-adoption included the failure to sustain levels of cattle and pig production that are necessary for feedstock supply, reduced availability of family labour required to operate the biogas digester, and inability of the households to repair biogas digesters after malfunctioning.
- *LPG*: is a cleaner burning fuel that has comparatively lower life cycle impacts than the currently used wood and charcoal. LPG exhibits poor relative performance in total energy demand when compared to other African countries with the exception of Kenya. This is driven by the distribution phase within fuel processing as the model assumes this fuel needs to be imported. It is used mainly by wealthier citizens in urban areas. Some consumers perceive LPG as dangerous. Although the supply of LPG in cities is fairly reliable, there is little or no infrastructure for rural distribution. Smaller LPG cylinders would make this fuel more affordable for a greater share of the population; however, poorer households may need assistance from the government or NGO programs to acquire an LPG cookstove, and the barriers within the distribution and supply chain would still need to be overcome.

Table 1: Summary of Environmental Indicators for Cooking Fuels in Uganda

	Unprocessed Solid Biomass	Processed Solid Biomass						Liquid/Gas					
Indicator*	Firewood	Charcoal Briquettes from Wood	Charcoal Briquettes from Bamboo	Non-Carbonized Briquettes from Sawdust	Non-Carbonized Briquettes from Crop Residues	Wood Pellets	Wood Chips	Ethanol from Sugarcane	Ethanol from Wood	Biogas from Dung	LPG	*Median*	*All-fuel average***
TED (MJ/HH/YR)	39,705	78,111	76,858	45,211	21,616	14,775	19,289	38,731	12,611	10,540	39,125	*13,693*	*22,032*
NED (MJ/HH/YR)	33,752	72,159	70,905	39,259	15,664	8,823	13,337	32,779	6,659	4,588	33,173	*7,741*	*18,394*
GCCP (kg CO_2 eq/HH/YR)	4,464	7,027	2,200	508	271	2,121	2,170	540	43.7	17.8	2,007	*157*	*1,187*
BC/SLCP (kg BC eq/HH/YR)	3.80	10.0	9.79	2.84	5.00	0.12	0.65	-0.040	0.027	0.061	0.042	*0.034*	*1.79*
PMFP (kg PM10 eq/HH/YR)	12.9	37.6	37.0	10.7	23.3	0.73	6.29	0.98	0.38	0.31	1.18	*0.56*	*7.31*
FFD (kg oil eq/HH/YR)	0.033	0.047	0.11	0.18	0.24	12.8	1.50	91.9	6.36	0	923	*0.040*	*57.6*
WD (m^3/HH/YR)	0.25	1.52	1.37	16.4	24.7	1,304	1.65	411	1.66	19.0	379	*1.44*	*120*
TAP (kg SO_2 eq/HH/YR)	3.07	0.87	1.76	2.51	1.28	0.54	1.51	3.00	0.47	0.091	2.99	*0.51*	*1.01*
FEP (kg P eq/HH/YR)	0.81	0.41	0.40	0.48	0.39	0.018	0.39	0.21	1.9E-05	0	0.047	*0.0092*	*0.17*
POFP (kg NMVOC eq/HH/YR)	138	168	169	103	18.1	0.98	66.7	1.94	1.18	0.48	9.77	*1.08*	*37.7*

*TED = Total Energy Demand; NED = Net Energy Demand; GCCP = Global Climate Change Potential; BC/SLCP = Black Carbon and Short-Lived Climate Pollutants; PMFP = Particulate Matter Formation Potential; FFD= Fossil Fuel Depletion; WD = Water Depletion; TAP = Terrestrial Acidification Potential; FEP = Freshwater Eutrophication Potential; POFP = Photochemical Oxidant Formation Potential; CO_2= Carbon Dioxide; DME= Dimethyl Ether; MJ= Megajoules; NMVOC= Non-Methane Volatile Organic Compound; SO_2= Sulfur Dioxide; HH = Household; YR = Year.

**All-fuel average values calculate a straight average of the cooking fuels investigated for the country and do not consider the current weighted use of each fuel for cooking within the country.

Note: Descriptions of each environmental indicator are found in Table 2-2. Dark green represents the lowest 5th percentile fuel by impact, light green represents fuels between the 5th and 25th percentile by impact, grey represents fuels between the 25th and 75th percentile by impact, orange represents fuels between the 75th and 95th percentile by impact, and red represents fuels greater than the 95th percentile by impact. All values in the table are displayed to three significant digits. When determining percentiles (and accompanying color-coding), more significant digits were used. As a result, values that appear the same in the table may be color-coded differently.

Source: GACC, 2017:3-65. For detailed definitions of the different indicators see http://cleancookstoves.org/technology-and-fuels/facit/index.html

Deforestation

Forest cover is estimated at between 15 – 26 percent of total land area in Uganda. Biomass requirements have contributed to the degradation of forests as trees and shrubs are harvested at alarming rates to meet fuel wood demand. Growing populations are putting large demand on land which is been cleared for agriculture and settlements. FAO reported that between 1990 and 2005 Uganda lost 26 percent of its forests. 21.8 percent of the rural population live in areas of high woody biomass deficit (GVEP International, 2012b). ICS and fuel-switching is hoped to reduce this rate. For example, in Senegal, the growth in LPG use in the 1970s resulted in the avoided consumption of about 70,000 tonnes of fuelwood and 90,000 tonnes of charcoal annually (equivalent to 700,000 m3 of wood per year). The Ministry of Energy estimated a 15 percent decrease in deforestation rates due to LPG adoption (Bruce et al, 2017).

Improved health

Burning solid fuels in open fires or traditional inefficient stoves generates hundreds of pollutants from incomplete combustion, including particulate matter (PM2.5), carbon monoxide, nitrogen oxides, and various organic substances (Rehfuess et al, 2014). The use of biomass with basic cooking devices combined with unsuitable cooking spaces is the main cause of indoor air pollution (IAP) in Uganda. Female cooks and children are the main groups exposed to IAP which is linked to acute respiratory infections responsible for 8.2 percent of infant deaths (GVEP International, 2012b).

Until very recently, most intervention research into IAP has focussed on behaviour change and the adoption and sustained use of improved solid fuel stoves. However, the effectiveness of these interventions in reducing health-damaging emissions has been highly variable (Rehfuess et al, 2014). Puzzolo et al (2016) highlights that these interventions have had generally limited effects on levels of IAP in relation to PM2.5 and black carbon, with levels being above WHO recommended levels. Reasons for these findings include only partial adoption and intermittent use of interventions, and the contributions from other sources of combustion within the home and from outside sources. A recent study by Mortimer et al (2016) in rural Malawi found no evidence that an intervention comprising cleaner burning biomass-fuelled cookstoves reduced the risk of pneumonia in young children. They concluded that an important implication of these observations was that tackling any individual source of air pollution exposure in isolation is unlikely to be effective for improving health; an integrated approach to achieving clean air that tackles rubbish disposal, tobacco smoking, and other exposures, as well as robust cleaner cooking solutions (e.g., cleaner stoves and fuels) that achieve a high rate of acceptance is probably needed to deliver health benefits (Mortimer et al, 2016).

Household level stove use and fuel collection

To maximise the energy-saving and potential health impacts from ICS, the improved stoves must first be acquired, then used correctly and consistently. Perhaps most critically, the stoves must come to displace the use of the traditional stoves (Shankar et al, 2014). An SNV market intelligence survey (2014: p.13) found that “64 percent of the [surveyed] households purchase their main cooking fuel while 31 percent collect their main cooking fuel. The rest (5 percent) both buy and collect fuel. Over the past 3-5 years, households reported an increase in their monthly fuel expense from average of UGX 22,000 to UGX 40,000. The time taken to gather firewood increased from 2.4 hrs /week to currently 3.6 hrs /week over the same period. With the current deforestation rate as well as population growth, this trend is expected to continue. This situation will compel the households to find alternative ways of reducing fuel consumption hence presenting an opportunity for uptake of ICS". The majority of surveyed households (94 percent) indicated willingness to purchase ICS, the main motivations for this included: fuel saving (41 percent), reduction of cooking time (22 percent), stove durability (16 percent) and reduced kitchen smoke (10 percent). It is important to note as well that cost didn't feature as highly as would be traditionally expected (SNV, 2014).

At the household level, the benefits of ICS may include reducing the time, money, and labour required for acquiring fuel (Shankar et al, 2014). Lower costs of cooking, time savings, cleaner kitchens and cooking vessels have also been put forward as favourable results of ICS and fuel switching (FRESH Air Uganda et al, 2015). A report for the KfW Development Bank (Bruce et al, 2017) summarises that switching to LPG by a substantial proportion of current global biomass/kerosene users would result in a reduction in women and children's labour time in fuel collection and cooking. The added convenience and time savings offer the potential for making more of employment and education opportunities. In Sri Lanka, for example, this time saving was estimated at 2 to 3 hours per day. However, several studies have found that poor rural communities, where fuel and labour are both abundant, do not consider the opportunity costs of time spent on cooking or fuel collection to be important (see Rehfuess et al, 2014).

Reduction in fuel demand

Rehfuess et al (2014) carried out a systematic review of factors that enable or limit large-scale uptake of ICS in low- and middle-income countries. They found that fuel savings, whether perceived or measured, are widely reported as an important incentive. Fuel savings comprise savings in fuel collection time and/or household expenditure when fuel is bought. Garland et al (2015) present results from three United States Environment Protection agency sponsored field studies which assessed the fuel consumption impacts of household energy programmes. They found that in Uganda, the homes using LPG consumed approximately 31 percent less charcoal than those not using LPG, although the total energy consumption per household was similar between the baseline and LPG user groups. Brooks et al (2016) used data from in-house weighing of fuel conducted in rural India to examine the impact of cleaner cookstoves (most of which were LPG stoves) on three key outcomes related to solid fuel use. Their results suggest that using a clean cookstove is associated with daily reductions of about 4.5 kg of biomass fuel, 160 fewer minutes cooking on traditional stoves, and 105 fewer minutes collecting biomass fuels. Their results support the idea that efforts to promote clean stoves among poor rural households can reduce solid fuel use and cooking time, and that rebound effects toward greater amounts of cooking on multiple stoves are not sufficient to eliminate these gains.

Many of the purported environmental and livelihoods benefits of non-traditional cookstoves stem from the assumption that these reduce fuel consumption and harmful air pollution emissions. Yet empirical evidence of the impact of such technologies remains surprisingly limited and inconclusive, and is primarily focused on improved biomass stoves (Brooks et al, 2016).

4. Barriers to Market Acceleration

Lack of availability, skills and imports

The SNV study (2014) found that most of the households surveyed that bought unimproved charcoal stoves indicated to have purchased them from retail outlets (54 percent), while households that purchased improved charcoal stoves indicated to have purchased them mainly from open market or exhibitions (38 percent). This discrepancy shows a greater abundancy of unimproved charcoal stoves closer to the last-mile customers who depend more on retail shops near them for supplies. The findings indicate that there is a good network of retail outlets in the districts which should be taken advantage of as selling points for ICS. There are few distributers or vendors in areas beyond Kampala, which makes ICS accessibility hard (SNV, 2014).

There are several Ugandan ICS manufacturers, many of who are located in and around Kampala. Of these, only Ugastove and Green Bioenergy are able to produce stoves in quantities exceeding 5,000 per month (SNV, 2014). Other small production centres exist all over the country, but often with low production capacity and producing poor quality stoves (GVEP International, 2012b). For example, SNV (2014) found that limited use of ICS in the surveyed households was partially attributed to the absence of established ICS producers in Buikwe and Mbale districts. The artisans that there were in the district had limited production capacity. A commercial market for improved stoves exists in the whole country but many stoves are of poor quality. Most of the artisans lack technical skills as well as technological capacity (in terms of equipment and other infrastructure) to produce good quality stoves (SNV, 2014). There is also a growing increase in raw material costs as a result of long distances travelled to outsource the materials such as clay. This not only has impacts on the stove prices, but also hinders the production rate.

In addition to local production, stoves have been imported into Uganda over the past 3-5 years by mainly UpEnergy. These stoves, which are mainly wood burning, include brands like Envirofit, JikoPoa, Biolite and Ezy Stoves. The sale of the imported stoves which was initially concentrated in urban and peri-urban areas has currently spread to other parts of the country. According to UpEnergy, 500 stoves are currently sold per month across the country. Despite this, the ICS production and importation numbers are too low to cover the market in the country (SNV, 2014). Research by the World Bank's ACCES initiative and Dalberg Global Development Advisors (2015) found that tariffs and taxes on imported ICS together can account for up to nearly 50 percent of the cost of the stoves themselves and suggest lowering these to encourage foreign imports.

Consumer protection and quality assurance

One key challenge is the absence of relevant standards on cookstove performance in Uganda, thus no strong incentive for stove producers to improve on stove quality. There are also no labelling systems for ICS on the market. Hence it is difficult to identify the right quality of stove that uses less wood fuel, has low emission levels, is safe to handle and durable. Subsequently the benefits for promotion and use of ICS are undermined (UNACC, 2016). With no consistent testing protocol, results of quality often vary and are therefore inconclusive. Contributing to this is the fact that testing, for many, is prohibitively expensive. Some local testing centres charge up to USD1500 for a complete stove test (GVEP International, 2012a). There is urgent need to develop a national standard and labelling system for accelerating the adoption of ICS in the country (UNACC, 2016). Uganda has a biomass cookstove standard that came into force in 2007 but this only looks at efficiency. However, its revision is under way to include other testing parameters like emissions, durability and safety (SNV, 2014).

Efforts are currently underway to develop global standards on clean cooking through the ISO; however, this process will take quite some time. In the meantime, the standards and testing working committee for the Uganda National Alliance for Clean Cooking (UNACC), is working with the Uganda National Bureau of Standards (UNBS) towards defining some guidelines / benchmarks for cookstove performance and labelling. This will provide a base for improvement in the quality manufactured stoves and more user awareness (UNACC, 2016). Local manufacturers especially have need of these guidelines as a means to help them strive for better performance in regard to efficiency, emission reduction, fuel savings, and durability. With the influx of imported stoves, local producers need a nationally accepted stove performance baseline against which to measure their own stove performance (UNACC, 2016).

Design

Rehfuess et al (2014) found in their systematic review that many of the studies confirmed the fundamental requirement that ICS are designed to meet user needs in preparing local dishes with traditional cooking utensils and available fuels. Failure to effectively address these issues almost guarantees that the ICS will not be adopted and used long-term or that it will be used for some but not the majority of purposes. Household requirements are rarely met in a "one-size-fits-all" fashion, emphasising the importance of incorporating user requirements in research and development and of offering a choice of high-quality designs. Even if the stove is well-designed to meet local needs, its use will decline if durability is poor and chimneys (where used) break or become blocked quickly. Design and durability also affect the requirements for, and costs of, cleaning and maintenance, which can be a disincentive if high. SNV (2014) also emphasised the need for stove producers to consider users' needs when designing ICS in order to meet users' expectations and to sustain the ICS market.

Price and financing

Rehfuess et al (2014) highlight the cost of high quality ICS is an important barrier to adoption and/or repurchase, which may be overcome through government- or market-led economies of scale or stove subsidies. SNV (2014) highlighted that the traditional (and prevalent) 3-stone fire places and other unimproved wood stoves in Uganda were cost-free for households; on the other hand, the average cost of ICS was UGX 26,300. Charcoal stoves costs ranged from UGX 5,300 for unimproved charcoal stoves, UGX 14,000 for improved charcoal stoves (SNV, 2014). When potential ICS users were asked how much they would be willing to pay for ICS, they indicated an average of UGX 16,000 for an improved wood stove, and UGX 11,000 for an improved charcoal stove. The stove prices mentioned above, in particular for improved wood stoves, are much lower than the stove prices for most types of improved stoves on the market (SNV, 2014). The GACC (2017) study reviewed the price per household per year for the cooking fuels in Uganda for which cost data was available. They found that charcoal was the most expensive fuel, at USD475 per household per year; LPG was the second most expensive fuel with annual costs of USD338 per household. Purchased firewood and non-carbonised crop residue briquettes are similar in price, between USD260 and USD290 per household per year (GACC, 2016: p.A-241).

Access to consumer finance for ICS is still a major challenge in Uganda. Producers struggle with lack of access to enterprise financing to scale up their businesses. With an exception of those with access to carbon project funding, ICS producers have to mobilise funds internally. Given the high prices of raw materials, there is need to create financial linkages in order for the producers to scale-up their business as well as curb down the high stove prices benefiting from the economies of scale (SNV, 2014).

Women are far more likely to be exposed to IAP in their role as primary cook. Although women are involved in household purchasing decisions, men have more purchasing power and ability to pay upfront. In Uganda, 29 percent of households in rural areas are female headed, compared to 35 percent in urban areas. Women's involvement in micro enterprises and access to local networks has extended into the cookstove sector. Women are mainly involved in production and stove assembly. Women are integral to any consumer awareness and education campaign as the primary users of cookstoves. But, they often have less access to finance and own less collateral, hence finding it difficult to secure a loan for business expansion or purchase of ICS. By improving the ability of women to participate in the sector, cookstove programmes can take advantage of existing skills and networking capability (GVEP International, 2012b).

Lack of political support

Uganda's Renewable Energy Policy was adopted in 2007 whose targets were to increase the rate of adoption of efficient charcoal stoves from 20,000 in 2007, to 2,500,000 by 2017 in urban areas and efficient fuel wood stoves from 170,000 in 2007, to 500,000 by 2012 and 4,000,000 by 2017 (SNV, 2014). In addition, the policy was to offer training opportunities for artisans at the village level for the manufacture, installation and maintenance of efficient cooking stoves. However, the current status of how much has been achieved is unknown. The country has not had the financial and technical support, nor created the enabling conditions required to attract the level of private investment needed to create a thriving market for clean cookstoves and fuels. There is also weak collaboration between government and private sector in the drive to meet the policy targets (SNV, 2014). There are also number of NGOs, development partners and stakeholders working in the ICS sector.

Consumer awareness and understanding

Lack of consumer awareness is a key barrier to ICS and fuel adoption in Uganda. Mercy Corps conducted focus groups with women and surveyed them to understand the drivers behind cookstove and fuel purchases to determine the existence of a viable market for cookstoves in the East Acholi region of Uganda. Initially, the study focused on willingness to pay and cost barriers to cookstove adoption, but the quantitative surveys used to explore this question did not provide clear answers. Thus, the focus of the study shifted to collecting qualitative details behind purchasing decisions, which were capable of yielding deeper insight into what was driving stove acquisition. It turned out that cost was a barrier for only a small subset of consumers who tended to be more rural or dependent on a spouse for income. Mercy Corps identified the lack of consumer understanding around the benefits of using clean cookstoves as a primary barrier to purchase (GACC, n.d.). Findings from a SNV (2014) market intelligence study in Uganda indicate that awareness creation among last mile users is still lacking and that concerted effort needs to be taken to fill the knowledge gap that exists. The study also found that a sizeable portion of the potential users are not aware of existence of ICS and those that are aware have mostly learnt about it through neighbours. Without appropriate and adequate awareness creation, marketing, and outreach, last mile users remain unaware and or uncomfortable with ICS (SNV, 2014).

Cultural acceptability

Rehfuess et al (2014) highlight that a generic issue at the household level emerging from many countries and settings is the phenomenon of habitual “fuel/stove stacking.” This describes multiple fuel and stove use, which may include a variety of solid fuels, an improved stove used alongside a pre-existing (set of) traditional stove(s), or solid fuels used in combination with LPG or kerosene. In the 2016 review by Puzzolo et al they underline that while there was evidence that fuel/stove-stacking can potentially facilitate uptake of an additional clean cooking technology where it may represent a stage in the transition process, it is also, by definition, a barrier to exclusive use of a clean fuel where this is combined with solid fuel or kerosene. Stacking appears to be most relevant to rural households, due to the perception of lower fuel costs and availability of labour (mainly female) to collect biomass fuel associated with traditional practices. Diminishing or improper use of ICS may entail little to no benefits, or even exacerbate an already inferior environmental equilibrium. This is not an insignificant problem, research increasingly highlights that 'stacking' of polluting and improved technologies is nearly ubiquitous, and that this behaviour can compromise emissions reductions (Usmani et al, 2017).

5. Enablers to Market Acceleration

In a systematic review on available evidence of adoption and sustained use of clean fuels, Puzzolo et al (2016: p.231) found that “the evidence suggests that in practice the reported factors influencing uptake and use of clean fuels tend to operate on a spectrum: if factors are present or satisfactory they act as enablers; conversely, if absent or unsatisfactory, they act as barriers. For example, while adoption is facilitated by higher income, lower income is a barrier – although strategies for subsidy, credit and other financing can modify this relationship. They found that the available evidence suggests that whilst certain factors such as meeting cooking needs, higher income levels, fuel savings, fuel availability, appropriate financing and governmental support are critical for success, none are sufficient on their own to ensure adoption and sustained use. The findings also show that some of these factors relate to circumstances and perspectives in the household and local community, while others relate to wider programmatic and societal issues. Accordingly, all of these considerations require attention in the planning, implementation and evaluation of initiatives to introduce and scale-up clean fuels. The specific combination and relative importance of factors that determine the success of adoption and sustained use will, however, depend on the fuel type and associated technology, the setting (i.e. country, geography, urban/rural status, etc.) and the pre-existing conditions in terms of policy and governance”.

Market based approach to scaling

A market approach needs to be based on an understanding of the existing and potential customers for stoves (GVEP International, 2012b). GVEP International (2012b) carried out an analysis of the existing market in Uganda for ICS. This is fairly small scale with urban and peri-urban areas predominating, but could potentially be significantly larger. Even with subsidies, market based approaches will only reach certain segments of the population and more research is required to identify true market segments and potential for commercial development. The

Uganda cookstove sector has developed producers at scale that have demand for products and have utilised carbon finance, and there is potential for further scaling up of production of quality stoves to reach further markets. There are still some gaps in the market knowledge, particularly with regards to rural >USD3 segments, the north of the country, urban firewood users and the extent of improvement and use of the ICS in Ugandan households (GVEP International, 2012a).[3]

Enabling environment and government support

There is need for government to provide more financial resources to the ICS sector in Uganda for capacity development of ICS producers and awareness creation of ICSs country wide. It is important that testing and certification of ICS for quality be conducted and improved (SNV, 2014). To ensure a dynamic cookstove market, the enabling and regulatory environment must actively support innovation, enable scale-up, and facilitate competition. Standards are also important at the outset, to ensure that poor-quality products do not harm market development. Studies of the cookstove sector in India emphasise the importance of mechanisms that support technological experimentation to explore different technologies and business models; foster market linkages that facilitate increased technology diffusion; and set rules to establish a fair and competitive market that does not depend on subsidies (see Johnson et al, 2015 for references).

A comparison of SNV approaches in Cambodia, Kenya, Nepal and Rwanda highlights that there is growing awareness of the need to take a systems perspective to stimulate cookstove market transformation (Johnson et al, 2015). The case study analysis from this report finds that a holistic approach to cookstove market transformation, including capacity-building activities, is common to all the programmes examined. It finds flexibility in the exact mode of engagement and technological focus in each country, determined by local contextual factors. Drawing on the case studies, three key features are found to characterise SNV's cookstove programmes: emphasis on knowledge co-creation; commitment to trust-building; and freedom to adapt.

Rehfuess et al (2014: p.126) highlight that "most programmes will benefit from some degree of government support (i.e. program subsidies). Direct/indirect government financial support (e.g., grants, loans, tax incentives) toward improved stove programmes is a major enabler of uptake, especially in relation to adequate upfront entrepreneurial capital for stove business development. Financial incentives for stove construction and maintenance and support toward research and development and raising awareness are also important".

Value-chain strengthening

Both government-led and market-based programmatic approaches ultimately rely on functional, self-sustaining businesses to produce, disseminate, and maintain ICS in order to be successful (Rehfuess et al, 2014). The challenge to sustain income is an important issue for ICS businesses. An entrepreneurial mode and appropriate business skills emerge as keys to success and financial viability of markets; however, the lack of interest in providing after-sales services may be a barrier to sustained use of ICS (Rehfuess et al, 2014). For example, Rehfuess et al, (2014: p.126) report that despite the potentially large unmet demand, the experience of many Indian stove companies suggests that a relatively poor market segment and the seasonality of stove production result in modest returns. Approaches adopted to ensure sustained income among small- and larger-scale producers include: combining sales through a government

[3] See GVEP International, 2012b for more information on the Uganda Market in 2012

programme with sales on the open market; cross-subsidising sales to households through sales to institutional customers; specialising in the production of stove parts; pursuing indirect sales via outlets or direct sales via manufacturers; exploring opportunities for the joint sale of two or more products; or ensuring an independent second source of income.

For clean fuels, Puzzolo et al (2016:231) highlight that "to encourage adoption and sustained use, factors should be considered across the entire supply and demand chain, from production/importation (where applicable), to infrastructure, distribution networks and end-use by consumers. A system-wide perspective is particularly important for gaseous and liquid fuels, as their sustained use depends not only on initial stove acquisition and affordability for refills, but also on consistent and reliable fuel availability and accessibility. These considerations are particularly important in relation to equitable scaling-up of clean fuels. The evidence reviewed high-lights an urban-rural dichotomy in energy access for cooking and the fact that poorer households are often unable to transition to cleaner fuels and technologies without some form of financial support – although cost is by no means the only barrier".

Several value chain options exist for the dissemination of cookstoves in Uganda. Larger producers tend to make complete cookstoves and sit in a smaller value chain, whereas smaller producers may source components separately and do assembly. Interventions must consider ways to strengthen links in the value chain and create distribution channels to reach underserved markets (GVEP International, 2012b). ICS manufacturers also need technical training on stove design and stove quality assessment in order to scale-up production (SNV, 2014).

Financing and business model

Finding appropriate business models is vital to achieving a sustainable market where enterprises earn enough to keep going, users can afford the product, and financial backers get an adequate return on their investment (Johnson et al, 2015). Access for finance for ICS manufacturers is also needed to scale-up production of ICS in Uganda (SNV, 2014). This can potentially be in the form of loans from financial institutions (Micro Finance Support Centre, Post Bank, SACCOs among others) or local/international grants. However, many small producers struggle to access traditional sources of finance. Some institutes in Uganda such as Finca and Wekembe SACCO are starting to develop energy portfolios (GVEP International, 2012b). Carbon credits have also opened up new sources of revenue presenting a significant opportunity for local and foreign ICS manufacturers to attract financing to increase their production and distribution capacity to reach previously unreachable market segments (SNV, 2014).

On the demand side, the poorest households often have difficulty managing the upfront cost of an ICS. Innovative financing mechanisms, such as allowing households to pay in instalments, linking with village-level savings and loan schemes, and working with microfinance institutions to market and distribute stoves, can help overcome this barrier (Johnson et al, 2015), however their relevance and success can vary according to stove price and target population (Rehfuess et al, 2014). In the SNV study (2014: p.18) "when respondents were asked what alternative financing mechanisms they would consider if they didn't have upfront funds to purchase ICS, the majority (57 percent) indicated that they would prefer instalment payments or stove credit. Other households (24 percent) would prefer to take time and first collect/accumulate the required funds while only 14 percent would prefer to take a loan from an MFI or friend. Hence loans for ICS may not be the recommended option since only 14 percent were willing to take a loan to purchase ICS". Beltramo et al (2015) studied willingness to pay for fuel-efficient cookstoves in rural Uganda. They compared willingness to pay for two different contracts, one with payment due within a week and one with equal instalment payments over 4 weeks. Consistent with household financial constraints, time payments raised willingness to pay by 40 percent. A study by Levine et al (2016) found that a sales offer combining free trial, time payments, and the option of returning the product can overcome barriers such as liquidity constraints and poor information about benefits and usability of health-improving technologies. They tested this sales offer (and alternatives) in an experiment with a fuel-efficient charcoal stove in urban Uganda and a fuel-efficient wood stove in rural Uganda. This offer dramatically increased uptake – in urban Kampala, from 4 to 46 percent, and in rural Mbarara, from 5 to 57 percent. About a third of those who accepted a sales offer with time payments in the urban setting paid it off early and about a fifth paid off early in the rural setting. This result could suggest that once consumers had used the stoves and learned whether they fit their needs and how much fuel they saved, that financial constraints perhaps became less important. However, this behaviour is also consistent with qualitative evidence that suggests many Ugandans consider debt undesirable.

Subsidies toward a stove or its component parts enable initial adoption, with several studies emphasising that the poorest households would not have gained access to ICS without them (Rehfuess et al, 2014). However, findings from surveys show that large direct price subsidies of clean cookstoves may deter market development. Direct price subsidies may increase barriers for commercialisation as it reduces the intrinsic value of clean cookstoves, which lowers customers' willingness to pay. Also entry of carbon finance-subsidised stoves into the markets will make it harder for other ICS manufacturers to compete if they cannot access the funding (SNV, 2014).

Usmani et al (2017) augmented capital-cost subsidies that have been traditionally employed to enhance ICS adoption with rebates linked to stated and objectively measured use in order to investigate impacts on both initial and sustained adoption of ICS in rural Cambodia. Their results showed that households responded to these rebates by adopting the intervention ICS at significantly higher rates, and by using it more frequently and for longer periods. Consistent with these stove-use patterns, solid-fuel use and time spent collecting or preparing fuels also declined. However, this effect appeared to diminish over time. Thus, while economic inducements may significantly increase adoption and use of new environmental health technologies, corresponding reductions in environmental or livelihood burdens are not guaranteed. The success of incentive-based interventions depends on how they are designed, how incentives are delivered, and how they interact with personal or societal norms and motivations (Usmani et al, 2017).

Where all or most cooking fuel is purchased, which occurs mainly in urban and peri-urban settings, LPG has been shown to cost no more than kerosene, wood fuel, biomass pellets or charcoal (Bruce et al, 2017). Bruce et al (2017) identify a number of options that are available to address issues with LPG refill costs for low income families, including smaller cylinders which are well-established, along with newer initiatives involving pay-as-you-go LPG use and partial cylinder refills (although this last example has raised safety concerns). Some households may also need assistance with the initial acquisition of the stove, cylinder and associated equipment. For poorer and more rural populations currently gathering all or most of their fuel, initial and ongoing costs for LPG refills present significant barriers. This is why smart subsidies or other forms of financial support, which preferentially assist poorer households, have a role in facilitating acquisition and use of LPG outside urban centres. This type of targeted financial assistance is already a key component of policy on LPG access in several countries, including India, Brazil and Peru (Bruce et al, 2017).

Quality assurance

A natural challenge in a market with limited standards and high degrees of fragmentation is variable and unknown quality. Many stoves which have been tested have demonstrated little to no efficiency improvements over a traditional three stone fire in cases where the stoves were badly made. Rehfuess et al (2014) found that relatively few studies report on the role of this domain, but the clear message is that standards and their enforcement are critical for large-scale promotion of high quality ICS. By lowering test costs and simultaneously developing standards, there is opportunity to raise quality across the market (GVEP International, 2012a). Whilst regulating quality is an important step in the development of a commercial cookstove market, it’s also proposed that efforts are made to increase the sector’s appreciation for quality and improved fuels. This way, as product quality is driven up, producers have a potential market for their products (GVEP International, 2012a).

Design, availability and marketing

Understanding what users want and how to shift behaviour and mobilise demand is key to market development. The technical specifications of the stoves used in the intervention must actually meet the goals of improved efficiency and reduced emissions, but must also be desirable to the end user in terms of utility, cultural appropriateness, aesthetics, and perceived improvement over the old stove (Johnson et al, 2015). Marketing plays a powerful role in demand creation and in the accumulation of goods in almost every society (Shankar et al, 2014). In their review, Rehfuess et al (2014) found that modes of demand creation comprise general awareness raising activities about the benefits of ICS and personal contact through women’s organisations or company representatives. Product demonstrations and “word-of-mouth” advertising appear to be the most important general drivers of adoption. A demand-driven approach facilitates long-term adoption and use, whereas coercive approaches based on deliberate misinformation or false promises are likely to favour rejection of the technology despite initial uptake. Respondents in the SNV study (2014) indicated that in order to increase access to ICS in the communities, opening up retail outlets in both rural and urban communities as well as use of community based organisations or women/youth groups would be the best approaches to use. The other approaches recommended include door-to-door sales, use of mobile trucks, church gatherings, use of village meetings/gatherings as well as stove demonstrations on open market days.

There is substantial evidence that health related messaging, while important in increasing health knowledge, does not actually increase ICS sales and adoption. There is a critical need to understand underlying user preferences and hidden costs beyond health in the design and delivery of ICS, specifically, how external and intra-household relations shape decisions regarding energy and technology acquisition and use (Shankar et al, 2014). Beltramo et al (2015) studied willingness to pay for fuel-efficient cookstoves in rural Uganda, comparing the effect of informational marketing messages and time payments on willingness to pay. A randomised trial tested the following marketing messages: “This stove can improve health,” “This stove can save time and money,” and both messages combined. None of the messages consistently increased willingness to pay. For ICS to be adopted, retailers need to engage with users directly, but engagement should not stop at the point-of-sale. With any new technology, there is a user learning curve. In addition to training at the point-of-sale using formal and informal input, customers should receive regular follow-up visits until they have mastered the technology. These visits are critical to fostering correct and sustained use of the new stove (Shankar et al, 2014).

Equity and gender

Rehfuess et al (2014) found that equity is critical in scaling up ICS use. “Programmes with an explicit goal of reaching socioeconomically disadvantaged households or areas have achieved greater adoption through various mechanisms, including a) a tiered approach offering different stove models and prices for higher- versus lower-income households; b) subsidies; c) payments in instalments; and d) access to credit. However, exclusively market-based approaches fail to penetrate beyond a certain level of poverty because disadvantaged groups with limited education tend to perceive other household priorities as being more pressing and therefore tend to generate little or no demand for ICS” (Rehfuess et al, 2014: p.126).

Women’s decision-making power is often limited because men typically exercise greater budget control. There appear to be gender-specific preferences with respect to stove attributes, with women valuing health benefits and men favouring fuel efficiency and monetary savings. These should be taken into account in marketing campaigns, where men have been insufficiently targeted to date (Rehfuess et al, 2017). Growing evidence shows that uptake will be limited unless women gain more say in household purchases and access to credit. As we move toward expanding acquisition globally, it will be critical to recognise the challenges of gender-related dynamics and to find opportunities to engage women more effectively across the value chain (Shankar et al, 2014). Women are uniquely positioned to promote use of ICS. As the primary energy consumers and beneficiaries of ICS, women are well-versed in understanding the challenges of ICS adoption and continued use and are therefore integral to any consumer awareness and education campaign. Women can also play central roles in microenterprise and as extension workers supporting maintenance and as leaders, networkers, and promoters for ICS in their region. It will be key to effectively engage women in ways that accommodate or help overcome existing constraints while building intrinsic and extrinsic supports for their successful involvement (Shankar et al, 2014).

Sustained fuel-switching

Puzzolo et al (2016) carried out a systematic review on the evidence of adoption and sustained use of clean cooking fuels – LPG, biogas, and alcohol fuels. For the three fuels they summarised the factors affecting uptake as:

- *LPG*: “For many homes mainly using solid fuels or kerosene for cooking, LPG is considered an aspirational fuel, but start-up costs are a key barrier to adoption, particularly for poorer households. Refill costs vary, depending on whether LPG is sold at market price or at a subsidised price. In some countries, and in particular for urban areas, costs can compete with kerosene and solid fuels when these have to be purchased rather than freely gathered. Exclusive use of LPG for cooking appears restricted to higher-income and typically urban households. In rural areas, price and reliability of supply of LPG affect fuel choice. Among lower-income LPG consumers, some complementary use of traditional solid fuels is often reported (‘fuel stacking’). Adequate LPG supply and delivery infrastructure are important drivers of adoption in both urban and rural settings. Appropriate government policy, rigorous enforcement of safety-related rules and price stabilisation mechanisms to control price volatility and/or subsidies to consumers (particularly those for poorer households) are also critical determinants of LPG adoption and use, with potential for scale at a national level” (2016: p.225). Van Leeuwen et al (2017) highlight that the key barrier may be accessibility, with affordability only a secondary barrier that can be mitigated through cross-subsidisation.

- *Biogas*: "A set of necessary conditions is required for production and use of biogas. These include having adequate numbers of livestock (usually two large animals for small-sized plants) and sufficient land to build and labour to manage the digester. An adequate amount of water is needed to operate the biogas digester efficiently. Installation costs are high and vary depending on digester type (approximately US$ 200–500 in the reviewed studies). Provision of subsidies or other forms of financial support is the norm to support the plant installation. Biogas has been found to be well-liked by households as a fuel for everyday use, as long as the plant is working well and maintained. In addition to providing clean and convenient fuel, it saves time, effort and also the cost of collecting and/or buying solid fuels. It also produces fertiliser slurry and can be used for lighting if production is sufficient. Linking the digester to a latrine improves sanitation while also providing additional feed. Biogas plants do require ongoing attention and periodic repair, without which they will not continue to meet the needs of the households" (2016: p.227).
- *Ethanol*: "As a renewable, clean, safe and cost-competitive cooking fuel, ethanol appears to have considerable potential in some settings where local production or importation can be guaranteed. A wide variety of feedstock can be used to produce ethanol, but effective land management is required to ensure non-interference with food crops. Strong and consistent policy are also required to address transport and pricing issues that arise if there is not clear separation of fuel ethanol from that destined for use in alcoholic beverage markets – particularly those deemed illegal" (2016: p.229).

6. References

Beltramo, T., G. Blalock, D.I. Levine and A.M. Simons (2015) 'The effect of marketing messages and payment over time on willingness to pay for fuel-efficient cookstoves', *Journal of Economic Behavior & Organization*, 118, 333-345. http://dx.doi.org/10.1016/j.jebo.2015.04.025

Brooks, N., V. Bhojvaid, M.A. Jeuland, J.J. Lewis, O. Patange and S.K. Pattanayak (2016) 'How much do alternative cookstoves reduce biomass fuel use? Evidence from North India', *Resource and Energy Economics*, 43, 153-171. http://dx.doi.org/10.1016/j.reseneeco.2015.12.001

Bruce, N.G., K. Aunan and E.A. Rehfuess (2017) *Liquefied Petroleum Gas as a Clean Cooking Fuel for Developing Countries: Implications for Climate, Forests, and Affordability,* KfW Development Bank – Materials on Development Financing, No. 7. https://www.kfw-entwicklungsbank.de/PDF/Download-Center/Materialien/2017_Nr.7_CleanCooking_Lang.pdf

FRESH Air Uganda, Global Alliance for Clean Cookstoves, and UNACC (2015) *Clean Cooking and Public Health in Uganda*, Meeting Report, 20th August 2015: Kampala. https://cleancookstoves.org/binary-data/ATTACHMENT/file/000/000/267-1.pdf

GACC (2016) *Comparative Analysis of Fuels for Cooking: Life Cycle Environmental Impacts and Economic and Social Considerations: Appendix A: Detailed Environmental, Economic and Social Technical Analyses*, Global Alliance for Clean Cookstoves. http://cleancookstoves.org/assets-facit/Comparative-Analysis-for-Fuels-Appendix-A.pdf

GACC (2017) *Comparative Analysis of Fuels for Cooking: Life Cycle Environmental Impacts and Economic and Social Considerations*, Global Alliance for Clean Cookstoves. http://cleancookstoves.org/assets-facit/Comparative-Analysis-for-Fuels-FullReport.pdf

GACC (n.d.) *Market Research in the Clean Cooking Sector: Tools and Tips*, Global Alliance for Clean Cookstoves. https://cleancookstoves.org/binary-data/RESOURCE/file/000/000/411-1.pdf

Garland, C., K. Jagoe, E. Wasirwa, R. Nguyen, C. Roth, A. Patel, N. Shah, E. Derby, J. Mitchell, D. Pennise, and M.A. Johnson (2015) 'Impacts of household energy programs on fuel consumption in Benin, Uganda, and India', *Energy for Sustainable Development*, 27, 168-173. http://dx.doi.org/10.1016/j.esd.2014.05.005

GVEP International (2012a) *Uganda Market Assessment: Intervention Options*, Global Alliance for Clean Cookstoves. http://cleancookstoves.org/resources/177.html

GVEP International (2012b) *Uganda Market Assessment: Sector Mapping*, Global Alliance for Clean Cookstoves. http://cleancookstoves.org/resources/178.html

Johnson, O., H. Wanjiru, C. Muhoza, F. Lambe, M. Jürisoo, W. Amatayakul and A. Chenevoy (2015) 'From Theory to Practice of Change: Lessons from SNV's Improved Cookstoves and Fuel Projects in Cambodia, Kenya, Nepal and Rwanda', Stockholm Environment Institute Working Paper No. 2015-09. https://www.sei-international.org/publications?pid=2787

Levine, D.I., T. Beltramo, G. Blalock, C. Cotterman, and A.M. Simons (2012) 'What Impedes Efficient Adoption of Products? Evidence from Randomized Sales Offers for Fuel-Efficient Cookstoves in Uganda', *CEGA Working Paper Series No. WPS-059*, Centre for Effective Global Action, University of California, Berkley. http://www.tractionproject.org/sites/default/files/Levine percent20Efficient percent20adoption.pdf

Lwiza, F., J. Mugisha, P.N. Walekhwa, J. Smith and B. Balana (2017) 'Dis-adoption of Household Biogas technologies in Central Uganda', *Energy for Sustainable Development,* 37, 124-132. http://www.sciencedirect.com/science/article/pii/S0973082617300145

Mortimer, K., C.B. Ndamala, A.W. Naunje, J. Malava, C. Katundu, W. Weston, D. Havens, D. Pope, N.G. Bruce, M. Nyirenda, D. Wang, A. Crampin, J. Grigg, J. Balmes, and S.B. Gordon (2016) 'A cleaner burning biomass-fuelled cookstove intervention to prevent pneumonia in children under 5 years old in rural Malawi (the Cooking and Pneumonia Study): a cluster randomised controlled trial', *the Lancet*, Published online December 6, 2016. http://dx.doi.org/10.1016/S0140-6736(16)32507-7

Puzzolo E, N. Bruce and D. Stanistreet (2015) *Creating markets for equitable access to clean cooking: How should we address the problem*? University of Liverpool, Unilever. http://www.tractionproject.org/sites/default/files/Unilever percent20cook percent20stoves percent20report_0.pdf

Puzzolo, E., D. Pope, D. Stanistreet, E.A. Rehfuess and N.G. Bruce (2016) 'Clean fuels for resource-poor settings: A systematic review of barriers and enablers to adoption and sustained use', *Environmental Research*, 146: 218-234. http://www.sciencedirect.com/science/article/pii/S0013935116300020

Rehfuess, E.A., E. Puzzolo, D. Stanistreet, D. Pope, and N.G. Bruce (2014) 'Enablers and barriers to large-scale uptake of improved solid fuel stoves: a systematic review', *Environmental Health Perspectives*, 122:120–130. http://dx.doi.org/10.1289/ehp.1306639

Shankar A, M. Johnson, E. Kay, R. Pannu, T. Beltramo, E. Derby, S. Harrell, C. Davis and H. Petach (2014) 'Maximizing the benefits of improved cookstoves: moving from acquisition to correct and consistent use', *Global Health: Science and Practice*, 2(3):268-274. http://dx.doi.org/10.9745/GHSP-D-14-00060.

SNV (2014) *Grassroots solutions for scaling up improved cookstove access in Uganda: A Last-Mile Community Market Intelligence Report*, SNV Uganda. https://stoves.bioenergylists.org/files/snv_market_intelligence_study_report_for_mail.pdf

UNACC (2016) *Development of National Standards and Labeling System for Improved Cookstoves Development*, Uganda National Alliance on Clean Cooking, Policy Brief No. 3. http://unacc.ug/wp-content/uploads/2016/04/3_Policy_recommendation_paper_3-_Standards.pdf

Usmani, F., J. Steele and M. Jeuland (2017) 'Can economic incentives enhance adoption and use of a household energy technology? Evidence from a pilot study in Cambodia', *Environmental Research Letters*, 12(3): 1-12. http://iopscience.iop.org/article/10.1088/1748-9326/aa6008/meta;jsessionid=9E5F43DAA54FD0D6571C4931D6F949BD.c2.iopscience.cld.iop.org

Van Leeuwen, R., A. Evans and B. Hyseni (2017) Increasing the Use of liquefied Petroleum Gas in Cooking in Developing Countries, Live Wire: 2017/74. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/26569

The World Bank's ACCES initiative and Dalberg Global Development Advisors (2015) *Health, wealth, and growth: why lowering cookstove trade barriers makes sense*. http://www.cleancooking2015.org/wp-content/uploads/2015/05/150911-Cookstove-Trade-Barriers_Clean-Cooking-Forum-Presentation-vFinal.pdf

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