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Household Energy for Cooking
Project Design Principles

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ACRONYMS AND ABBREVIATIONS

ACR	American Carbon Registry
CAR	Climate Action Reserve
CBFM	Community-based forest management
CCT	Controlled cooking test
CDM	Clean Development Mechanism
CER	Certified emission reduction
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2eq	CO_2 equivalent
DNA	Designated national authority
EU	European Union
EUEI	EU Energy Initiative
GACC	Global Alliance for Clean Cookstoves
GEF	Global Environment Facility
GHG	Greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GPOBA	Global Partnership on Output-Based Aid
GPS	Global positioning system
GS	Gold Standard
GTF	Global Tracking Framework, Sustainable Energy for All
HH	Household
IAP	Indoor air pollution
IBRD	International Bank for Reconstruction and Development
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
KPT	Kitchen performance test
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
MDG	Millennium Development Goal
NCV	Net calorific value
NGO	Nongovernmental organization
NRB	Nonrenewable biomass
ODA	Overseas development aid
PDD	Project Design Documentation
PFM	Participatory forest management
PIN	Project Idea Note
PM	Particulate matter
U.N.	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
VCS	Verified Carbon Standard
VER	Verified emission reduction
WBT	Water-boiling test
WHO	World Health Organization

FOREWORD

Energy for cooking is a critical dimension of the energy access agenda that has too often been overlooked by policy-makers and financiers alike. There are signs that this is beginning to change. The Sustainable Energy for All (SE4ALL) initiative has placed universal access to modern cooking solutions as a global objective for the year 2030 on an equal footing with the universal electrification goal for that same year. Efforts under the SE4ALL will be able to build upon a worldwide coalition already forged around this agenda by the Global Alliance for Clean Cookstoves. The World Bank and other international organizations are bringing out a growing number of publications and initiatives focused on energy for cooking. All this is good news, given the wide range of benefits that modern cooking solutions can bring encompassing improved health, better living and working conditions for women, poverty reduction, environmental protection and climate change mitigation.

This report on Household Energy for Cooking: Project Design Principles is timely as it provides a digest of some of the key operational design challenges that will aid operational teams in thinking through the issues and finding solutions that are appropriately tailored to local realities and constraints. We hope that these insights will help to translate the growing political momentum behind this important—and too often overlooked—aspect of energy access into operational interventions on the ground to the benefit of households in developing countries.

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EXECUTIVE SUMMARY

Interventions to improve energy access for the poor have focused mainly on electricity access and have often neglected nonelectricity household energy access. While 1.2 billion people lack access to electricity, more than double that number—about 2.8 billion people, mainly in Asia and Sub-Saharan Africa—still rely on solid fuels for cooking and heating (World Bank and IEA 2013). Projections indicate that the developing countries in Asia will make progress in providing clean cooking solutions to people, but the situation will worsen in Sub-Saharan Africa where the number of people without clean cooking facilities will increase.

It is well documented that exposure to indoor air pollution (IAP) from the inefficient combustion of solid fuels in low-quality stoves is a significant public health hazard. Burning solid fuels in traditional stoves emits smoke composed of a mixture of particulate matter (PM), carbon monoxide (CO), hydrocarbons, formaldehyde, and benzene, which have been shown to significantly exceed safe levels (Smith and others 2000; Smith and others 2009; Venkataraman and others 2010). Recent data indicate that about 4 million people die prematurely every year from illness attributable to household air pollution from household solid fuel use (Lim and others 2012).

The reliance on fuelwood for cooking and heating is increasingly drawing attention to the role in global warming of black carbon originating from incomplete combustion of fossil fuels, particularly diesel, and other sources including biomass. There is a growing body evidence that black carbon *acting alone* might be the second most important factor affecting the rise in global temperatures after carbon dioxide (CO_2) (Ramanathan and Carmichael 2008; Gustafsson 2009; Bond and others 2013). However, the impact of co-emitted species (such as organic matter and sulfate aerosol precursors) in the combustion of biomass offsets the global warming impact of black carbon emissions, introducing large uncertainties in the net impact (Bond and others 2013).

Recently, the realization that potential co-benefits in the areas of health, gender, environmental protection, poverty reduction, and climate change can be gained from household energy interventions has created a new momentum for action. This is driven by the realization that considerable health benefits in line with the Millennium Development Goals can be gained by improving IAP with the use of clean cookstoves and fuels. An important milestone of this mobilization is the launch of a public-private initiative, the Global Alliance on Clean Cookstoves (GACC) led by the United Nations Foundation to help 100 million households adopt clean and efficient stoves and fuels by 2020 (United Nations Foundation 2010). The GACC conducted consultations with more than 350 global cookstove experts and concluded that the creation of a thriving global market for clean cookstoves and fuels is the most viable way to achieve universal adoption (GACC 2011a).

Another important milestone is the recognition by the U.N. Sustainable Energy for All Initiative that providing efficient cook stoves and clean fuels to poor households should be part of the broader objective of energy access for all by 2030 (United Nations 2012). The Global Energy Assessment has identified the diffusion of clean and efficient cooking appliances as one of the main pathways to improve energy access in developing countries. It is estimated that, to provide clean cooking solutions, about $17–22 billion per year would be needed by Sub-Saharan Africa, South Asia, and Pacific Asia. These estimates include grants and microlending to help address affordability issues at the level of households (GEA 2012).

This note builds on five main reports produced by the World Bank Group on clean cooking solutions over the last three years:

- "Household Cookstoves, Environment, Health, and Climate Change: A New Look at an Old Problem."
- "Household Energy Access for Cooking and Heating: Lessons Learned and the Way Forward."
- "One Goal, Two Paths Achieving Universal Access to Modern Energy in East Asia and Pacific."
- "Wood-Based Biomass Energy Development for Sub-Saharan Africa."
- "What Have We Learned about Household Biomass Cooking in Central America?"

It provides broad project design principles related to household energy for cooking with the understanding that context-specific considerations should play an important role in project design decisions. The overwhelming role of local institutions to undertake project design and implementation is recognized.

The following broad principles are discussed:

- Interventions should be developed within strategic frameworks owned by the government in consultation with local communities, including men and women.
- Interventions should be designed and differentiated to target different market segments.
- Designs should be sensitive to consumer preferences and behavior.
- Clean cooking technology choices should be made to ensure that expected co-benefits are effectively gained with sustained use.
- Testing, standard setting, and certification should be an integral part of interventions.
- Business models should be context-specific and fully integrate producer, distributor, and user-financing issues.
- Consumer fuel subsidies and direct subsidies to the acquisition to cookstoves should be avoided, and indirect subsidies to support the scaling up of clean cooking solutions should be carefully designed.
- Monitoring, evaluation, and impact assessment frameworks should be developed, starting with the initial stages of project design and adapted as needed.

1. INTRODUCTION

The objective of this note is to assist task teams with broad project design principles related to household energy for cooking. It follows five main reports produced by the World Bank Group over the last three years:

1. "Household Cookstoves, Environment, Health, and Climate Change: A New Look at an Old Problem"
2. "Household Energy Access for Cooking and Heating: Lessons Learned and the Way Forward"
3. "One Goal, Two Paths Achieving Universal Access to Modern Energy in East Asia and Pacific"
4. "Wood-Based Biomass Energy Development for Sub-Saharan Africa"
5. "What Have We Learned about Household Biomass Cooking in Central America?"

These reports make the case for a re-engagement of the World Bank Group in the household energy access sector. This call is resonating well with operational units within the energy practice through the launching of regional initiatives, such as the Africa Clean Cooking Energy Solutions and the East Asia Clean Stove Initiative, and a growing interest on the part of task teams from South Asia and the Latin America and the Caribbean regions to include household energy access components in operations.

This note is organized into two sections: (a) context and background, and (b) project design principles. A set of appendixes is attached to the note with specific information. In particular, Appendix 1 provides a list of World Bank–funded projects with fuelwood and stove components. Appendix 2 is devoted to the sustainable supply of wood-based biomass energy. Appendix 3 presents stove performance monitoring methodology. Appendix 4 provides a brief guide on how household energy projects can be supported with carbon finance. Appendix 5 provides examples of options for facilitating household use of LPG, and Appendix 6 presents an example of typology of the cost and benefit analysis of cookstove interventions.

Context and Background

Reliance on solid fuels for cooking is an indicator of energy poverty. It is recognized that access to modern energy services—including electricity and clean fuels—is important for achieving the Millennium Development Goals (MDGs) (UNDP 2005). For example, access to modern energy services is essential for increasing productivity in agriculture and for increasing the potential of micro-enterprises to generate employment opportunities that are likely to help eradicate extreme poverty and hunger (MDG1). Access to modern energy services can reduce women's domestic burden of collecting fuelwood and allow them to pursue educational, economic, and other employment opportunities that can empower them and promote gender equality (MDG3). Similarly, the use of clean cooking and heating fuels in efficient appliances can contribute to reducing child mortality (MDG4). Without access to modern energy services, the likelihood of escaping poverty is very low.

In most societies where solid fuels, and particularly fuelwood, are used for cooking and heating, women are generally the ones who devote most of their time to collection and transport. In times of fuelwood scarcity, the distance they have to go to find wood increases and requires more time. The literature has described how fuelwood collection deprives women and girls of the opportunity for education, for engaging in income-generating activities, and for having leisure time (Clancy, Skutch, and Batchelor 2004; Blackden and Wodon 2006). Köhlin and others (2011) suggested that energy interventions can have significant gender benefits if they are carefully designed and targeted based on context-specific understanding of energy scarcity and household decision-making dynamics.

Interventions to improve energy access to the poor have focused mainly on electricity access and have often neglected nonelectricity household energy access. While 1.2 billion people lack access to electricity, more than double that number—about 2.8 billion people, mainly in South Asia and Sub-Saharan Africa—are still relying on solid fuels for cooking and heating (GTF 2013). Projections indicate that the developing countries in Asia will make progress in providing clean cooking solutions to people, but the situation will worsen in Sub-Saharan Africa where the number of people without clean cooking facilities will increase.

Household energy for cooking in particular has received little policy attention in the overall energy sector dialogue, and consequently its lending volume remains low in spite of the magnitude of the development challenge its represents. For example, a review of World Bank–financed energy projects between fiscal 2000 and fiscal 2008 revealed that only 4 percent of energy access lending—less than 1 percent of World Bank's total energy lending—was dedicated to increasing sustainable access to cleaner cooking fuels and more energy-efficient cookstoves (Barnes, Singh, and Shi 2010). According to International Energy Agency (IEA) estimates, only about US$3.8 billion per year is needed to achieve universal access to clean cooking facilities between 2011 and 2030 (IEA 2012). Facilitating the access to clean cooking solutions to households in developing countries seems to be within the reach of governments and development agencies tackling the eradication of poverty.

Recently, there is a new and growing global mobilization about household energy access issues. This is driven by the realization that considerable health benefits in line with the Millennium Development Goals can be gained by improving IAP with the use of clean cookstoves and fuels. A important milestone of this mobilization is the launch of a public-private initiative, the Global Alliance on Clean Cookstoves (GACC) led by the United Nations Foundation to help 100 million households adopt clean and efficient stoves and fuels by 2020 (United Nations Foundation 2010). The GACC conducted consultations with more than 350 global cookstove experts and concluded that the creation of a thriving global market for clean cookstoves and fuels is the most viable way of achieving universal adoption (GACC 2011a).

Another important milestone is the recognition by the U.N. Sustainable Energy for All Initiative that providing efficient cook stoves and clean fuels to poor households should be part of the broader objective of energy access for all by 2030 (United Nations 2012). Discussions in the climate change community on black carbon have also drawn significant attention to the issues of clean cooking and cookstoves, although the net impact on global warming in the case of biomass combustion has large uncertainties (Bond and others 2013). These recent developments have reinforced the recognition that household energy access interventions have potentials to provide benefits in the areas of health, gender, environmental protection, and climate change. At the same time, there is also evidence indicating that households in developing countries are following complex energy transition pathways in a constantly changing context of markets, a situation that dictates a realistic and context-specific approach to clean cooking solutions.

Benefits for Health

It is well documented that exposure to IAP from the inefficient combustion of solid fuels in low-quality stoves is a significant public health hazard. Burning solid fuels in traditional stoves emits smoke composed of a mixture of particulate matter (PM), carbon monoxide (CO), hydrocarbons, formaldehyde, and benzene, which have been shown to significantly exceed safe levels (Smith and others 2000; Smith and others 2009; Venkataraman and others 2010). Recent data indicate that about 4 million people die prematurely every year from illness attributable to household air pollution from household solid fuel use (Lim and others 2012). This is double the number previously recorded by the World Health Organization (WHO 2006). Growing evidence suggests that exposure to IAP is also associated with heart disease, stroke, and cataracts. There is evidence of lung cancer in women cooking with open coal stoves in China (Smith 2002). Women and children in developing countries are particularly affected by these negative health outcomes of IAP from the use of solid fuels (von Schirnding and others 2002; WHO 2006). Switching to modern fuels, such as liquefied petroleum gas (LPG), is identified as the most effective way of reducing IAP, while having a fuel-efficient stove and improving ventilation conditions can reduce IAP considerably as well (Ezzati and Kammen 2002; Díaz and others 2008). Health-damaging IAP exposures can be reduced by more than 90 percent in comparison to solid fuels (Smith, Rogers, and Cowlin 2005; MacCarty and others 2010).

Although there are many studies on solid fuels, IAP, and their health outcomes, research gaps remain that need to be filled to inform the design and monitoring of interventions better. At the same time that strong evidence exists that links IAP to childhood pneumonia, chronic obstructive pulmonary disease, and lung cancer (from coal) in adults, the evidence is weak on how inhaling wood smoke is associated with tuberculosis, low birth weight, and cataracts. What we do not know is the exposure-response relationship between IAP and different negative health outcomes. In other words, we do not know what different dose levels of IAP cause different negative health outcomes. Evidence on the exposure-response relationship is important in order to ensure to what level exposure should be reduced to start gaining positive health outcomes. Three main areas of further research are generally acknowledged: (a) the need for better exposure assessment to make more direct measurement of exposure-response relationships;

(b) the need to handle confounding better by using more adequate statistical methodology to control the effects of confounders, such as poverty, malnutrition, and the housing environment; and (c) the importance of intervention studies to complete findings of observational studies (von Schirnding and others 2002; Ezzati and Kammen 2002; and Jaakkola and Jaakkola 2006).

Benefits for the Protection of Forest Resources

It is now widely accepted that the clearing of land for arable and pastoral agriculture is the main cause of deforestation rather than the use of wood for energy, as was believed in the past. With the rapid urbanization in many countries in Sub-Saharan Africa and South Asia, inefficient production of charcoal for growing urban populations might be threatening forest cover in the neighboring catchment areas (Arnold and others 2003). In these countries, in addition to households, small and medium-sized enterprises, such as bakeries, laundries, and restaurants, rely heavily on charcoal. The energy efficiency of charcoal production ranges from 25 percent in Africa, which uses mainly artisanal methods, to 48 percent in Brazil, which uses industrial kilns with extensive energy and material recovery. A recent study conducted in Tanzania by the World Bank (2009) reveals that between 2001 and 2007, the proportion of households in Dar es Salaam using charcoal climbed from 47 percent to 71 percent, and about half of Tanzania's annual consumption of charcoal takes place in Dar es Salaam, amounting to approximately 500,000 tons per year. Unsustainable production and use of forest resources affect wildlife habitat and watershed functions (Geist and Lambin 2001). Sustainable production and supply of fuelwood through community forest management and a modernization of the charcoal supply chains to urban areas are likely to reduce the pressure on forest resources for wood energy and generate revenues for households usually bypassed by an illegal trading of fuelwood.

Benefits for Climate Change

The reliance on fuelwood for cooking and heating is increasingly drawing attention to the role in global warming of black carbon originating from incomplete combustion of fossil fuels, particularly diesel, and other sources including biomass. There is a growing body evidence that black carbon *acting alone* might be the second most important factor affecting the rise in global temperatures after carbon dioxide (CO_2) (Ramanathan and Carmichael 2008; Gustafsson 2009; Bond and others 2013). Black carbon is formed from the incomplete combustion of fossil fuels, biomass fuels, and biomass burning. Black carbon warms the planet by absorbing heat from the atmosphere and by reducing albedo, the ability to reflect sunlight, when deposited on snow and ice. Black carbon stays in the atmosphere for only several days to weeks, whereas CO_2 has an atmospheric lifetime of more than 100 years. Because black carbon remains in the atmosphere only for a few weeks, reducing black carbon emissions may be the fastest means of slowing climate change in the near term. It is estimated that approximately 40 percent of black carbon comes from fossil fuels, 40 percent from open biomass burning (such as natural fires and slash and burn), and 20 percent from burning biomass in stoves in the household and service sectors and from burning it in industrial processes, such as crop drying, food manufacture, and brick and tile production. However, the impact co-emitted species (such as organic matter and aerosol precursors) in the combustion of biomass offsets the global warming impact of black carbon emissions, introducing large uncertainties in the net impact (Bond and others 2013). Open burning of biomass may have a net cooling effect in many instances; closed combustion of biomass for cooking and heating may have a net warming or cooling effect, depending on the specific local circumstances.

2. PROJECT DESIGN PRINCIPLES

World Bank projects have generally approached household energy for cooking projects from three main dimensions: (a) institutional strengthening; (b) supply-side interventions; and (c) demand-side interventions.

The first dimension is about designing or strengthening institutions entrusted with missions that generally include the following: (a) formulation of policies and strategies accounting for the multidimensional nature of household energy issues; (b) design and implementation of massive awareness-raising campaigns on clean cooking solutions; (c) design and improvement of legal and regulatory mechanisms to support interventions; and (d) creation of an enabling environment for capacity reinforcement of private sector operators, research institutions, nongovernmental organizations (NGOs), village associations, women's groups, and consumers involved in the sector.

The second dimension is supply-side interventions. In general, interventions include (a) participative community forest management activities; (b) development and institutionalization of forestry-based geographical information systems; (c) promotion of eco-friendly agro-forestry income-generation activities; and (d) reforms to improve the charcoal value chains to increase the sustainability of fuelwood production and supply. The third dimension is demand-side interventions. It includes production and dissemination of cookstoves, interfuel substitution activities, such as the promotion of modern fuels (LPG, liquefied natural gas (LNG), biogas, and liquid fuels, such as ethanol and kerosene) with their appropriate stoves. Ekouevi and Tuntivate (2012) provide a detailed account of these dimensions with a review of the performance of projects that have included them. In Appendix 1, a list of the projects reviewed that have more or less included these dimensions is presented.

Any of these dimensions can be adopted by a project team depending on the specific circumstances faced on the ground. The sector dialogue should, however, acknowledge the importance of all three dimensions and encourage government to eventually address them. This section mainly focuses on aspects of the first dimension and of the third dimension mainly the production and dissemination of cookstoves. The second dimension is not covered, since it is in the domain of forestry, natural resource management, and the environment sectors. Task teams in the energy sector rely on specialists from these sectors to design and supervise these interventions. Appendix 2 provides insights on challenges and barriers in developing supply-side interventions and basic principles to modernize the fuelwood production and the fuelwood supply chains.

The project design principles builds on lessons learned described by the "Household Energy Access for Cooking and Heating: Lessons Learned and the Way Forward" paper (Ekouevi and Tuntivate 2012). This paper outlined the following lessons: (a) a holistic approach to household energy issues is necessary; (b) public awareness campaigns are prerequisites for successful interventions; (c) local participation is fundamental; (d) consumer fuel subsidies are not a good way of helping the poor; (e) both market-based and public support are relevant in the commercialization of improved stoves; (f) the needs and preferences of stoves users should be given priority; (g) durability of improved stoves is important for their successful dissemination; and (h) with microfinance the poor can gradually afford an improved stove.

Figure 1 shows the main areas from which project design principles are drawn.

Figure 1: Main Areas of Project Design Principles

Interventions should be developed within strategic frameworks owned by the government in consultation with local communities including men and women.

Local ownership of interventions at the village, district, or province level is important from the early stages of project design to the implementation and impact assessment stages. A stocktaking and mapping exercise is needed to identify key stakeholders involved in the sector and to apprehend their roles and responsibilities. The Bangladesh rural and renewable energy project is an example. The renewable energy strategy included a rationale for household energy interventions, and consultations with different stakeholders were held to define the interventions.

Household energy access issues go beyond the energy sector. They cut across many sectors, such as health, the environment, climate change, gender, and forestry. Recently, household energy stocktaking and mapping exercises were conducted as part of the GACC market assessment studies in Bangladesh, Brazil, Colombia, East Timor, Ethiopia, Ghana, Indonesia, Kenya, Mexico, Nigeria, Peru, Rwanda, South Africa, Tanzania, Uganda, and Vietnam. Results of this work include, for each country, information on the overall macro-environment sustaining the sector, IAP, cookstove consumer profiles, status of the cookstove industry, and the existence or not of carbon finance initiatives in the sector.

Ad hoc interventions without local grounding tend to be sporadic experiences with little chance of sustainability. The challenge of providing clean cooking solutions to households requires an intensive awareness-raising on the health hazards associated with IAP from the use of solid fuels in inefficient cookstoves. These awareness campaigns should capitalize as much as possible on existing social networks that have proven track records for inducing change in social behavior in the targeted communities. Projects that have assumed that households would adopt spontaneously alternative fuels and cookstoves have failed. Households need to perceive and to be convinced about the direct and indirect benefits associated with interventions aimed at helping them gradually adopt clean cooking solutions.

Many household energy interventions failed because they were top-down and donor-driven with little local ownership. Project designers should ensure, through extensive consultations with government institutions, civil society organizations, local communities, and consumer groups, that the rationale of the interventions is broadly shared locally and adapted to local circumstances and conditions. Usually, stakeholder consultations are conducted at the initial stages of project design, as well as during project preparation and implementation, to ensure that local parameters are being sufficiently integrated. In some cases, these consultations lead to the design of national household energy or biomass energy strategy documents with formal validation and approval. The existence of a national strategy can provide a framework to shape stakeholder interventions and help avoid fragmented approaches to the sector.

A household energy program with a strong institutional structure is the Chinese National Improved Stoves Program initiated in the early 1980s is a widely cited program that has demonstrated features of local ownership in the implementation of cookstove interventions. Local artisans and entrepreneurs were very involved in the program. The European Union Partnership Dialogue Facility and the Deutsche Gesellschaft für Internationale Zusammenarbeit's (GIZ's) Poverty-Oriented Basic Energy Services Programme have elaborated a detailed step-by-step Biomass Energy Strategy Guide for Policy-Makers and Energy Planners (EUEI and GIZ 2011). This guide provides guidelines on how to conduct stakeholder analysis, baseline sector analysis, and the development of scenarios, development of strategy, action planning, and adoption and implementation. This approach was used to develop biomass energy strategies for Botswana, Lesotho, Malawi, and Rwanda.

Interventions should be designed and differentiated to target different market segments.

Market segments must be targeted for specific menus of clean cooking solutions. Households, depending on their residence—whether rural, peri-urban, or urban—have access to different energy carriers and energy services. Project design should integrate the availability of household energy fuels in targeted locations and structure interventions accordingly. In addition to availability issues, the affordability of modern fuels and cooking devices is an important issue to deal with. Products and services aimed at market segments at the bottom of the pyramid, where affordability is an issue, may be different from those aimed at upper-income market segments. Similarly, while LPG promotion might make sense in an urban middle- to upper-class market segment, it has lower chances of success in a poor rural setting where affordability issues are more prominent; consumer profiles are often different in rural, urban, or peri-urban areas. Characteristics of market segments play an important role in technology choices and in the design of business and financing models. Products and services for households may be different from those directed to be used by institutions and commercial users. It is also important to factor in that adoption of new cooking technology may be different for female-headed households vs. male-headed households in some settings (Köhlin and others 2011). Figure 2 shows the results of a market segmentation of the cookstove market in Nigeria. In addition, households and institutions, such as boarding schools, universities, and commercial users, were identified.

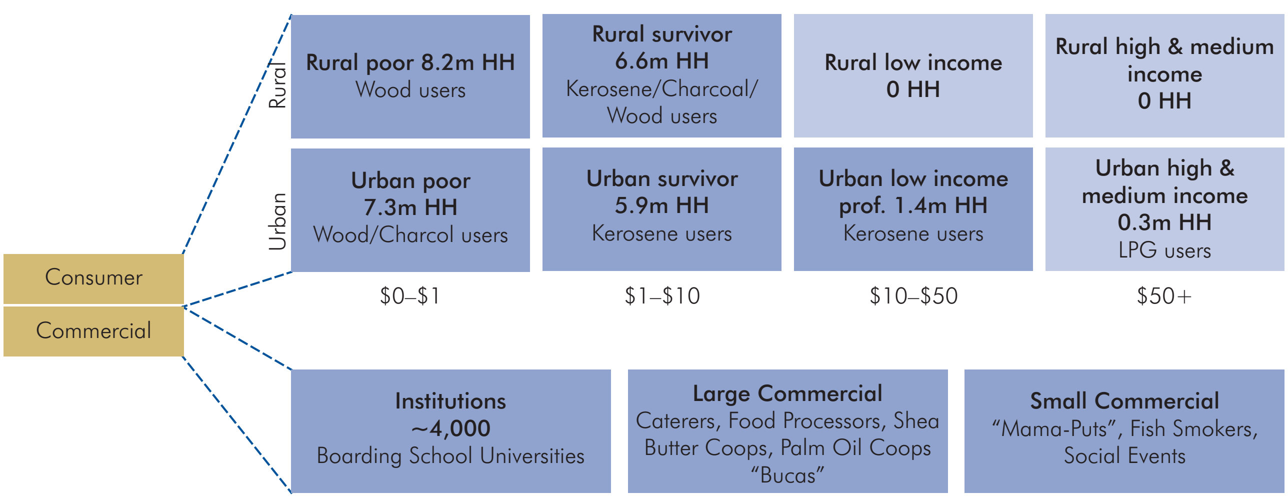
The market segmentation exercise paid attention to consumers based on their area of residence and income levels. It also differentiated the needs of institutions, such as schools, small commercial, and large commercial users. The approach used is well described in the GACC market segmentation report on Nigeria (GACC 2011b).

Designs should be sensitive to consumer preferences and behavior.

The technical performance of fuels and cookstoves in fuel efficiency and emissions efficiency are usually not the primary factors of adoption and use. Preferences, tastes, habits, culture, and other nontechnical factors play an important role in the decision-making process of households in fuel switching and in the acquisition and sustained use of a new cookstove. Working with households—and particularly women—to determine energy for cooking solutions that responds to their specific needs and preferences is critical. The fact that women are the main users of cookstoves in many settings dictates a dedicated effort to specifically reach out to them, bearing in mind the complexities of household decision making across cultures and the particularly disadvantaged situation experienced by female-headed households.

A promising approach to help account for consumer preferences and behavior is the use of human-centered design (HCD), which was pioneered by the commercial sector but recently applied in developing countries to achieve positive outcomes such as improved sanitation coverage. HCD is an iterative design process that uncovers habits, preferences, aspirations and motivations and builds on these insights to inform product design and the communications and business models that could support them. IDEO, a global leader in HCD and GACC recently teamed up to understand the cookstove users and sellers in rural Tanzania (GACC and IDEO, 2012). Key research insights and recommendations include the following:

Figure 2: Results of Market Segmentation of the Cookstove Sector in Nigeria



Source: GACC 2011a.

1. *From Acquisition to Use:* People are purchasing cookstoves, but not always using them. We need to shift the focus from the point of purchase to a focus on frequency of use by enabling people to use the best technology available to them more often;
2. *From Stove to Fuel:* Fuel drives the decision making process. In order to release people from the burden of fuel expenses, we need to shift the focus from a single stove to an integrated solution that includes the stove and the fuel;
3. *From Status to Utility:* Embrace the low margin, high volume nature of low-cost cookstoves and create innovative business models to increase innovation. Alternatively, to support more advanced cookstoves, redefine the product category and value proposition by radically shifting the functionality and performance of the cookstove;
4. *From Saving Fuel to Cooking with Ease:* Ensure that, at a minimum, fuel efficiency and emissions don't undermine the ease of use of a cookstove. Furthermore, we need to increase the functionality of improved cookstoves to make them a convenient choice when compared to less efficient—but easier to use—technologies; and
5. *From Health to Comfort:* Because people care more about personal comfort and are focused on near term realities, reframe the messaging around clean cookstoves in terms of immediate comfort rather than long-term health.

Clean cooking technology choices should be made to ensure that expected benefits are effectively gained with sustained use.

A cookstove can provide expected performance efficiency only when it burns an associated fuel. While selecting technology options for targeted market segments, it is important to offer a menu of solutions for households and other users. Fuel efficiency and emissions reduction efficiency are important factors in technology choices, but from the perspective of the users, durability and safety are equally important factors. In the design process project designers should consider that the durability of cookstoves depends on the quality of the materials used in the production of the stove, the resistance of the stove in the climatic context where it is used, how it used, and the maintenance that is needed. It is important to account for durability issues associated with the design and construction of cookstoves, in addition to technical considerations, such as heat transfer efficiency and combustion efficiency.

Project designers should recognize that products offered to consumers should be continuously improved with feedback received from users to guarantee sustained adoption and use.

Fuel-efficient cookstoves, commonly called "improved stoves," are inspired by traditional cooking systems based on their configuration and use, although they perform better in fuel efficiency. Traditional stoves have an efficiency level between 5 and 15 percent, and some fuel-efficient cookstoves can reach a fuel efficiency level of about 30 percent. Fuel-efficient cookstoves do not change people's cooking habits, and they do not need to change the type of fuel used. They are designed and constructed with two primary technical considerations in mind. The stoves need to simultaneously improve heat transfer to the pot and improve combustion efficiency. Heat transfer efficiency decreases fuel use, while combustion efficiency decreases harmful emissions.

Advanced Combustion Stoves aim at maximizing the burning of solid fuels to minimize as much as possible the emission of pollutants. While fuel efficiency has been the guiding factor for improvement in stove design and the focus of fuel-efficient cookstove programs, "cleanliness" is a central parameter and major aspect of advanced combustion stove design in addition to fuel efficiency issues. There is a range of advanced combustion stoves with varying level of combustion efficiency. Some examples are rocket stoves, natural draft gasifier stoves, forced draft gasifier stoves, and fan-assisted biomass cookstoves. Each of these advanced types of combustion stoves have different requirements for fuel to operate. Some use unprocessed fuelwood, and others require processed fuels in the form of pellets or small cuttings. WHO (2011) has produced a classification of stoves by fuel with some useful comments on performance and a ranking of the potential of the stoves to reduce health damaging pollutants and reduce climate change pollutants, and the potential for renewability of the fuel supply. Particular attention was paid to ranking stoves by their potential for reducing health-reducing pollutants and climate change pollutants. High emissions reductions are defined as ≥ 90 percent, moderate as ≥ 30 percent and < 90 percent, and low as < 30 percent. Many of the advanced combustion stoves have shown excellent performance at the laboratory. They need to be field tested in order to see how real field conditions will affect their performance.

Testing, standard setting, and certification should be an integral part of interventions.

A considerable amount of research has been conducted on stove performance in the past 10 years, and significant advances in the ability to measure emissions that impact health, such as CO and fine PM, have been made. Research evidence has shown that laboratory performance test results are often different from field test results. Field tests that consider the variation of local cooking practices, building materials, and modification of stove design are also needed.

Venkataraman (2010) indicated the following important factors to consider in evaluating the performance of a cookstove:

- Combustion efficiency—how much of the energy and carbon in the fuel is converted to heat and CO_2.
- Heat transfer efficiency—how much of the heat is absorbed by the pot.
- Overall thermal efficiency—how much energy in the fuel is absorbed by the pot (the product of multiplying the first two efficiencies together).

MacCarty, Still, and Ogle (2010) assessed 50 cookstoves in 7 categories: (a) simple stoves without a combustion chamber, (b) stoves with a rocket-type combustion chamber, (c) gasifier stoves, (d) fan-assisted stoves, (e) charcoal-burning stoves, (f) liquid or gas fuel stoves, and (g) wood-burning stoves with chimneys. This categorization is based on basic geometry and operating principles of the stove rather than on designers or manufacturers. This research finds that fuel use, a measure of how efficiently heat is transferred to the pot, is dependent on geometry of the cookstove and flow of hot gases around the bottom and sides of the pot. CO emission depends on the temperature in the cookstove, the mixture of air in the cookstove, and flame above the charcoal bed. Similarly concentration of PM also depends on the mixture of air, flame in hot spaces, and the characteristics of combustion chamber.

Many early cookstove programs overestimated the potential of a fuel-efficient stove. As documented by Maniblog (1984), efficiency overestimation was largely caused by inconsistent efficiency measurements, large discrepancies between laboratory and field performances, and degradation over time. In the case of wood combustion, estimating thermodynamic efficiency can be complicated—varying significantly with the duration of the fire, moisture content of the fuelwood, and the power cycle. Additionally, prior stove programs would often only use a laboratory-based test—but would not account for performance under "low" power (simmering food) or the possibility of a well-tended fire in field conditions. Tradeoffs in stove material production could cause breakage over time and reduce performance. In some cases, fuel-efficient stoves provided significantly lower benefits than previously conceived and created little to no demand that drove further production. When considering program design, it is therefore imperative that stoves be tested in field conditions, and that long-term performance degradation be accounted for and accurate testing techniques be used.

A cookstove program can be successfully implemented, but actually deliver few health benefits. There are tradeoffs when it comes to stove design. For example, the mud or sawdust stove frequently sold in Africa is very cheap, and it can reduce fuel use by roughly 10 percent, but it nearly doubles the PM emissions compared to a three-stone fire. Additionally, improper use and maintenance or variations of stove design can reduce health benefits accrued in women and young children. Initial field tests, training of proper use, and monitoring are essential to ensure that the stove is being properly used to accrue health benefits—particularly when testing for CO and small PM that is invisible to the eye, yet often causes the most health damage.

In 2011, the PCIA and the GACC established an interim rating system and a testing methodology called the Lima Consensus for evaluating stove models that, "reflects the varying tiers of performance in the areas of fuel efficiency, indoor air quality, emissions of PM and carbon monoxide, and safety."[1] This work was later validated in February 2012 during an International Organization for Standardization (ISO) workshop where an International Workshop Agreement was developed. The methodology ranks stoves into four tiers based on fuel use, overall emissions, indoor emissions, and safety. These standards for clean cookstoves are intended to help manufacturers, distributors, and users sufficiently assess their efficiency, quality, and safety in different operating environments. Work is still in progress within

[1] For more information: http://www.pciaonline.org/files/Lima_Consensus_Signed.pdf.

the leadership of the GACC to enable the institutional environment to enhance testing protocols and capacity.

Appendix 4 describes (a) the basics of testing methodology; (b) metrics for cookstove performance; (c) comparison of cookstove performance; and (d) some cookstove testing resource. Work is still on-going to improve the metrics and testing methodology. While there is progress on the setting of international standards, there is a need for national and regional standards since local climatic conditions, patterns of use, and characteristics of fuel affect cookstove performance. Provisions should be made by project designers to ensure that a testing facility is closely associated with the design and implementation of projects. Financing should be made available to strengthen testing, standard setting capacity at the national level and work should be encouraged on setting regional standards within the framework of internationally agreed protocols.

Business models should be context-specific and fully integrate producer, distributor, and user-financing issues.

Business models should be context-specific and fully integrate producer, distributor, and user-financing issues. From a producer's perspective, a challenge is to secure capital to establish a business and to ensure cost recovery to maintain and eventually expand production. From a distributor's perspective, an objective is to create effective delivery channels, ensure cost recovery, and eventually expand service coverage and maintenance. Sustainability of projects suffers if business models do not envisage the full enterprise development and expansion processes. From the perspective of the user, financing issues also need to be addressed to help solve the affordability problem. Some programs have integrated microfinance models as an integral part of their business strategy to facilitate a consumer's acquisition of new cooking devices. (Zerriffi 2011) summarized producer financing issues as follows: (a) explore ways to improve access to credit from financial institutions; (b) facilitate the use of venture capital, since households without efficient and clean cookstoves represent significant markets; (c) determine whether producers can be financed through cross-subsidization from high-income consumers from large utilities; (d) explore how to extend and involve NGOs and social enterprises; and (e) consider the use of carbon finance. For consumer financing he noted (a) the need to consider direct financing options by producer with multiple payment plans; and (b) the need to consider micro-credit options.

With the recent development of technologies for advanced combustion stoves, some private sector enterprises are entering the clean cooking sector with purely commercial for-profit objectives. Their view is based on the changing perception of the bottom of the pyramid now considered to be financially viable markets. These enterprises are using marketing and sales techniques to approach the scaling-up of clean cooking solutions by targeting market segments for their products. They believe that scaling up is possible only if an entrepreneurial mindset is adopted with supply and distribution models operating on a commercial basis.

Two main innovative features are making inroads in the clean cooking sector: (a) the involvement of social enterprises and (b) the increasing use of carbon finance.

Social enterprises are also developing innovative business models to scale up clean cooking solutions. Their approach is to apply market-based business solutions to social problems. Social enterprises include such nonprofit entities as NGOs and for-profit organizations with an activity on clean cooking solutions as part of their corporate social responsibility. The overarching objective pursued is to create sustainable enterprises to provide the poor with clean cooking solutions by developing business models that provide cooking appliances to the poor in an affordable way. This process often entails an expectation of a lower return on investment as compared to a purely commercial venture. A notable example of a successful enterprise in the delivery of energy products to the poor is Grameen Shakti in Bangladesh. Grameen Shakti has developed an approach combining soft credit for consumers, adaptive technology to lower costs, maximization of income generation, and effective after-sales service, including consumer-friendly options, such as a buy-back system (Barua 2007).

Carbon finance is increasingly being used to scale up the delivery of clean cooking solutions. The dissemination of clean cookstoves results in efficient combustion and may lead to efficiency in fuel consumption. Their dissemination therefore can result in reduced greenhouse gas (GHG) emissions, assuming the fuels (including biomass) are nonrenewable. If this activity is combined with afforestation and reforestation activities even more, GHG reductions can be achieved.

Clean and more energy-efficient cookstoves can conservatively save at least 1 metric ton of CO_2 emissions per year under the right conditions. Many advanced combustion stoves are believe to save twice that amount. In carbon markets, a value is given for each ton of CO_2 reduced. Therefore, revenues from carbon credits could be used to support the financing (upfront or repayment costs, or both) and dissemination of clean cookstoves. With the growing interest in the use of carbon finance, a special appendix is devoted to household energy and carbon finance to help project designers identify the eligibility of their interventions (Appendix 5). It covers both demand-side interventions and supply-side interventions. It describes the methodology for estimating emissions reductions and additionality; and it provides the general nontechnical requirements of carbon finance–supported interventions, including the requirements of monitoring, validation, and verification. Three examples of registered cookstove programs financed through carbon finance as part of the CDM Programmes of Activities are the Bangladesh, Guatemala, and Nigeria and programs. Consumer fuel subsidies and direct subsidies to the acquisition to cookstoves should be avoided, and indirect subsidies to support the scaling up of clean cooking solutions should be carefully designed.

Consumer fuel subsidies should be avoided as they tend to benefits middle to upper income households and not the poor. Policies to promote the use of modern fuels such as kerosene and LPG rely heavily on price subsidies that are fiscally unsustainable. Kerosene subsidies are generally viewed as having the most pro-poor distribution effect. However, there is evidence of leakages to the transport sector as kerosene can be diverted to be used as an automotive fuel. In cases of LPG price subsidies, evidence suggests that middle to upper income households who could afford LPG at market price tend to be the ones to benefit from these subsidies (Clements and many others 2013; Vagliasindi 2012).

The price competitiveness of household fuels is an important factor in the transition to the use of modern fuels. Where cleaner fuels and especially petroleum fuels like LPG are highly priced compared to fuelwood, the likelihood of their use by the poor is low. In settings where prices of fuelwood have substantially increased mostly in urban areas, the adoption of modern fuels such as LPG becomes a viable possibility. Kojima (2011) indicated that substitution of biomass with LPG is more likely in areas where the costs of biomass for cooking are high and where reliable infrastructure for reliable delivery of LPG delivery exists. Otherwise, if the uptake of LPG is not occurring in urban middle-class households, it is unlikely that such LPG promotion program will be successful with poor or rural households.

It should be noted that in many urban communities, even when households can afford LPG, they are concerned about safety and reliability of supply issues. Explosions of LPG cylinders and the casualties they provoke are serious barriers to LPG uptake. Some middle and upper income household would simply not adopt LPG because of safety issues. The frequent supply shortages of LPG are also a barrier preventing systematic uptake in some cases. The promotion of LPG needs to be integrated into a household energy policy that is intended to address both supply side and macro stakeholder barriers as well as demand side user barriers of accessibility, affordability, and acceptability. Appendix 5 shows examples of options for facilitating household use of LPG extracted from Kojima (2011). They are articulated around five main goals: (a) lower the costs to consumers; (b) enhance safety; (c) target financial assistance; (d) minimize shortages; (e) raise awareness and involve consumers in improving market conditions.

Direct subsidies to the acquisition of cookstoves should be avoided as they do not necessarily translate into adoption and sustained use. Experiences from some improved stoves programs, such as the National Program for Improved Chulhas (NPIC) in India showed that the high subsidies on improved stoves resulted in poor maintenance by households. And households simply switched to traditional stoves when improved stoves were broken.

Indirect subsidies to support the scaling up of clean cooking solutions should be carefully designed and include a phasing out strategy. A market based approach in the commercialization of clean cooking solutions is often viewed as the best way to ensure their sustainability. Evidence also indicates that a certain level of public funding is necessary at the initial program stages for their takeoff. This is particularly true in settings where the business environment is not well developed; basically most of the settings where clean cooking solutions need to be developed. Public financing is required to support research and development activities, standard setting, certification, quality control, training related to stove design and maintenance, and monitoring and evaluation. The health, environment, and climate benefits associated with clean cooking make the case for public investment in research and development for technical innovative solutions. The commercialized Anagi stove in Sri Lanka, which has reached over 3 million households, benefited from donor funds in product development and testing over two decades (GVEP, 2009). The success of the Chinese National Improved Stove Program is partly due to a strong support from the central and county government funds to set standards and to enforce certification to gain consumer confidence (Bailis and others 2009).

Public financing is also needed to support awareness raising and the removal of the barrier pertaining to the poor access to clean cooking solutions by the implementation of policy, legal and regulatory reforms to improve the business environment. This includes working in partnership with private operators to expand distribution networks to reach remote locations.

Monitoring, evaluation and impact assessment frameworks should be developed starting with the initial stages of project design and adapted as needed.

From the standpoints of project implementers, donors, government, and beneficiaries, monitoring and evaluation systems are able to account for performance, results, and outcomes of interventions. It is necessary to tackle their conception upfront from the project design stages and to budget their associated activities accordingly.

Monitoring and evaluation are important activities to measure progress in the number of households adopting and using efficient cookstoves and fuels. In the context of a project with a carbon finance component, monitoring and evaluation are even more important, since the granting of carbon finance requires verification of the effective use of cookstoves. The traditional methods of monitoring include observation, household surveys, questionnaires, and interviews. However, monitoring and evaluation can now also be undertaken through more sophisticated information technology-based means, most notably through mobile monitoring and an emerging generation of sensor-based tools, such as microchips. These new advanced technologies allow continuous and objective monitoring of the stove-adoption and use processes. In general, the advantages of using these advanced monitoring schemes include scalability, offline data entry, data visualization, and simple user interfaces, unlike the traditional means, which are very often too resource-intensive to be performed continuously or on a large scale.

Mobile technology presents an unexplored, but relatively easy medium for monitoring cookstoves. In a project in the rural highlands in Honduras, the Proyecto Mirador LLC, a nonprofit that has built more than 25,000 fuel-efficient cookstoves, used a new monitoring system based on mobile technology. Each household stove installation is recorded using a global positioning system (GPS) mapped by a monitoring system. GPS maps are generated that work with Proyecto Mirador equipment and a platform to track installations using interactive, high-resolution satellite and aerial imagery that covers the entire project area. Maps and installation and household data are available from the office or the field enabling project management to easily track installations and locate households for follow-up supervisory visits. The implementation of the system has required the transfer of the technology of handheld smart phones and computerized record-keeping to Hondurans who have previously known only paper records and hand-generated solutions for deploying field workers and monitoring installations.

Cost-benefit analyses should be conducted to assess the net benefits associated with interventions. In order to determine the levels of the expected benefits associated with health, local environmental protection, and climate change, the appropriate methodology needs to be used. GTZ (1999) elaborated a detailed guide to micro- and macroeconomic analysis and data assessment on the economics of fuel-efficient cookstoves. This guide shows, through examples, the calculation of simple key figures and ratios for the economic assessment of fuelwood savings with the adoption of fuel-efficient cookstoves in a language for noneconomists. The microeconomic calculations are intended to show the economic benefits of the use of fuelwood- and charcoal-saving stoves. The macroeconomic calculations are intended to show the impacts of fuelwood savings in targeted areas of interventions. In 2006, WHO (2006) prepared an evaluation of the costs and benefits of household energy and health interventions at global and regional levels. This work included a methodology to assess the costs and benefits of interventions aimed at demonstrating the benefits of investments to improve access to clean cooking solutions. These benefits include time savings because of less illness and a reduced need for fuel collection and shorter cooking times.

Recently, Jeuland and Pattanayak (2012) developed a modeling framework for the systematic accounting of the costs and benefits of improved cookstoves with simulations aiming at showing the impacts on health, forest, and climate from both the household and social welfare perspectives. They compared the costs and benefits of households switching from traditional wood-burning stoves to six alternatives, including fuel-efficient, wood-burning stoves, charcoal-burning stoves, kerosene stoves, LPG stoves, and electric stoves. The results confirmed that time efficiency and the opportunity cost of time are critical factors in affecting the relative private returns of the use of fuel-efficient cooking technologies compared to traditional stoves using solid fuels. Appendix 6 shows the typology of costs and benefits of cookstoves and equations used for their calculations.

3. CONCLUSIONS

The growing mobilization on clean cooking solutions is a unique opportunity that should be seized to produce results on the ground. This note draws some broad principles that could inspire the design of interventions. These principles are not meant to be exhaustive, since it is recognized that contextual conditions and constraints are fundamental in project design decisions. Depending on the context, some principles might be more relevant than others.

The recent development of cookstove technologies and the emergence of innovative business models to support their dissemination are encouraging factors. Efforts should build on these developments, bearing in mind the fundamental principle of accounting for the cookstove user's preferences for adoption and sustained use.

APPENDIX 1

World Bank–Funded Projects with Access to Fuelwood and Stove Components
(US$ million)

	Project	Year	Total project cost	IBRD, IDA, GEF, GPOBA	HH energy access component	% of total project costs	Project closing date
1	Niger: Energy Project	1989	65.9	30.4	16.2	25	12/31/96
2	Mali: Household Energy	1995	11.20	11.20	11.20	100	12/31/00
3	Madagascar: Energy Sector Development	1996	102.60	44.20	2.90	3	12/31/05
4	Senegal: Sustainable and Participatory Energy Management (PRODEGE I)	1997	19.93	19.93	19.93	100	12/31/04
5	Chad: Household Energy	1998	6.30	5.27	6.30	100	6/30/04
6	Mongolia: Urban Stove Improvement (GEF)	2001	0.75	0.75	0.75	100	3/31/07
7	Ethiopia: Energy Access Project	2002	199.12	132.70	5.44	3	6/30/13
8	Mali: Household Energy and Universal Access	2003	53.35	35.65	13.47	25	6/30/12
9	Madagascar: Environment Program	2004	148.90	40.00	2.50	2	6/30/11
10	Senegal: Electricity Services for Rural Area	2004	71.70	29.90	4.60	6	12/31/12
11	Benin: Energy Services Delivery	2004	95.70	45.00	6.20	6	12/31/11
12	Rwanda: Urgent Electricity Rehabilitation	2004	31.30	25.00	0.90	3	4/30/10
13	Chad: Community-Based Ecosystem Management	2005	94.45	39.76	2.50	3	3/30/11
14	Benin: Forests and Adjacent Lands Management (GEF)	2006	22.35	22.35	22.35	100	11/30/11
15	Burkina Faso: Energy Access	2008	41.00	41.00	6.70	16	4/30/13
16	Benin: Increase Access to modern Energy	2009	178.50	72.00	5.50	3	6/30/15
17	Rwanda: Sustainable Energy Development (GEF)	2009	8.30	8.30	8.30	100	N/A
18	Mozambique: APL for Energy Development and Access	2010	80.00	80.00	6.30	8	6/30/15
19	Senegal:2nd Sustainable and Participatory Energy Management (PRODEGE II)	2010	19.37	15.00	19.37	100	11/30/16
	Total		**1,250.72**	**698.41**	**161.41**	**13**	
	Average loan/credit		**65.83**	**36.76**	**8.50**		

Source: Ekouevi and Tuntivate 2012.

APPENDIX 2: SUSTAINABLE SUPPLY OF WOOD-BASED BIOMASS ENERGY

In most developing countries, access to firewood and charcoal is not regulated in practice, much less managed in a sustainable manner. Where firewood and charcoal are sold, market prices almost entirely reflect extraction costs. Landless domestic migrants and the poorest segments of urban populations typically spearhead the commercialization of firewood and charcoal, because they have few other choices left. Middlemen and retailers play a catalyst role, mostly in larger cities. Under such conditions, the only limit to firewood "production" is the existence of trees within a physically or economically tolerable distance from the place of consumption.

Challenges and Barriers

Overall, the wood energy sector is characterized by very weak governance, law enforcement, and other regulatory capacity. Low capacity to enforce regulations and effectively collect revenues is often undermined by corruption at checkpoints along charcoal transport routes. In many Sub-Saharan African countries, for example, the charcoal trade is dominated by a small number of powerful and politically connected entrepreneurs who are able to use their influence to further avoid and evade payments of fees and obtaining of licenses. The tight control of the sector by a small number of people has two important implications.[2] First, it means that efforts to reform and regularize the sector will be intensely resisted and will require significant political support. Second, it means that the bulk of charcoal profits are concentrated within a narrow band along the production-marketing chain. Producers, small-scale transporters, and retailers (who far outnumber the more powerful wholesalers and transporters) receive a very small share of the final market price. This provides a strong disincentive toward sustainable forest management and afforestation and reforestation investments by charcoal producers.

Obviously, such extraction regimes may hardly be called sustainable. They usually result in rapid depletion of forest resources and tend to cut off society's poorest and most vulnerable segments from much needed basic energy services first. Given that most charcoal is harvested without any payments being made for the raw material (wood), and that licenses and levies are largely evaded, the cost of charcoal to the consumer does not reflect its real value. The impact of these lower costs is to undermine any efforts made by producers or traders to comply with the law by paying all licenses and levies, or to invest in efficiency savings, such as improved conversion technology, long-term sustainable forest management, or the establishment of plantations and woodlots. Without improving the regulatory and fiscal frameworks of the sector, the market price of legal and sustainably produced charcoal will always be undercut by unregulated and unsustainable products.

In contrast to its economic potential, environmental implications, and importance for the energy security of a majority of the Sub-Saharan African population, the wood-based biomass sector is currently viewed almost entirely negatively in most countries. Prevailing policies and laws tend to focus on regulations, enforcement, restrictions and, where possible, moving from the sector altogether to other energy sources. However, if the sector was formalized, and involved modern, supportive policies, this could create employment opportunities and further broaden the revenue base for national and regional governments.

Basic Design Principles for Sustainable Wood Production

Raising prices of sustainably produced fuelwood has opportunities, but requires the introduction of efficiency measures at the consumption level. As in any country, raising fuel prices is strongly opposed—it would be a politically challenging consequence of reform of the production and consumption segments of the fuelwood value chain. However, raising price of fuelwood would create two important opportunities. First, it would provide a more favorable environment for small-scale entrepreneurs to invest in efficient production and conversion measures, such as tree planting, participatory forest management, and kilns. Second, it would deliver greater incentives to consumers to invest in simple technology (such as fuel-efficient stoves) designed to reduce the consumption of wood for energy, and hence cost. An increased demand for energy-saving technology would also act as a powerful stimulus for urban entrepreneurs to develop and market energy-efficient stoves. Supporting measures are proposed that would

[2] For a formal analysis of the political economy of the charcoal sector in Tanzania, see, for example, World Bank 2010.

reinforce moves to make the wood-based biomass energy sector more sustainable and inclusive, and to achieve greater impacts on poverty reduction, if implemented alongside the policy reforms mentioned above. These are as follows:

- Harvesting plans need to be developed for forest areas administered by central or local governments. Taking into account the lack of reliable data on forest resources in many countries, harvesting and licensing decisions are currently driven by inaccurate estimates of standing stock or resource availability. To address this issue, it will be critical that more accurate assessments are undertaken. Once assessments are made and harvesting plans are implemented, it is crucial that compliance with harvesting plans is closely monitored.
- Scaling up community-based forest management (CBFM) will help secure tenure for rural producers. The most devolved form of participatory forest management (PFM)—community-based forest management—offers communities the opportunity to declare forest reserves on village lands, which are managed in line with local development priorities. While this would require continuous engagement from external sources, since establishing community-based forest management arrangements incur substantial initial costs, fiscal reforms as proposed earlier would ultimately increase revenue collection at local government levels, which has the potential to cover the support costs of community-based forest management in the long term.
- Small-scale plantations and woodlots could increase supplies of wood for charcoal and trigger economic opportunities and land use planning in rural areas. Although natural forests are expected to continue supplying much of the raw material for charcoal production, considering the projected increase in charcoal demand, natural forests will not be able to meet these demands in a sustainable manner. Consequently, the establishment of private or group-based woodlots or plantations could, in the long term, complement supplies outside forest reserves. Subsidies and incentive payments might be necessary in the early stages to trigger local-level investments in establishing planted woodlots. Complementary measures to improve the overall regulation and formalization of the fuelwood sector must be introduced to gradually replace subsidies with more market-based credit provision in the medium to long term. As farmers begin to secure financial benefits from the sale of wood for energy, it is likely that other farmers would engage in similar activities. In this context, the potential carbon finance opportunities need to be further explored.
- Effective pricing policies of raw material by charcoal producers could provide an incentive to adopt technologies that improve the efficiency of charcoal production. Considering that the raw material has no cost, charcoal producers currently have no incentive to invest in more efficient technologies. When raw materials carry a price—that is, the investment costs for sustainable forest management or plantation establishment—producers would be provided with an incentive to invest in relatively simple though effective technologies that improve the efficiency of turning wood into charcoal. While semi-industrial charcoal kilns may achieve significant efficiencies, they may only be a viable option for large-scale production enterprises. However, small-scale producers should be provided with simple training on how efficiencies of traditional charcoal production (earth kilns) can be improved. These efficiency improvements would help producers offset initial investments costs.
- The promotion of fuel-efficient stoves can compensate for expected increases in sustainable fuelwood prices. With fuelwood prices likely to increase as fiscal incentives are implemented that favor sustainably produced fuelwood, fuel-efficient stoves must be further promoted in order to compensate for increased consumer prices. By improving the availability of high-quality, fuel-efficient stoves, consumers would have the possibility to offset increased prices. However, price premiums on fuel-efficient stoves need to be smaller than the monetary savings expected through reduced wood and charcoal quantities in order to provide a true incentive.
- Designing successful policies also entails giving attention to the views and opinions of the various actors involved in and affected by the policy at different levels, the roles they play, the ways they relate to each other, and their networks of information exchange and learning. Under such a process, it is acknowledged that a policy in general is not only formulated and implemented, but also interpreted, contested and resisted, repelled, and potentially modified. This underlines the characteristics of a policy process rather than a single-standing, one-time intervention.

Basic Principles to Modernized Fuelwood Supply Chain

The measurable impact on the ground depends just as much on how a wood-based biomass energy policy is implemented as it does on the issues raised above. In this sense, shaping such policies means to deliberately promote adequate selection and use of governance instruments (laws and regulations, incentives, planning, and information). As policies change over time, shaping wood-energy policies must be regarded as a learning process. This calls for flexibility in implementation, continuous observation of changing circumstances, and impact monitoring. It likewise requires capitalizing on experience and the lessons learned, including those from other countries.

As a first step, significant changes need to be introduced to regularize and legalize the currently informal sector. This would require a major shift both inside and outside government with regard to how wood energy is viewed and managed from a policy perspective. Currently, the sector is viewed almost entirely negatively, and as a result, prevailing policies and laws tend to focus on regulation, enforcement, restriction and, where possible, moving away from the sector altogether to other energy sources. This perception will need to be changed and instead a more enabling environment created that allows for responsible, sustainable, and profitable enterprises to flourish within the sector. Recommendations to formalize the sector—changing the regulatory, fiscal, and pricing frameworks—include, but are not limited to, the following:

- Ensuring that the revenue collection responsibilities of local governments associated with wood-based biomass energy use are matched with an ability to retain a larger share of revenue collected.
- Supporting local governments in reinvesting income derived from fuelwood trade and consumption, with the objective of further improving revenue collection and promoting sustainable forest management.
- Introducing fiscal incentives that reward sustainably produced wood-based biomass energy and place additional costs on whatever is illegally produced.
- Governments need to strengthen their capacity for monitoring and enforcing rules and regulations on the production, transport, and trade of fuelwood.

Given the current political economy in many countries, bringing the fuelwood trade into the tax-based economy is a significant challenge that needs to be tackled head-on. It requires strong political support if the vested and powerful interests that currently control the sector are to be confronted. Furthermore, as reforms gather pace, increasing amounts of traded charcoal would enter the formal economy, reflecting the true costs of production (including raw material costs and all fees and taxes). As a result, the end price to consumers is expected to rise.

APPENDIX 3: PERFORMANCE MONITORING METHODOLOGY

A considerable amount of research has been conducted on stove performance in the past 10 years, as well as on significant advances in the ability to measure emissions that impact health, such as CO and fine PM. Research evidence has shown that, in addition to standard laboratory tests, field tests that consider the variation of local cooking practices, building materials and modification of stove design are also needed.

The Basics of Testing Methodology

The descriptions below detail the most common cookstove testing methodologies.

- The **water-boiling test (WBT)** is the most basic technique, and it provides a standardized, easy method of comparing stove efficiencies under controlled laboratory conditions. There are a number of standard tests, including the VITA 85 International Testing Standard protocol, Indian and Chinese Standard WTA, comparative WBT and now, as of 2012, the WBT 4.12.[3] The VITA test was originally the most commonly used, although now the WBT 4.12 addresses efficiency measurement inconsistencies.[4] Water boiling tests are the only tests that can determine an actual physical efficiency. The standard water boiling test should be done under high power (water quickly brought to a boil) and low power (water kept at steady temperature while simmering) to more accurately predict fuel use for different cooking tasks. There are some drawbacks in water boiling tests when testing fuelwood, which often has varying moisture content and can run through various burn cycles, depending upon their char/pyrolizing solid ratios. Additionally, water boiling tests are often void of cultural variables, such as specific woods used for cooking, methods by which fire is created and food is cooked.
- The **kitchen performance test (KPT)** is a field-based test that measures how much fuel is used in actual households when cooking normally over a few days. The amount of wood the family used per day is calculated in this test. The KPT is an excellent way to observe real world energy consumption—it measures all household energy consumption, including fuelwood not just used for cooking, but also when it is used to cook animal feed or heat bathwater, or used for a variety of meals under varying conditions. The test, however, has very little control and can require more resources.
- The **controlled cooking test (CCT)** serves as a bridge between the KPT and WBT. It is a field test that measures stove performance in comparison to traditional cooking methods. The test essentially trains a number of local beneficiaries to prepare the exact, same local meal both under normal cooking conditions and with a fuel-efficient cookstove. The CCT is designed to assess stove performance in a controlled setting using local fuels, pots, and practice. It reveals what is possible in households under ideal conditions, but not necessarily what is actually achieved by households during daily use. The test can serve on a stand-alone basis or be used to double-check the results from a WBT.

Metrics for Stove Performance

- There are a number of ways to measure performance of a cookstove, depending on the overall project objective or the community's needs. For example, programs focused on reducing overall fuel consumption in charcoal would value fuel saved, while health-focused projects would measure PM or CO emissions. Those projects with a gender focus might focus on variables, such as time saved, giving wood or increased productive income. Ultimately, choosing an appropriate stove requires an iterative process between stove designers, laboratory results and, most importantly, the local cooks that will use the stoves. In some cases, programs can adapt an efficient stove chamber, such as the rocket design, into a locally adaptable design, while in others, a standardized manufactured stove is more appropriate. The list below briefly describes relevant metrics.
- **Time to boil:** Often an important factor when considering consumer demand. Past field studies have shown that women prefer less time to boil and an adjustable stove heat to cook various meals (for example, to simmer or boil, or to cook tortillas). The standard test boils 5 L with both cold and hot start phases of the WBT. Cookstoves that boil water faster than a three-stone fire often have narrow channels around the pot to force hot gases to flow against the surface of the heating container.

[3] Up-to-date testing protocol can be found here: http://www.pciaonline.org/testing.
[4] As addressed by the 2003 Still, Ogle, and Bailis paper asserting that efficiency tests can vary widely in low- and high-power situations.

- **Efficiency:** Specific fuel consumption and energy required for cooking. While the amount of fuel is a direct weight-based measurement, the energy required takes into account the energy density of alternative fuels, such as kerosene or alcohol. In measuring the amount of fuel, it is important to establish consistent fuel types and moisture content. Typically stoves that significantly reduce the fuelwood needed often incorporate a fan,[5] or use "natural draft" to increase the velocity of the flame and hot gases surrounding the pot.
- **CO and particulate matter (PM) emissions:** CO and PM emissions cause a host of health impacts. Another common metric employed is the ratio of CO to CO_2. Stoves that produce less CO increase the time in which flames burn, increase the fire temperature, and turbulence to increase mixing with oxygen.
- **Cost:** Overall costs and availability of materials are an important factor, particularly when deciding on the project budget and the cash constraints of the project beneficiaries. Often the most effective stoves in preventing IAP can be more expensive, and they will need to be partially subsidized. Other factors, such as willingness to pay, can also be a factor. Some stove programs have begun including "add-ons," such as a thermoelectric generator to charge a cell phone, to increase consumer demand.
- **Monthly fuel use:** This is a measurement that is found through field tests; it accounts for variations of cooking and consumption habits.

Comparison of Stove Performance

Table 1 shows the results from a 2010 test using a WBT protocol in the Aprovecho test kitchen. The following chart may be used as a guide for project designers. However, it should be used in conjunction with field tests and iterative sampling.

Cookstove Testing Resources

Sometimes cookstove programs use a series of partnerships between academic institutions or national research laboratories to help design, measure, and compare cookstoves. The following list is a set of resources available to project designers and programs in need of more information or consulting services in cookstove testing technology.

- **U.S. EPA, North Carolina:** The EPA is now considered the foremost independent stove-testing facility. Website: http://www.epa.gov/nrmrl/appcd/index.html
- The **Aprovecho Research Center** has conducted 30 designing and implementing cookstove projects. The center provides research, consulting, and training to stove projects and testing of cookstoves. Website: http://www.aprovecho.org
- **Zamorano University** is a university in Tegucigalpa, Honduras, that assists NGOs and government agencies in training, testing, and certification of cookstoves. Website: http://www.zamorano.edu/english/campus/laboratories/natural-and-environmental-resources-laboratories/cookimproved-stove-certification-center/
- **Colorado State University:** The Engines and Energy Conversion Laboratory originally spun off Envirofit International cookstoves. The group also analyzes household air quality conditions, performs baseline and cookstove performance testing (in both the laboratory and the field), performs in field KPTs, and provide cookstove design services. It can also design, implement, and manage in-field market studies and customer feedback studies. Website: http://www.eecl.colostate.edu/research/household.php
- **Organismo Público Descentralizado del Sector Vivienda**, Construcción y Saneamiento (SENCICO), is an organization set up by the Peruvian government that offers evaluation and certification of cookstoves. Website: http://www.cocinasmejoradasperu.org.pe/documentacion/brochure/BROCHURE%20SENCICO.pdf
- **The Centre for Integrated Research and Community Development** (CIRCODU) is a Ugandan NGO that provides services such as third-party independent evaluation for carbon projects, KPTs, water boiling, and durability tests. It also offers consumer market research and is involved with a domestic biogas program. Website: http://www.circodu.org
- **Lawrence Berkeley Laboratory (LBL)** is a U.S. national laboratory based in Berkeley, California, that provides research and cookstove testing resources. Website: http://cookstoves.lbl.gov
- The **Partnership for Indoor Air (PCIA)** maintains a website that posts research and testing resources for cookstove programs. Website: http://www.pciaonline.org

[5] Currently fans are being tested in cookstoves that either operate by power from a battery, electricity (if available), or thermoelectric generator.

Table 1: Results from a 2010 Test Using a WBT Protocol in the Aprovecho Test Kitchen

	Time to boil (min)	Fuel used to cook (g)	Energy used to cook (kJ)	CO emissions (g)	PM emissions (mg)	Safety ratings (out of 40)	Cost to purchase (US$)	Monthly fuel use (kg/ month)
Wood-burning stoves without chimneys								
3-stone fire	26.7	1,118	19,496	55.7	2,363	21	0.0	67.1
Ghana wood	21.8	996	15,190	50.4	4,287	32	5.0	59.8
20 L can rocket	22.3	733	12,579	15.3	1,289	33	0.0	44.0
Mud or sawdust	16.0	793	13,107	48.5	2,352	33	0.0	47.6
VITA stove	14.0	689	11,553	42.8	2,150	29	2.0	41.4
Wood-burning stoves with chimneys								
Justa stove	46.7	1,367	23,573	24.1	792	38	75.0	82.0
Uganda 2-pot	16.2	720	11,380	22.3	678	37	40.0	43.2
Patsari prototype	34.8	1,277	21,324	19.4	879	36	35.0	76.6
Onil stove	28.0	1,386	21,503	31.5	1,343	39	72.0	83.2
Ecostove	38.6	2,014	37,395	48.0	5,102	34	67.0	120.8
Wood-burning stoves with electric fans								
Wood flame fan	19.5	626	10,510	9.2	48	35	229.0	37.6
Wood gas fan	23.7	459	9,434	6.9	27	33	99.0	27.5
Charcoal stoves								
Mali charcoal	38.6	674	19,801	112.8	260	33	2.4	—
Gyapa charcoal	28.4	694	18,013	135.2	587	32	5.9	—
Solar cooker								
Parabolic solar cooker	70.0	0	0	0	0	32	55.0	—
Liquid fuel stoves								
Propane	23.0	139	6,670	0.5	5	33	18.0	—
Alcohol—clean cook	31.6	317	6,766	5.3	4	37	25.0	—
Kerosene	41.9	247	9,623	7.8	10	35	9.5	—

Source: Aprovecho Research Center 2011.

APPENDIX 4: SUPPORTING HOUSEHOLD ENERGY INTERVENTIONS WITH CARBON FINANCE

Since cookstove projects result in more efficient combustion, they also achieve reduced fuel consumption (demand-side activities). Therefore, their dissemination can result in reduced GHG emissions, assuming the fuels (including biomass) are nonrenewable. If this activity is combined with afforestation and reforestation activities (supply-side activities), even more GHG reductions can be achieved. Clean and more energy-efficient cookstoves can conservatively save at least 1 metric ton of CO_2 emissions per year under the right conditions. Many modern, efficient models can even save twice the amount of GHGs compared to traditional cooking stoves. Since in carbon markets a value is given to each ton of CO_2 reduced, revenues from carbon credits could be used to support the financing (upfront and/or repayment costs) and dissemination of cookstoves. This guide is intended to enable readers to identify whether their projects would benefit from carbon finance.

Carbon Markets—The Basics

Carbon markets are either regulated or voluntary. Regulated and voluntary markets exist side by side. The commodity traded in all carbon markets is a ton of CO_2 equivalent (CO_2eq). In regulated markets, this is usually referred to as a certified emission reduction (CER). In voluntary markets, it is a verified emission reduction (VER). All GHGs are converted into CO_2eq by referring to the global warming potential (IPCC 2007) of each gas.

Regulated markets are almost twice the size of voluntary markets in the volume of tons of CO_2eq exchanged. Regulated markets are generally formed following a government decision to implement either a cap and trade scheme or a carbon tax to limit the amount of GHGs that may be emitted by specific industrial or economic sectors. To ensure cost-effective reductions, the companies targeted by the cap and trade or tax regime can comply with their obligations by purchasing GHG emissions reductions from projects that follow predefined rules. The Clean Development Mechanism (CDM) governs the largest share of existing carbon markets. In this guide, we will refer to the CDM when discussing regulated markets.

The voluntary market is not governed by regulations. Demand for VERs is driven by (a) companies and individuals who neutralize their GHG emissions through investment in reductions elsewhere (referred to as offsetting) and (b) entities that purchase emissions reductions that they hope will be recognized by future cap and trade regulations (precompliance offsets). The prices for VERs have to date been more constant than in the regulated market, which is currently suffering from lack of demand. Although not regulated, it is important to buyers in the voluntary market that real emissions reductions are achieved from their investments. Therefore, different organizations have developed standards for VERs. These standards basically operate as a label recognized as a sign that projects are achieving "real" GHG mitigation. Over the last five years, the voluntary market has developed multiple standards, registries, and project types (Peters-Stanley 2012). The top four standard-setting agencies in 2011 included the following:

- The Verified Carbon Standard (VCS).
- The Climate Action Reserve (CAR).
- The Gold Standard (GS).
- The American Carbon Registry (ACR).

Although different, there are some similarities between the regulated and the voluntary carbon markets in the end users or buyers, suppliers, intermediaries, types of transaction, and project risks and financing. Key differences exist in the eligibility and methodological application.

Feasibility of Using Carbon Finance

Host Country

The location of a project or activity is critical. The project or activity must be located in a "non–annex I country," as defined in the Kyoto Protocol, to be eligible for regulated carbon markets. Furthermore, the host country must have an established, designated national authority (DNA). Under the CDM, the DNA is responsible for ensuring that a project contributes to a countries sustainable development.

The voluntary market has no restrictions on which country is a host country. However, the GS requires the host country to retire a number of emissions allowances if the host country has an emissions cap. The GS requires the project proponent to assess whether a project contributes to sustainable development. Other voluntary standards, such as the VCS, do not require this.

Can My Project Activity Be Supported with Carbon Finance?

Once it is clear that the location of the project is appropriate, it is useful to assess the economic value of pursuing carbon finance for a project or activity by undertaking a basic cost-benefit analysis. Such an analysis requires the identification of the costs of disseminating fuel-efficient stoves or advanced combustion stoves and then and evaluation of the potential GHG savings from the project. The GHG emissions reductions are calculated by referring to either a CDM methodology or voluntary standards defined by the standard-setting agencies. Methodologies and standards exist for both demand-side activities and supply-side activities. CDM methodologies are found on the United Nations Framework Convention on Climate Change (UNFCCC) website, and the voluntary standards are found on the website of each of the separate standard-setting agencies.

> **NOTE:** CDM methodologies are summarized in a booklet found at : http://cdm.unfccc.int/methodologies/documentation/meth_booklet.pdf

Demand-Side Interventions

For demand-side cooking stove projects, the assumption is that new stoves reduce the amount of nonrenewable fuelwood used for combustion compared to previous cooking approaches. The applicable methodologies ensure that the projects or activities increase end-user energy efficiencies of fossil fuel–based stove technologies at the household level. However, other stove types, such as biogas or fossil fuel cookstoves, are also eligible, since they can apply methodologies for (a) fuel switches from fossil fuels or (b) nonrenewable biomass to renewable energy sources in thermal applications (such as biogas stoves and solar cookers).

Supply-Side Interventions

On the supply side, the basic calculation is based on biomass growth used to fuel the stoves. Credits are based on the difference between the amount of biomass or carbon estimated under the baseline and actually observed under the project. This is corrected for leakage where the main sources of leakage involve biomass loss outside the project boundary because of displacement of activities. (For example, if trees are planted on agricultural land and these agricultural activities are moved to a different location, and if biomass is removed at this location to make room for the agriculture, this is considered leakage.) Project examples can be found on the UNFCCC website at http://cdm.unfccc.int/Projects/projsearch.html.

Estimating Emissions Reductions and Additionality

What Key Data Are Needed to Determine Emissions Reductions?

The monitoring methodologies and standards define the data requirements that need to be provided ex ante and during monitoring, usually each year, that is, ex post. In general terms, the emissions reductions are calculated thus:

Baseline Emission – (Project Emissions + Leakage Emissions).

In general for the GHG emissions generated from the demand side, the baseline scenario is the use of fossil fuel for meeting similar thermal energy needs. According to the applicable CDM small-scale methodology entitled "AMS-II.G," the amount of wood biomass that is substituted is calculated as the product of the number of appliances multiplied by the estimate of average annual consumption of woody biomass per appliance (tons per year). This can be derived from historical data or estimated using survey methods, or it can be calculated from the thermal energy generated in the project activity using the efficiency of the appliance and the net calorific value (NCV) of the fuel used.

The emissions reductions are calculated as the product of the amount of woody biomass that is saved, the fraction of woody biomass used, the NCV of the nonrenewable woody biomass, and the emission factor of the nonrenewable woody biomass. Default values can be used for the NCV and the emission factor of the nonrenewable woody biomass.

The amount of woody biomass saved and the fraction of woody biomass are two critical parameters. Woody biomass that is saved can be estimated using one of the following methods:

- Option 1: The difference between the quantity of woody biomass consumed in project and the baseline scenario measured according to the KPT protocol.

- Option 2: Based on the efficiencies of the appliance in the baseline and project case. The efficiency of the baseline system can be measured using representative sampling methods or based on referenced literature values. Alternatively, default values can be used based on the type of system replaced. The efficiency of the project system must be established using the WBT protocol.

Option 3: Based on the specific fuel consumption or the fuel consumption rate of the systems replaced and deployed. These values are to be determined using the CCT protocol.

For these three options, the amount of woody biomass that would have been used in the project case is determined as following:

- Calculating the product of the number of systems multiplied by the estimated average annual consumption of woody biomass per appliance (tons per year).
- Calculated from the thermal energy generated in the project.

The second critical parameters in demand-driven cooking stove projects are the fraction of nonrenewable biomass. In the small-scale CDM methodology, "AMS-II.G" is derived from the demonstrably renewable biomass and the nonrenewable biomass (NRB). The following link can provide additional information: http://cdm.unfccc.int/filestorage/H/2/9/H29X6EKQMJU7RY85DIT4ZPFAL3O1GW/eb67_repan22.pdf?t=SU98bWFuNTZrfDBcvhFBwGw8ZzwPauJ3MHMO

Box 1: Emissions Reductions per Household per Stove per Year

$$ER_y = B_{y,savings} * f_{NRB,y} * NCV_{biomass} * E_{projected\_fossilfuel}$$

Typical values:

fNRB = 0.5 to 0.96 (see the link on the next page for the value of each country)

NCV = 0.0156 TJ/ton (can vary)

EF = 81.6 tCO2/TJ (can vary depending on the baseline fuel)

Biomass savings (By): Varies from household to household; could be in the range of 40–60 percent of the consumption and on the efficiency of old and new stoves.

The demonstrably renewable biomass variable is defined as the woody biomass from either forest or nonforest land that is sustainably managed and where the conservation regulations are complied with. On a project-specific basis, this is typically addressed by using inventory data from the forest area that is protected or sustainably managed. Additionally, by requesting evidence for increasing fuelwood scarcity, AMS-II.G requires field studies that are often costly and time-demanding to project developers.

The basic calculation for emissions reductions generated as a result of changes in the supply side of biomass for cookstoves is based on biomass growth. Biomass can be determined using fairly standard forest inventory methods where trees are measured in sample plots and their volume or mass calculated using species-specific defaults. This biomass consists partly of carbon and partly of other things (like water), so the biomass is converted to tons of carbon using default values that make this conversion. The defaults are provided in the methodologies.

Credits are based on the difference between the amount of biomass or carbon estimated under the baseline and actually observed under the project. This is corrected for leakage where the main sources of leakage involve biomass loss outside the project boundary because of the displacement of activities.

Checklist to Assess Whether Key Data Are Available

Demand-Side Methodologies

Is default nonrenewable woody biomass available? If not, is it possible to calculate the fraction of nonrenewable woody biomass (NRB).	Yes ☐ No ☐
Is it possible to calculate the fraction of designated renewable biomass used?	Yes ☐ No ☐
Is it possible to calculate the amount of woody biomass saved?	Yes ☐ No ☐
Can the emissions from the fuel used prior to the project for cooking be calculated?	Yes ☐ No ☐
Can the efficiency of the new cookstove be measured?	Yes ☐ No ☐
Has leakage been accounted for?	Yes ☐ No ☐

Supply-Side Methodologies

Can the baseline biomass be determined (using standard forestry methods)?	Yes ☐ No ☐
Can leakage be accounted for?	Yes ☐ No ☐

General Nontechnical Requirements of Carbon Finance

Early Consideration

The aim of carbon finance is to trigger GHG emissions reductions that would not have happened without the carbon finance. Therefore, it is necessary to prove that carbon credits have been an integral component of the project since before the investment decision was made to implement. A number of proofs that are accepted in the regulated CDM market by the CDM executive board include the following:

- A public announcement that states that the project will go ahead thanks to the inclusion of carbon credits.
- Correspondence with either the host country DNA, the GS or the UNFCCC.
- Inclusion of carbon revenues in the feasibility study.
- A record of a board decision to implement the project as a result of the inclusion of carbon revenues.

Under voluntary markets, early consideration is also necessary. The GS requires the same evidence as under the CDM. The VCR, CAR, and ACR also accept business meeting minutes as justification of early consideration.

Stakeholder Consultation

- It is mandatory for any planner of a project activity in the carbon market to conduct a Local Stakeholder Consultation in order to ensure the general acceptance of the project activity, as well as the willingness to participate (that is, the monitoring process) on the part of the target group and the neighboring population. The consultation is to be based on either a detailed, substantive PIN or a draft Project Design Documentation (PDD).
- The recommended participants for a local stakeholder consultation include (a) local people affected by the project and their official representatives, (b) local policy makers and representatives of local authorities, and (c) local NGOs working on topics relevant to the cookstove projects. For CDM projects under the GS, an official representative of the DNA of the host country must also attend the stakeholder consultation, as well as a local GS expert or regional representatives of the relevant international NGOs supporting the GS. The GS requirements for reporting on planning, calling, conducting, and responding to stakeholder consultations are more detailed than those of the CDM EB or the other voluntary standards ACR, VCR, and CAR.
- Environmental Impact Assessment
- All projects seeking carbon finance must comply with the host country's requirements for environmental sustainability. An ex ante assessment of possible environmental impacts of the project must be included the project design documentation. The CDM regulations in the regulated market and the voluntary standards defined by VCR, ACR, and CAR require Environmental Impact Assessments if they are part of the host country's DNA requirements. The GS requests a detailed assessment of the project's impacts on sustainable development, including environmental impact assessment.
- Sustainability Assessment
- Under CDM, VCR, ACR, and CAR standards, the host country approves the sustainability of a project. The DNA has the right to withdraw a letter of approval in the event that a project fails to contribute to national sustainable development requirements. The project developer is not required to monitor the impact of a project on sustainable development once the project is registered.
- The GS requires more detailed assessment of a project's impact on sustainability. It is necessary to undertake a "no harm assessment," which assesses a project's impacts on human rights, labor standards, and environmental protection and anticorruption. Furthermore, the GS requires the completion of a sustainable development metric in which clear environmental, social, economic, and technological development indicators must be assessed. Finally, the impacts on sustainable development must be monitored.
- Clarifying Overseas Development AID and Carbon Finance
- Overseas development aid (ODA) is a category of finance from developed countries to developing countries with the aim of promoting economic development and welfare. ODA funding can be used to cover the transaction costs associated with project identification and PDD development, but not for the purchase of credits that will be used to meet emissions reduction obligations. As a result, public

funding for CDM projects and voluntary projects must be disclosed.

- Nontechnical Issues Checklist
- Check that all the nontechnical issues have been considered. If there is a negative response to the questions below, your project may not be eligible for carbon finance.
- CDM, VCR, ACR, CAR Standards

Early consideration: Is there evidence of early consideration of carbon finance prior to the investment decision?	Yes ☐ No ☐
Stakeholder consultation (SC): Will the SC review a detailed project design?	Yes ☐ No ☐
Environmental impact assessment: If the country requires an EIA has this or will this be implemented prior to operations?	Yes ☐ No ☐
Impact on sustainable development: Has the DNA approved the project complies with national sustainable development objectives in the form of a letter of approval?	Yes ☐ No ☐

GS Standard

Are the DNA representative and a local GS representative attending the local stakeholder consultation?	Yes ☐ No ☐
Are the sustainable development assessment and matrix complete?	Yes ☐ No ☐

Monitoring, Validation and Verification (MRV)

Monitoring

Monitoring involves the repeated observation of factors and procedures on which baseline, project, and leakage emissions are based. The GS standards provide the most detailed requirements for monitoring.

In general, monitoring is to consist of an annual check of all appliances in use or a representative sample thereof. The EB has issued "Draft General Guidelines on Sampling and Surveys—Efficiencies of Stoves in Use" (if stoves are being replaced—for example, because they have reached their projected life span—it must be ensured that the replacement stove has a similar efficiency as the stove being replaced) or an incentive scheme is in place to replace the old stove.

Key parameters to be monitored include the following:

- Disposal of old appliances and/or halting fuelwood consumption with old stoves that are still in use Leakage factors.
- Fraction of nonrenewable biomass.

Every stove distributed must have a number (that is, it should be labeled), so that it can be clearly identified. Additionally, a customer database is required in which the address and telephone number of the stove purchaser are included. It is recommended that project developers planning a CDM stove project or voluntary standard other than the GS take the much more detailed monitoring requirements of the GS methodologies into account. Monitoring under the GS standards requires the maintenance of a total sales record, a detailed customer database and, a project database. The following must be monitored from the project:

- The efficiency of the project appliances and their continuation of operation (such as by representative sample)—a biannual check.
- The amount of woody biomass saved under the project—annual monitoring.
- The amount of thermal energy generated by the new renewable energy technology under the project.
- The amount of woody biomass saved under the project (based on surveys) that is used by nonproject households and users (who previously used renewable energy sources).
- Ensuring that old equipment is disposed of.

In addition, the GS methodology requires conducting a survey every three months. The sample size for the kitchen surveys must be 10 percent of the number of customers, but a minimum of 25 randomly selected customers. It is advisable to train additional staff to be solely responsible for the annual monitoring surveys and observations. A detailed monitoring plan and manual should help the monitoring staff with their surveys.

APPENDIX 5

Examples of Options for Facilitating Household Use of LPG		
Goal	**Option**	
Lower costs to consumers	Exploit economies of scale	Hospitality arrangements, third-party access
		Bulk purchase, joint purchase, large import parcels
		Large refineries
	Lower barrier to entry	Hospitality arrangements, third-party access
	Minimize demurrage charges	Rapid customs clearance
		Reduced port congestion
		Round-the-clock staffing by port authorities
		Adequate port receiving capacity
	Minimize short-selling	Clear marking of cylinder tare weight
		Enforcement of scale calibration and date of last scale calibration visible to customers
		Customer's right to check cylinder weight
		Industry association's (voluntary) seal of quality or certification
		Publication of names of companies found short-selling
	Increase price competition	Posting of prices by company, location, and cylinder size on government website
		Competition policy
	Improve auxiliary infrastructure	Improved road conditions
		Improved port infrastructure in importing countries
Enhance safety	Establish clear regulations	Formal adoption of international standards by reference
		All regulations posted in one place on the Internet in reverse chronological order
		Training of supply personnel legally required
		Education of consumers about safe handling of LPG legally required
	Enforce safety regulations	Where there is a ban on cross-filling, ban effectively enforced
		Small fee levied to finance monitoring and enforcement
		Registry of certified installers
		Clearly marked date of last cylinder recertification
		Registry of certified private inspectors operating under government supervision
		Training workshops organized by LPG industry association
		Publication of names of companies violating safety rules
	Educate consumers	Pictorial guides in local languages, newspaper/radio/TV advertisements, Internet posting of safety information
		Neighborhood demonstrations by retailers, industry association, and consumer groups
		In-house demonstration of proper cylinder and stove handling by installers

(continued on next page)

Examples of Options for Facilitating Household Use of LPG *(continued)*

Goal	Option	
Target financial assistance	Move away from universal price subsidies	Expansion of social safety net program to help pay for LPG, such as cash transfers or vouchers
	Spread or reduce upfront adoption cost	Dealer incentives for cylinder deposit fee and stove
		Dealer-financed installment plan
		Microfinance scheme
		Small cylinders in niche market
Minimize shortages	Require minimum commercial and/or strategic stockholding in regulations	
	Ensure reasonable returns (through, for example, removal of universal price subsidies) to efficient operators to build capital for construction of storage facility	
	Encourage hospitality and third-party access	
Raise awareness and involve consumers in improving market conditions	Government: Publish price information, industry statistics, frequently asked questions, safety tips, and names of companies violating rules that directly affect consumers on the Internet and in reports; establish a simple mechanism for registering complaints	
	Industry association: Publish information, frequently asked questions, and safety tips on the Internet; publish brochures; take out newspaper/radio/TV advertisements; publicize information on retailer location and contact details; establish quality control and issue seals of quality for companies in compliance; establish a simple mechanism for registering complaints against members	
	Companies: Disseminate information on proper handling of LPG cylinders, frequently asked questions, and safety tips; have installers show new customers in their homes how to handle an LPG cylinder and stove properly; establish a simple mechanism for registering complaints	

Source: Kojima 2011.

APPENDIX 6: TYPOLOGY OF THE COSTS AND BENEFITS OF COOKSTOVES AND THE EQUATIONS USED FOR THEIR CALCULATIONS

Costs	Examples	Benefits	Examples
Capital ("hardware") [*Cap*]	Cost of new technologies: Improved cookstoves; ventilation/cooking space improvements; etc.	Morbidity & mortality reductions [*Morb*]; [*Mort*]	Benefits from reduced incidence of and mortality from disease (acute respiratory infections (esp. ALRI); COPD; etc.)
Program ("software") [*Prog*]	Cost of implementation/delivery: Marketing and promotion materials; NGO/government staff time; etc.	Time savings [*Timesav*]	Benefits of reduced cooking time (due to more efficient heating)
Operation and maintenance [*O&M*]	Cost of replacing/cleaning of equipment, including time	Aesthetic gains	Benefits from reduced in-house exposure to unpleasant soot and smoke; reduced indoor cleaning
Fuel [*Fuel*]	Cost of fuel, in collection and preparation time and/or money	Improved social standing	Benefits of improvements in household status from acquisition of improved stoves
Learning [*Learn*]	Costs of familiarization with the use of a new stove technology	Environmental [*Carb*]; [*Bio*]	Benefits from reduced emissions of black carbon and decreased tree cutting
Inconvenience	Costs related to any undesirable changes in cooking practices made necessary by the new stove		
Equations			
Cap	$\mathrm{Cap} = (\mathrm{cc}_i \cdot \mathrm{crf})/12$		(Eq. 1)
Prog	$\mathrm{Prog} = \mathrm{cp}/12$		(Eq. 2)
O&M	$\mathrm{O\&M} = \chi \cdot (\mathrm{cm}_i - \mathrm{cm}_0)$		(Eq. 3)
Fuel	See main text for detailed derivation and discussion.		
	For wood-burning stoves: $\mathrm{Fuel} = \chi \cdot \left\{ \left[\left({}^{\varepsilon_{f0} \cdot \mu_0}/_{\varepsilon_{fi} \cdot \mu_i} \right) - 1 \right] \cdot [\mathrm{Fuel}_0 \cdot f \cdot p_0 + 30 \cdot \mathrm{collt}_0 \cdot (1-f) \cdot v^t \cdot w] + 30 \cdot \mathrm{prep} \cdot v^t \cdot w \right\}$		(Eq. 4a)
	For other stoves: $\mathrm{Fuel} = 30 \cdot \chi \cdot \left\{ \left[\left({}^{\varepsilon_{f0} \cdot \mu_0}/_{\varepsilon_{fi} \cdot \mu_i} \right) \cdot p_i - f \cdot p_0 \right] \cdot \mathrm{Fuel}_0 - \mathrm{collt}_0 \cdot (1-f) \cdot v^t \cdot w \right\}$		(Eq. 4b)
Learn	$\mathrm{Learn} = l \cdot v^t \cdot w \cdot crf/12$		(Eq. 5)
Morb	$Morb = hhsize \cdot \chi \cdot (\eta_i^{ARI} \cdot I^{ARI} \cdot COI^{ARI} + \eta_i^{COPD} \cdot p^{COPD} \cdot COI^{COPD} \cdot e^{-d \cdot \delta})/12$		(Eq. 6)
Mort	$Mort = hhsize \cdot \chi \cdot VSL \cdot (\eta_i^{ARI} \cdot I^{ARI} \cdot f^{ALRI} \cdot CFR^{ALRI}) + (\eta_i^{COPD} \cdot drate^{COPD} \cdot COI^{COPD} \cdot e^{-d \cdot \delta})/12$		(Eq. 7)
Timesav	$\mathrm{Timesav} = cookt_0 \cdot \chi \cdot (1 - \varepsilon_g) \cdot v^t \cdot w \cdot 30$		(Eq. 8)
Carb	$\mathrm{Carb} = ccarb \cdot \chi \cdot [\mathrm{Fuel}_0 \cdot (\gamma_0 \cdot \mu_0/\varepsilon_{f0}) - \mathrm{Fuel}_i \cdot (\gamma_i \cdot \mu_i/\varepsilon_{fi})]/10^6$		(Eq. 9)
Bio	$\mathrm{Bio} = \chi \cdot ce \cdot F_0$		(Eq. 10)
Total net benefits = Benefits − Costs = *Morb*+*Mort*+*Timesav*+*Carb*+*Bio* −*Cap*+*Prog*+*O&M*+*Fuel*+*Learn*			

Notes: All parameters are defined in Table 2; unless otherwise noted here. The capital recovery factor (crf) = $[\delta \cdot (1+\delta)^{T_i}]/[(1+\delta)^{T_i} - 1]$, where δ = discount rate; and T_i = lifespan of stove *i* (yrs). The following categories are not included in the model: Inconvenience costs, aesthetic gains, and improved social standing.
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Source: Jeuland and Pattanayak 2012.

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