Household Cookstoves, Environment, Health, and Climate Change:

A New Look at an Old Problem

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Preface

The nexus of cooking practices, household economics, health, forest and agricultural resource management, and global greenhouse gas (GHG) emissions has re-emerged as a transformative opportunity to improve individual lives, livelihoods, and the global environment. The value chain around cookstoves—perhaps the simplest and oldest household technology—presents an opportunity to put the integrative idea of sustainable development into practice.

Research on improved cookstoves dates back to the 1950s; the ensuing decades witnessed large-scale field programs centered on increasing the efficiency of certain stove designs. Over the past 30 years, the focus of the international community has gradually shifted toward the sociocultural contexts in which the stoves operate. While the stoves themselves may have been simple, their effects on household and regional health and economics have often been complex and far-reaching. In short, many approaches to introducing improved stoves have been tried, with some successes and many failures.

The legacy of investment by the World Bank Group (WBG) in stove research and practical action featured a household energy program in the 1980s, which included a focus on clean cooking; at that time, various national governments also directed efforts to cookstoves. Interest in household energy dissipated in the 1990s as the development focus shifted toward rural electrification. But in the last few years, interest in the myriad aspects of stoves has revived, with an increasing number of reports published within the World Bank and by a growing network of researchers and practitioners—ranging from the World Health Organization, the United Nations Development Programme, and the International Energy Agency to partners in academia and civil society.

In the process, there has emerged a more comprehensive view of the health risks of indoor air pollution and the effects of GHG emissions associated with the life cycle of stoves on the global climate. Currently, it is estimated that 2 million lives—mostly women and children—are lost annually, resulting from exposure to indoor biomass cooking smoke. While debate continues on the specific aspects of stove and fuel impacts and approaches, broad agreement has been reached on the extent of the problem and the need to partner globally.

Today, a promising new global partnership chaired by the United Nations Foundation, known as the Global Alliance for Clean Cookstoves (GACC), has emerged. Recognition of its potential impact as a globally coordinated, knowledge-sharing approach has meant a rapid rise in the GACC's involvement to a $100 million partnership. The WBG has joined the alliance through the Energy Sector Management Assistance Program (ESMAP) and a renewed commitment to a team focused on household energy issues.

Household Cookstoves, Environment, Health, and Climate Change: A New Look at an Old Problem takes stock of our collective knowledge of actions and opportunities centered on clean stoves. The report not only examines the lessons learned in specific stove campaigns; it builds the case for a multisectoral approach to understand the effects of stove policies and programs.

After reviewing the state of cookstove research and action, the report takes a welcome and much needed look at the potential "game changers" associated with cookstoves. It examines opportunities for technology development, leading to the availability of "advanced" biomass stoves; new sources and mechanisms of financing, including those linked to climate change; and the formation of new international coalitions and partnerships like the GACC. Based on these assessments, the report makes a compelling case for the WBG's re-engagement in the development community on many dimensions of a field that can benefit most from the reach, lessons sharing, and practical focus that a multinational development agency can offer.

As a researcher with a long personal memory of and engagement in cookstove projects and programs, I could not be more pleased to see this report published. Scaling up stove and fuel programs can provide a transformative tool for sustainable development. Providing clean cooking for the poor can deliver large health and multiple other benefits that are vital for human development. This timely report, which supports the WBG's re-engagement on this important topic, provides a roadmap for that effort.

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Acronyms and Abbreviations

ALRI	Acute Lower Respiratory Infection
ARI	Acute Respiratory Infection
BC	Black Carbon
BioCF	Bio Carbon Fund
BMZ	German Federal Ministry for Economic Cooperation and Development
CDCF	Community Development Carbon Fund
CDM	Clean Development Mechanism
CEIHD	Centre for Entrepreneurship in International Health and Development (now known as Impact Carbon)
CIF	Climate Investment Funds
DGIS	Netherlands Directorate-General of Development Cooperation
FCPF	Forest Carbon Partnership Facility
FIP	Forest Investment Program
GACC	Global Alliance for Clean Cookstoves
GEF	Global Environment Facility
GHG	Greenhouse Gas
GTZ	German Agency for Technical Cooperation
GWP	Global Warming Potential
IAP	Indoor Air Pollution
IFC	International Finance Corporation
LED	Light Emitting Diode
LPG	Liquefied Petroleum Gas
M&E	Monitoring and Evaluation
OC	Organic Carbon
PCIA	Partnership for Clean Indoor Air
PIC	Products of Incomplete Combustion
PM	Particulate Matter
REDD	Reduced Emissions from Deforestation and Forest Degradation
SFM	Sustainable Forest Management
SHS	Solar Home System
SREP	Scaling Up Renewable Energy Program
WBG	World Bank Group

Executive Summary

Context

Indoor biomass cooking smoke is associated with a number of diseases, including acute respiratory illnesses and even cancer, with women and young children affected disproportionately. They are exposed to levels of indoor cooking smoke, in the form of small particulates, up to 20 times higher than the maximum recommended levels of the World Health Organization (WHO 2005). It is estimated that smoke from cooking fuels accounts for nearly 2 million deaths annually (WHO and UNDP 2009), which is more than the deaths from malaria or tuberculosis; by 2030 over 4,000 people will die prematurely each day from household air pollution (IEA 2010).

Using traditional biomass stoves for household cooking in developing countries requires extensive local fuel collection and is linked to local environmental problems. Open fires and primitive stoves are inefficient at converting energy into heat for cooking; the amount of biomass cooking fuel required each year can reach up to 2 tons per family. Where demand for local biomass outstrips the natural regrowth of resources, local environmental problems can result. While many local communities can and do manage their biomass supplies sustainably, tremendous amounts of time—a burden shouldered disproportionately by women and children—may be spent collecting and managing these resources (Kammen 2002).

There is mounting evidence that biomass burned inefficiently contributes to climate change at regional and global levels, suggesting that the climate change debate needs to take household energy issues into consideration. In developing countries, about 730 million tons of biomass are burned each year, amounting to more than 1 billion tons of carbon dioxide (CO_2) emitted into the atmosphere. Other products of incomplete combustion and climate forcers further exacerbate the problem. With better fuels and more efficient cookstoves, such emissions could be reduced. Under conditions of sustainable production and more efficient fuel use, biomass energy is renewable. However, in many regions, little attention is paid to this issue, and scant research is undertaken to assess whether biomass energy is being produced and burned in a sustainable way.

Background

Though the solutions to these problems—such as replacing traditional cookstoves with improved or advanced biomass cookstoves or switching to liquefied petroleum gas (LPG) or other cleaner fuels—are straightforward, most studies indicate households will depend on biomass energy or solid fuels for decades to come. The reason is that LPG and other petroleum fuels are affordable only with higher incomes. Thus, this report focuses only on the promotion of better cookstoves to alleviate problems associated with the use of biomass or solid fuels.

Many past biomass cookstove programs have underperformed, leading to the misperception that all programs have failed. Unsuccessful past programs were often based on cookstoves that performed well in the laboratory or when first installed, but then deteriorated quickly, often breaking down within a year. Failure was due, in part, to a lack of standards and quality control. In addition, many past programs had short-term financing and were supply-driven, with little attention paid to stove design, market development, or the consumer research needed for long-term business growth.

Potential "Game Changers"

Significant recent developments can be potential "game changers" in the way biomass cookstoves and cookstove programs are perceived and implemented. Today, a new generation of advanced and more effective improved biomass cookstoves is available commercially.* In addition, significant experience has been accumulated in developing and implementing small-scale and disaggregated financing programs. Furthermore, new financing instruments and sources, especially those linked to climate-change mitigation, are available. Finally, coalitions supporting cookstoves and clean cooking are being formed, coincident with a resurgence of interest in household energy use.

The advanced biomass cookstoves are manufactured in factories or workshops, undergo rigorous consumer testing before public introduction, and pay attention to performance. Many of these cookstoves have been supported by a consortium of established private-sector organizations and donors. In addition, the less expensive, effective improved cookstoves that meet certain performance standards are also an option.

Lessons from financing small-scale energy funds provide a good starting point for cookstove financing. The experience of financing disaggregated renewable-energy projects, such as solar home systems (SHSs), can be useful in understanding how to defray high initial costs, move from niche to mainstream markets, scale up from pilots, and use grants and subsidies creatively. In addition, there is accumulated evidence from social and community funds, as well as other microfinanced enterprises.

With the advent of new funds, especially those affiliated with international climate finance, potential avenues for financing new initiatives are opening up. The Global Environment Facility, Carbon Funds, and Climate Investment Funds offer potential opportunities

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* For consistency, we have adopted the following terminology. *Traditional stove* refers to either open fires or stoves constructed by artisans or household members that are not energy efficient and have poor combustion features. *Improved cookstove* is used in the historical sense for stoves installed in "legacy" programs, usually with a firebox and chimney, but without standards and with poor quality control. *Advanced biomass cookstove* refers to the more recent manufactured stoves, based on higher levels of technical research; these stoves are generally more expensive and are based on higher, but as yet not well-defined, standards that include safety, efficiency, emissions, and durability; among others, they might include wood, charcoal, pellet, and gasifier stoves. Finally, the *effective improved cookstove*, cheaper but close in performance to advanced biomass cookstoves, is assembled on-site by qualified installers adhering to standards.

for financing. Another possibility worth exploring is private-sector development financing, such as through the International Finance Corporation.

New international coalitions and initiatives are forming around the issue of promoting advanced and effective improved biomass cookstoves and alleviating indoor air pollution. Worth mentioning here are the two most recent alliances/initiatives: (i) the Global Alliance for Clean Cookstoves (GACC), led by the United Nations Foundation and (ii) the Government of India's re-launched program on improved cookstoves, which will award a prize in partnership with the global X PRIZE Foundation.

The Challenge

Though these developments are promising, the road to larger-scale adoption is not without challenges. Scaling up requires strong and sustained support in a number of areas. These are: national institutions promoting advanced biomass cookstoves; financing institutions that can administer energy funds to support biomass cookstoves; development of performance standards and benchmarks on safety, (energy) efficiency, emissions, and durability; technical research and development; monitoring and evaluation (M&E) mechanisms; intelligent financing mechanisms that can target subsidies and grants; awareness raising, business development, and consumer research; adapting cookstoves and programs to country contexts; and taking account of consumer preferences and behavior.

Key components to be addressed include improvements in performance standards and protocols and methods to finance the higher initial costs of advanced biomass cookstoves. There will be a need to develop standards for stove performance and testing methods. The idea is that cookstoves should be certified as safe, reliable, efficient, and clean burning; however, there may be scope for tiers of certification. Certainly, the issue of methods to finance the high initial costs will need to be addressed, along with appropriate subsidy levels for the cookstoves themselves. It will be necessary to clearly understand and designate the respective roles of governments, nongovernmental organizations, microfinance organizations, and the private sector in programs to promote advanced biomass and effective improved cookstoves. Making these general recommendations more specific would require some country context.

A Way Forward

Developing and deploying the new generation of cookstoves at scale would cover a broad agenda, requiring cooperation among a range of diverse stakeholders on energy access. There is scope to support the technical development and innovation of all stove types under the umbrella of providing clean and affordable household energy to the poor. It would be crucial to have widely accepted standards and testing protocols, as well as active M&E protocols for both the advanced biomass and effective improved cookstoves. The required financial engineering would need to balance loans and grants, taking both cost and affordability into consideration; and the role of climate-finance instruments would need to be further explored. Scaling up deployment would require learning from other successful programs, including SHSs and water and sanitation interventions, and awareness raising and publicity, along with multiple complementary partnerships among government, the private sector, development partners, and nongovernmental organizations so that all stakeholders perform to their comparative advantage.

Today there is a renewed momentum to promote advanced biomass cookstoves that are affordable and burn fuel cleanly and efficiently. The building blocks appear to be falling into place: advanced biomass cookstoves backed by private-sector interest, new financing models and sources, and a coalition of the willing across stakeholder groups (e.g., the recently formed United Nations Foundation–led GACC, which the World Bank has joined). A point of entry for development institutions like the World Bank is the International Development Association (IDA) 16 consensus on mainstreaming gender and climate change in development assistance. Furthermore, the provision of clean and affordable household energy is an integral part of scaling up energy access for the poor. The social and economic consequences of reducing the hours women spend collecting biomass fuel, improving their health, and freeing up their time for more beneficial activities might well result in raising the living standards of an entire generation of children and households. Finally, at the global and regional levels, advanced cookstoves could contribute to a reduction in greenhouse gases and other climate forcers attributed to biomass burning.

Chapter 1. Introduction

Open fires and primitive stoves have been used for cooking since the beginning of human history. They have come in various sizes and styles, having been adapted to myriad cultures and food preparation methods. As society has progressed, more sophisticated stove models have been developed. Today's modern kitchens reflect the many types of standardized and specialized cooking devices available, from coffee and tea pots to toasters and gas cooktops.

But in many developing countries worldwide, the poor still burn biomass energy to meet their household cooking needs. These open fires are fairly inefficient at converting energy into heat for cooking; the amount of biomass fuel needed each year for basic cooking can reach up to 2 tons per family.[1] In addition, collecting this fuel sometimes can take an hour a day on average. Furthermore, these open fires and primitive cookstoves emit a significant amount of smoke, which fills the home; this indoor cooking smoke has been associated with a number of diseases, the most serious of which are chronic and acute respiratory illnesses, such as bronchitis and pneumonia. Moreover, where demand for local biomass energy outstrips the natural regrowth of local resources, environmental problems can result. There is evidence that biomass fuels burned in traditional ways contribute to a buildup of greenhouse gases (GHGs) (Venkataraman et al. 2010), as well as other climate forcers, including black carbon (BC), in the atmosphere (Ramanathan and Carmichael 2008).

Although the energy-efficiency aspects of this issue have been known since the early 1950s, it was not until the 1970s that they were broadly publicized. Labeled as the "other energy crisis" (Eckholm 1975), such health and environmental issues had gone virtually unnoticed for thousands of years. Today, such patterns of household energy use and local fuel collection linked to poor health and local environmental pressure are well recognized by most policy makers. The main sticking point is how to develop effective policies and programs to address the problem.

During the 1980s and 1990s, much research work was devoted to household energy issues in developing countries; at that time, the problem was viewed mainly as an interfuel substitution or biomass energy-efficiency issue, based on worries about fuel scarcity and deforestation (World Bank 1996). Beginning in the 1990s, the focus shifted more toward research on issues involving indoor air pollution (IAP) and its effects on health. Indeed, over the last 15 years, growing scientific evidence has revealed that household air pollution contributes not only to respiratory illness but to a range of other diseases, including cataracts and possibly cancer (Ezzati, Saleh, and Kammen 2000; Bruce, Perez-Padilla, and Albalak 2002). In the last 5 years, with the advent of climate change as a major international concern, it is apparent that the 730 million tons of biomass fuel burned annually in developing countries as household fuel contribute to the buildup

[1] By contrast, a family that uses LPG as its cooking fuel requires only about 0.2 tons per year.

of a variety of GHGs in the atmosphere. This fact has recently been recognized as relevant to the Clean Development Mechanism (CDM) under the United Nations Framework Convention on Climate Change (UNFCCC).

Unfortunately, the problem has not been addressed in a systematic way that would garner the attention of most country governments or international donors. According to a recent review of World Bank lending between 2000 and 2008, less than 1 percent of this financing was directed toward clean cooking (Barnes, Singh, and Shi 2010). A major difficulty is that household energy cuts across multiple sectors, including energy, forestry, gender, health, and climate change. Within such sectors as health, possible interventions are spread across a variety of diseases and populations, making it more difficult to interest policy makers, who are reluctant to assume responsibility for issues not squarely in their domain. Also, past programs to address biomass energy problems sometimes did not perform as well as they had hoped.

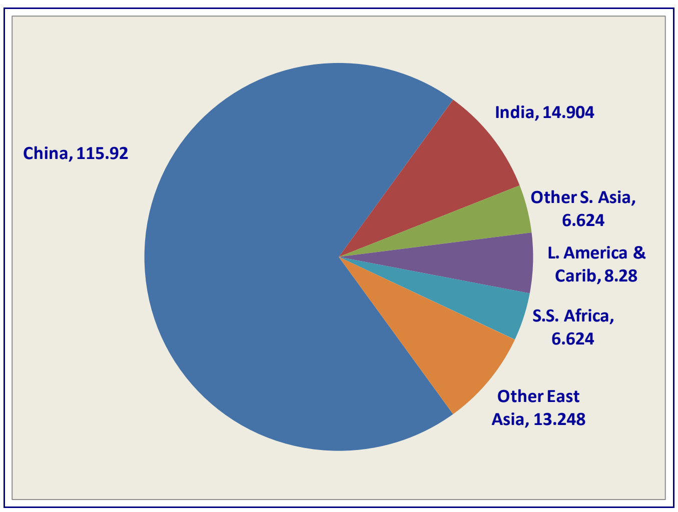
This report takes a fresh look at what new approaches might be used to tackle this well-known yet complex multi-sector issue. Although there are other ways to reduce household air pollution, including interfuel substitution and household ventilation, this study focuses mainly on the recently developed biomass cookstoves for developing countries and their financing models and sources. Known by many as “advanced biomass cookstoves,” these new cookstoves generally have better energy-combustion properties and reduce fuel consumption by about half. Such innovations warrant the development of a more serious program to deal with both the emissions and health issues resulting from cooking with open fires or traditional biomass cookstoves.

Chapter 2. What Is an Improved Cookstove?

Defining an improved stove, generally regarded as a relative concept, depends on several factors: (i) type of traditional stove considered, (ii) aim of the design improvement, and (iii) affordability issues. Traditional cookstoves can range from three-stone open fires to substantial brick-and-mortar models and ones with chimneys. An improved stove can be designed to improve energy efficiency, remove smoke from the indoor living space, or lessen the drudgery of cooking duties. In the early stages of most improved stove programs, many models were designed so that even the poorest customers could afford them. Valued at about US$5 or less, the best of these improved cookstoves represented an improvement over a three-stone open fire; still they were rudimentary devices.

Today there is growing sentiment to support a wider variety of more refined cookstoves, which are sometimes more expensive. Given the many cookstoves used by rural and urban populations in developing countries, improvements can differ markedly by country or region. Thus, "improved cookstove" is an umbrella term encompassing an array of diverse cookstoves.[2]

Figure 1. Distribution of Improved Cookstoves (millions of stoves)



Source: WHO and UNDP (2009).

Note: Data are from the most recent national household surveys that included questions on household stove types used. Cookstoves with enclosed fire boxes and chimneys, considered "improved," should not be confused with the advanced biomass cookstoves described in this report.

[2] The terms *stove* and *cookstove* are used interchangeably in this report.

Among many development specialists today, the mere mention of "improved cookstoves" may conjure up images of millions of cookstoves now broken or long since disposed of rather than the 166 million cookstoves still being used (Figure 1). Only China has a high percentage of households that have adopted better cookstoves, at about 40 percent, while adoption in the other regions generally has been much lower.

Despite these numbers, both large and small past programs experienced many challenges, as well as some successes. Many small-scale programs lacked technical standards to ensure delivery on improvements, and cookstoves of poor durability sometimes broke down within a year.

Review of Past Experience

The development of improved biomass cookstoves in many countries has witnessed several overlapping stages over the last 30 years (Kammen 1995). Currently, several types of programs exist concurrently. Out of a total solid-fuel population of 3 billion people, about 828 million in developing countries now use improved cookstoves (WHO and UNDP 2009). These findings are taken from international surveys that included questions on whether stoves were for cooking, were equipped with chimneys, and were enclosed or open.

Cookstoves with chimneys and closed combustion chambers were usually considered "improved." The number of households using these relatively inexpensive, improved cookstoves totals roughly 166 million, with 116 million in China, more than 13 million in the rest of East Asia, nearly 22 million in South Asia, about 7 million in Sub-Saharan Africa, and over 8 million in Latin America and the Caribbean (where there is extensive use of petroleum fuel). Out of every four developing-country households dependent on solid fuels for cooking, only one uses a stove with a chimney or smoke hood.

The main focus of the original stove programs developed during the energy crisis of the 1980s was energy conservation. During the 1990s, the literature on Indoor Air Pollution (IAP) began to link smoky stoves with health issues. At the time, it was accepted that a chimney was needed to remove smoke from the house. Thus, energy conservation and smoke removal became a popular mandate.

From 1980 until about 2002, hundreds or even thousands of artisan-produced cookstove models were developed. As one might imagine, with repeated heating and cooling, such cookstoves easily cracked and degraded. Their estimated two-year life span proved too optimistic; in practice, some failed within a year. A typical stove of this period was the Lorena, originally developed in Guatemala. The stove's name is derived from mud (*lodo*) and sand (*arena*), the primary materials used to build it. Popularity of the Lorena stove among Latin America's nongovernmental organizations (NGOs), governments, and donor agencies increased. But use of varying sizes and low-quality construction materials reduced reliability, leading to user dissatisfaction. Today the Lorena stove is only rarely produced in Latin America.

In the late 1990s and early 2000s, there emerged a second generation of cookstoves, which, while more expensive, were constructed of more durable materials. Examples can be found in both Latin America and China. In Latin America, the Plancha—so-named because of its prominent metal griddle (*plancha*)—was disseminated under Guatemala's social fund program. A more expensive, durable stove lasting a decade or more, the Plancha has a metal top used for roasting corn and preparing tortillas and other staple foods, a shelf for feeding wood, space on top for placing cooking utensils and equipment, and a chimney for venting smoke (Boy et al. 2000). Having a durable stove with many convenient features, combined with the freedom to select options, led to a high degree of continued stove use.

China's experience provides ample evidence that development of a program for better cookstoves can succeed, given that more than 100 million improved cookstoves are still in use in that country (Figure 1). China has achieved the largest improvement in energy efficiency as a result of its programs in the 1980s and 1990s (Smith and Deng 2010; Sinton et al. 2004). The National Improved Stove Program (NISP), implemented through county rural energy and other agencies, was an enormous success by any standard. The main program focus was energy efficiency and household smoke removal with a chimney. Although the program is no longer extensively funded, the private sector still produces stove components and is leading the way by producing more efficient and less polluting models. Many of the new biomass cookstoves are manufactured in factories in China and exported to many parts of the world.

These programs were at times popular among both donors and countries. That some 166 million cookstoves with an enclosed fire and chimney are still in use is quite a legacy for the efforts of many countries and donors. However, despite some very good programs during that period, significant problems were encountered in program implementation. A case in point is India, where, after two decades of attempting to promote improved cookstoves, the national effort was ended around 2002.

Terminology Clarification

There is no universally accepted definition of "cookstoves" linked to performance or technical standards. For now, it is virtually impossible to use a wider set of precise measures with which to distinguish an "improved" stove from an "advanced" stove. Thus, throughout this paper, the term *traditional stove* refers to either open fires or cookstoves constructed by artisans or household members that are not energy efficient and have poor combustion features. *Improved cookstove* is used in the historical sense for cookstoves installed in "legacy" programs, usually with a firebox and chimney, but without standards and with poor quality control. *Advanced biomass cookstove* refers to the more recent manufactured cookstoves, based on higher levels of technical research; these cookstoves are generally more expensive, and are based on higher, but as yet not well-defined, standards that include safety, efficiency, emissions, and durability; among others, they might include wood, charcoal, pellet, and gasifier cookstoves. Finally, the *effective improved cookstove,* cheaper but close in performance to advanced biomass cookstoves, is assembled on-site by qualified installers adhering to standards.

Chapter 3. Importance of Improving Household Cooking

In most countries, cooking is mainly considered the responsibility of women, who spend a significant amount of their time preparing food for their families. Cooking practices can be made easier by using more modern fuels (e.g., kerosene or LPG), improving the quality of charcoal production, and using electric appliances. In this report, we focus mainly on the role of cookstoves in reducing emissions, eliminating drudgery, and improving overall quality of life.

The pervasive use of biomass energy explains why the quality of the cookstoves used by developing-country households is so important. About half of the people in developing countries—and more than 90 percent of rural residents in many countries—use biomass energy (including wood, dung, and agricultural residue) as their main cooking and heating fuel. For the 2.5 billion people who rely on biomass energy (Table 1), collecting biomass for cooking is a frequent, arduous task. As mentioned above, the research evidence has been increasing on the links between indoor air pollution (IAP) from biomass-based fuel use and a variety of illnesses (WHO and UNDP 2009).

Table 1. Reliance on Traditional and Modern Fuels, 2007
(millions of people)

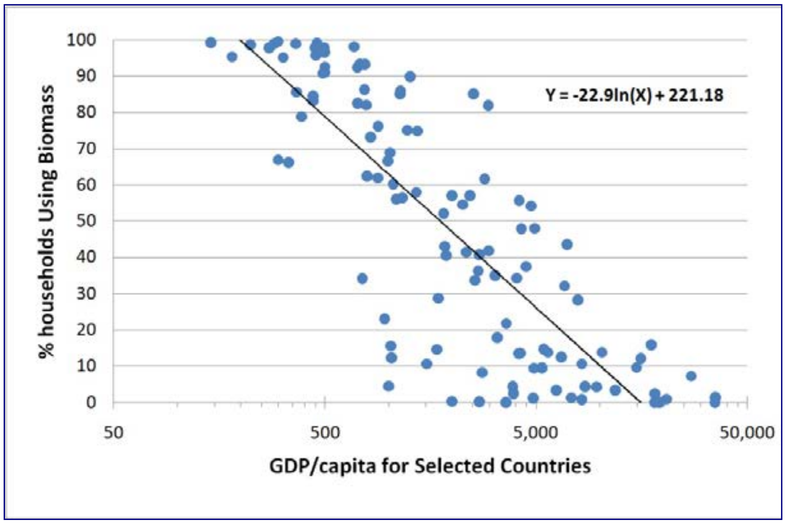
Developing region or grouping	Solid-fuel use			Modern-fuel use
	Traditional biomass	Coal	Total	LPG, kerosene, gas, and electricity
Total developing country	2,564	436	2,999	2,294
Less developed countries	703	12	715	74
Sub-Saharan Africa	615	6	621	132

Source: WHO and UNDP (2009).

Poverty and Biomass Use

Biomass use is also closely intertwined with poverty (Figure 2). As their incomes rise, households in developing countries generally switch to LPG fuel and various types of specialized electric cooking appliances. Thus, income growth is one obvious answer to the problems of biomass energy use in developing countries. However, a doubling of typical incomes in a country would reduce the number of people dependent on biomass energy for cooking by only 16 percent (formula, Figure 2), suggesting that the use of biomass fuel among developing-country households will continue for years to come (IEA 2009). Thus, it is necessary to consider programs that involve the complete combustion of biomass fuels, along with policies to encourage fuel substitution (Box 1).

Figure 2. Household Biomass Energy Use and GDP in Developing Countries, 2007



Source: WHO and UNDP (2009).

Box 1. Energy poverty and biomass energy: Recent findings from Bangladesh

Several approaches used to measure energy poverty over the past 20 years have defined the energy poverty line as the minimum quantity of physical energy needed to perform such basic tasks as cooking and lighting. Recent research in Bangladesh used a demand-based approach to define the energy poverty line as the threshold point at which energy consumption begins to rise with higher household income. At or below this threshold, households consume a bare minimum level of energy and should be considered energy poor.

This approach was applied using cross-sectional data from a comprehensive 2004 household survey representative of rural Bangladesh. The findings suggest that some 58 percent of rural households in Bangladesh are energy poor, versus 45 percent that are income poor. While both poor and non-poor households use biomass energy, the non-poor can collect and purchase higher-quality biomass fuels (table).

Energy use by energy poor and non-poor households in rural Bangladesh, 2005

Energy consumption (per capita/month)	Energy poor	Energy non-poor
Biomass (kgOE)	1.60	4.31
Kerosene (kgOE)	0.06	0.08
Grid electricity (kWh)	1.04	10.85
All energy sources (kgOE)	1.75	5.31

Note: kgOE = kilograms of oil equivalent; kWh = kilowatt hours.

These findings indicate that policies to support the energy poor generally should encourage more efficient use of traditional fuels; they also suggest that policies to support rural electrification and greater use of improved biomass stoves might play a significant role in reducing energy poverty.

Source: Barnes, Khandker, and Samad (2011).

Health Problems

Women and children in developing countries are exposed each day to pollution from indoor cooking smoke, in the form of small particulates, up to 20 times higher than the maximum recommended levels of the World Health Organization (WHO) and other environmental agencies around the world (WHO 2005). Smoke from cooking fuels is estimated to account for nearly 2 million deaths, more than 99 percent of which occur in developing countries (WHO and UNDP 2009). This means that a significant percentage of the annual burden of disease is caused by cooking smoke. Because mothers and their young children are the main household members who regularly breathe such cooking smoke, they are disproportionately affected by the related health issues. Children are especially vulnerable; indeed, strong evidence supports the causal linkages between biomass combustion emissions and acute respiratory infection (ARI) among children (Smith 2000; Smith et al. 2000a; Parikh et al. 2001; Kammen, Bailis, and Herzog 2002) (Box 2).

Box 2. Health benefits of Kenya's transition in household energy technologies

For women and children in developing countries, acute respiratory infection (ARI) is a major risk factor. For children under 5, acute lower respiratory infection (ALRI), a form of ARI, is a leading cause of death. Ezzati and Kammen have documented one of the few exposure-response relationships for ARI and ALRI to date, and have related it to the cookstove and fuel types used.

The 2001 study, conducted in rural Kenya, found that the highest average daily exposure was from three-stone fires (2,000–7,000 mg per m^3), followed by ceramic and wood stoves (1,000–2,500 mg per m^3), and charcoal stoves (less than 1,000 mg per m^3). The documented results show a clear exposure-response relationship for ARI in children under 5 and 5–49 year-olds, which can also be classified by stove/fuel type, with the odds of ARI incidence increasing with exposure (table).

Odds ratio for ARI incidence by stove/fuel type

PM_{10} exposure (mg/m^3)	Age group (years)		Stove/ fuel type
	Under 5	5–49	
< 200	1	1	Charcoal
200–500	2.42 (1.53–3.83)	3.01 (1.59–5.70)	Charcoal
500–1,000	2.15 (1.30–3.56)	2.77 (1.49–5.13)	Charcoal
1,000–2,000	4.30 (2.63–7.04)	3.79 (2.07–6.92)	Ceramic wood
2,000–3,500	4.72 (2.82–7.88)	..	Ceramic wood
2,000–4,000	..	4.49 (2.43–8.30)	Ceramic/three-stone wood
> 3,500	6.73 (3.75–12.06)	..	Three-stone wood
4,000–7,000	..	5.40 (2.85–10.22)	Three-stone wood
> 7,000	..	7.93 (4.11–15.27)	Three-stone wood

A 2002 follow-up study by Ezzati and Kammen found that switching from a conventional three-stone wood fire to a ceramic wood stove, which does not require a fuel shift, can reduce ARI by about one-quarter and ALRI by about one-fifth among infants and young children. With a larger transition in energy technology and the use of charcoal, ARI and ALRI reductions are on the order of 65 percent and 45 percent, respectively.

Sources: Ezzati and Kammen (2001, 2002).

According to the most recent summary of these issues (Smith, Mehta, and Maeusezahl-Feuz 2004), there is good evidence linking smoke from household cooking fires to childhood pneumonia. A meta-analysis of studies on pneumonia risk in children under 5 indicates that children exposed to solid fuels are more than 1.8 times more likely to contract pneumonia, compared to children without such exposure (Dherani et al. 2008). A new study that reviews, classifies, and summarizes studies conducted over the past 15 years on the relationship between household air pollution and health shows that household air pollution is linked to various health problems (Box 3).

Box 3. Household air pollution linked to multiple health risks

A new study on the global burden of disease shows household air pollution is related to a variety of illnesses. In its assessment of peer-reviewed medical studies over the past 15 years, the study found increased health risks for acute lower respiratory infection (ALRI), chronic obstructive pulmonary disease (COPD), cataracts, lung cancer, and cardiovascular disease. The increased probability of contracting such illnesses ranged from 78 percent for ALRI in children under 5 to more than 150 percent for COPD in women over 15 (table).

Increased probability of various illnesses by population group

Health outcome	Sex/ category	Age (years)	Range of reported increase in risk (%)
ALRI	Male and female/ children	< 5	45–118
COPD	Male/adults	> 15	95–275
COPD	Female/adults	> 15	15–213
Cataracts	Female/adults	> 30	61–273
Lung cancer	Female/adults	> 15	7–206

The medical studies analyzed were subjected to a strict set of measurement criteria to assess the validity and relevance of their findings.

Source: Smith, Bruce, and Mehta (2010).

The RESPIRE randomized cookstoves trial in Gautemala—the only known randomized intervention study published to date—found that the use of chimney woodstoves (*Plancha*) resulted in risk reduction for all respiratory symptoms, thus quantifying the improvements achieved in chronic respiratory symptoms with improved cookstove interventions in the field (Smith-Sivertsen et al. 2009).[3]

A recent study in India, in which the subjective self-reported respiratory symptoms and objective doctor-measured spirometry indicators were considered as health impacts of household air pollution, found that an increase of 1 mg per m^3 in $PM_{2.5}$ mean in the kitchen was associated with an 11.9 percentage point increase in the probability of reporting a respiratory symptom for

[3] The strength of such a study is its robust design, where the intervention and control groups are balanced with regard to potential confounders.

those typically in the kitchen (Zhang 2009). This effect is about half of the effect of smoking, which underscores household air pollution as a major health concern.

Another study in India found that, if a program on advanced biomass cookstoves were widely implemented, it would have significant benefits for both human health and GHG mitigation; for example, a program designed—theoretically, at least—to introduce 150 million cleaner burning advanced biomass cookstoves over a 10-year period would mean 2.2 million avoided deaths (Wilkinson et al. 2009). Using similar methods to estimate avoided deaths, if all biomass-burning households in 2005 had immediately switched to LPG, half a million deaths due to respiratory and other illnesses would have been avoided, with about a 3-percent reduction in the burden of disease, which is a remarkable figure (Venkataraman et al. 2010).

Gender and Household Drudgery

Biomass fuel is often collected from the local environment, most often by women. This time-consuming activity diverts time from productive and family activities. During a typical week, family members spend a considerable amount of time collecting fuel, whether from common village land or farmer's fields. In India, the time spent collecting fuel is estimated at an hour per day (World Bank 2002). Biomass fuel collection often entails walking long distances carrying heavy headloads and safety hazards. Furthermore, it can lead to a gradual deterioration of the local environment and deplete biomass supplies, meaning even longer walks and greater drudgery. It is possible that time not spent on household drudgery could be used for income-producing activities.

Time and Fuel Savings

A WHO review of fuel-collection time and biomass energy use among 14 countries in Sub-Saharan Africa found a wide range of estimates for the number of hours spent collecting biomass energy, from a low of 0.33 hours up to 4 hours per day (Dutta 2005; WHO 2006). Niger, Burkina Faso, and Ethiopia—countries with the highest levels of biomass scarcity—had the higher levels of biomass collection time. A partial explanation for this finding might be the various ways in which the survey questions were asked; nonetheless, the results generally support the notion that worldwide collection of biomass energy requires a significant amount of time for rural households.

Several WHO studies developed economic valuation methods for assessing time savings from fuel collection and cooking, avoided health costs, and environmental benefits (Hutton and Rehfuess 2006; Hutton et al. 2006; WHO 2007). For a typical South Asian household, the benefits of switching exclusively to improved cookstoves or from biomass to LPG amounts to about US$30 (Rs. 1,429) per year. This cost compares well to that of the advanced biomass cookstoves now being promoted around the world. Some can be purchased for US$15 and have a three-year life span. Thus, improved biomass cookstoves can significantly benefit rural households, even excluding the health and environmental benefits. One caveat is that, because switching to less polluting cookstoves and fuels may result in lowering fuel collection time rather than reducing cash expenditures, markets for such products may be slow to develop. Also, this particular study used a rather high estimate of the opportunity cost of time for fuel collection so the actual value of time saved might be somewhat lower.

It is possible to estimate the cost of using a stove for comparison purposes by valuing the time used to collect fuels. The cost-comparison method among stove types involves several steps. First, the value of the fuel used for cooking is calculated. For purchased fuels, the quantity of the fuel typically used per month is multiplied by the fuel price to give the monthly cooking costs. For collected fuels, two ways are used to establish the value of the fuel collected. If there is a local market for wood or other biomass fuels, a market price can be used; otherwise, the average fuel collection time per month is multiplied by the local agricultural wage rate.[4] In addition, it is necessary to estimate the costs of the cookstoves by dividing the stove price by its average life span. The comparative cooking cost is estimated by summing the stove costs, fuel cash costs, and value of fuel collection time (Annex 1).

Interestingly, once time use is factored into cooking costs, the traditional open fire is the most expensive form of cooking with wood (Figure A1-2). Once the price of an improved stove is spread over its life span, the stove costs are quite low and completely overshadowed by the value of saved biomass or reduced collection time. This might suggest that, in addition to the value of convenience and cultural cooking practices, a key to promoting improved cookstoves is to spread out the relatively unaffordable initial purchase costs. Once this is done, the new manufactured wood stove incurs the lowest expenses for cooking compared to all other stove and fuel combinations. The cost savings compared to an open fire can be as high as 40 percent. The conclusion is that the unvalued time spent collecting fuelwood is a benefit that, within a short period of time, would exceed the cash value of purchasing the stove.

Environment and Climate Change

A relatively new issue gaining greater attention in the development community is the potentially significant implications of household energy for climate change. Until recently, cooking with biomass energy was seldom addressed by climate-change practitioners since biomass was considered primarily a renewable energy source; but harvesting unsustainable levels of biomass can lead to pressure on biomass resources, with implications for the local and global environment (Box 4).

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[4] This method is based on the assumption that this wage rate is generally established by a market and essentially reflects the value of time for agricultural workers. This type of work is similar to the tasks involved in fuel collection.

Box 4. Charcoal and Tanzania's urban energy transition

Biomass energy, including charcoal, is used to meet 90 percent of Tanzania's energy needs. Some 70 percent of households in the capital of Dar es Salaam use charcoal, accounting for about half of the country's total charcoal consumption. Charcoal production in Tanzania's economy is valued at about US$650 million per year, and the industry provides work for some 300,000 households. Unfortunately, the charcoal trade is dominated by a small group of politically connected entrepreneurs in the informal trade, with most of the wood harvested unsustainably from woodlands 200 km from urban markets. The added investments required to make this trade sustainable would likely raise the price of charcoal for poor urban households, who already spend a large proportion of their income on energy.

While isolated stove interventions are not likely to resolve Tanzania's charcoal fuel production and distribution issues, improved charcoal stoves can reduce charcoal demand and thus lessen unsustainable harvesting and contain fuel costs at reasonable levels for poor families.

Source: World Bank (2009a).

Recent evidence suggests that the climate-change debate needs to focus more on household energy. In developing countries, about 730 million tons of biomass are burned every year (WHO 2007), amounting to more than 1 billion tons of carbon dioxide (CO_2) emitted into the atmosphere. If the use of biomass fuels in developed countries for all purposes is added to the massive quantities of fuelwood burned in developing countries, the total biomass used for energy is estimated at about 2–2.5 billion tons (Yevich and Logan 2003; Fernandes et al. 2007).

Box 5. Climate and health co-benefits of Kenya's household energy transition

A 2005 study by Bailis, Ezzati, and Kammen that compared scenarios of the household energy transition in rural and urban Kenya between 2000 and 2050 demonstrates the potential co-benefits of interventions that facilitate an energy transition. But even under a sustainable biomass scenario, significant cumulative global-warming emissions are likely.

The analysis compared scenarios ranging from firewood and charcoal to electricity, kerosene, and LPG. The biomass-based scenarios examined the impact of sustainably harvested biomass and charcoal production technology on emissions. For each scenario, the study compared emissions of carbon dioxide (CO_2) and non-CO_2 GHGs (methane [CH_4] and nitrous oxide [N_2O]) from production and consumption.

Results showed that transitioning from unsustainable to sustainable firewood harvesting and charcoal production reduced cumulative emissions from about 33 to 66 percent. But the levels still accounted for 5–10 percent of Sub-Saharan Africa's cumulative emissions, down from about 7–17 percent in the unsustainable scenario.

Without systematic changes in household fuel use, biomass-based fuel use would result in an estimated 9.8 million premature deaths between 2000 and 2030. Of these, up to 2.8 and 3.7 million could be avoided with rapid transitions to charcoal and fossil-fuel scenarios, respectively; children accounted for up to 85 percent of avoidable deaths, with the rest among adult women.

Source: Bailis, Ezzati, and Kammen (2005).

One could argue that the emitted CO_2 is sequestered into the biomass as it regrows; but the amount of regrowth is open to question, and is likely to vary geographically. In Kenya (Bailis, Ezzati, and Kammen 2005) and Mexico (Johnson et al. 2009), it has been shown that, in some regions, biomass for household fuel use can be a net contributor to global warming since all biomass harvested for household fuel use is not renewable (Box 5). But according to the FAO (2010), estimates of global emissions reduction from the improved efficiency of cookstoves are uncertain since the underlying data are either unavailable or subject to considerable fluctuation.

It is estimated that the new generation of advanced biomass cookstoves would reduce CO_2 emissions by about 25–50 percent. While some of this reduction might not be counted toward CO_2 reduction because it derives from sustainable biomass, a substantial fraction could come from the biomass resources contributing to resource depletion. These figures do not even count household heating.

Box 6. Black Carbon emissions and sources

Smoke from biomass cooking emits both black carbon (BC), which is largely elemental carbon, and organic carbon (OC), where carbon is combined with other elements, such as oxygen and hydrogen. BC and OC are referred to as aerosols (fine particles suspended in the atmosphere), and have a significant impact on climate. BC absorbs sunlight, and has a significant net warming effect, while OC reflects sunlight back into space and has a cooling effect on the atmosphere. Both BC and OC are the components of soot, a carbonaceous substance generally defined by its means of production, incomplete combustion, rather than by its chemical or physical properties.

The aerosol emissions from biomass cookstoves consist of both BC and OC; hence they combine warming and cooling agents (these are accounted for separately from GHGs, such as CO_2). Moreover, aerosols interact with clouds and affect the climate in ways that are not yet fully understood. While the emissions characteristics of biomass burning in cookstoves are considered critical for climate science, there is surprisingly little concrete scientific data on such key factors as the ratio of OC to BC. This ratio is critical for calculating the effect of household biomass combustion in global climate models. As a result, there is still significant uncertainty about whether BC emission from use of biomass in cookstoves has a net warming effect on climate globally (Annex 2).

Source: Ramanathan and Carmichael (2008).

Biomass fuels inefficiently burned due to incomplete fuel combustion generally release products of incomplete combustion (PIC) with a high global warming potential (GWP), which linger in the atmosphere (Smith 2000b; WHO 2006). These PICs include such gases as methane (CH_4) and nitrous oxide (N_2O), and fine particles in the form of black carbon (BC).[5] However, PICs also include organic carbon (OC), which has a cooling effect on the atmosphere (Box 6) (Annex 2). Thus, not only are potentially high levels of CO_2 emissions being produced in open or semi-open fires; various other products are being emitted that also affect the climate.

Problems in Past Programs

Many past stove programs—and even some current ones—were based on cookstoves designed in laboratories and built by local artisans. These cookstoves often performed well in the laboratory or when first installed, but over time, their efficiency and ability to remove smoke from the

[5] Charcoal production and use, in particular, emit significant amounts of non-CO_2 GHGs, such as CH_4, in addition to non-CH_4 hydrocarbons and carbon monoxide (CO) (Bailis, Ezzati, and Kammen 2003) (Annex 2).

household deteriorated. This was due, in part, to the use of local materials for which there was no quality control. The poor durability of such cookstoves often caused them to break down in less than a year. Once the poorer-quality cookstoves broke down, they were never replaced by consumers. A partial reason was that many past programs were overly supply-driven, with little attention paid to market development and other factors necessary for long-term business growth.

Many of the poorer legacy programs—perhaps based on short-term financing, poor stove designs, little consumer research, and lack of monitoring—have contributed to the misperception that all such programs have not performed well, helping to explain why the lessons of quite successful programs were not developed on a larger scale. Indeed, a number of India's programs, perceived by many today as failures, featured innovative and successful practices (Barnes, Kumar, and Openshaw, forthcoming) (Box 7). Lessons from these programs have been used to develop better improved-stove programs in many parts of the world.

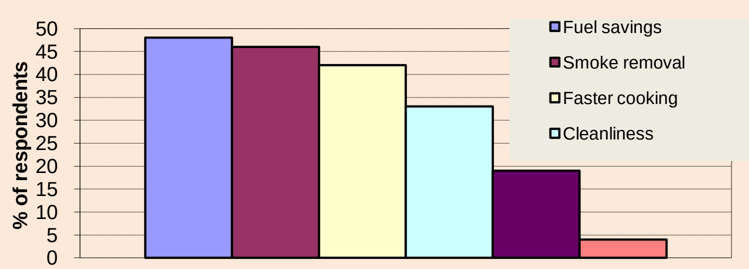
Box 7. Lessons from India's legacy program in Maharashtra

At the close of India's improved stoves program, results of a 2000 research project showed that satisfaction among women users in Maharashtra state was largely attributable to the initiative and sustained efforts of the Appropriate Rural Technology Institute (ARTI), the state's technical backup unit.

ARTI interacted regularly with village communities and stove makers. Its unique approach involved traditional potters in stove design, development, promotion, and sale. One or two potters were located in each village, which raised users' awareness about the stove technology and its benefits. ARTI also understood the importance of user training, user-based surveys, and consumer testing to provide stove designers feedback for developing more user-friendly models.

Women users appreciated that the stoves were developed by traditional potters. About half of users—most of whom would have otherwise purchased fuelwood for lack of crop residues—reported fuel savings as a major benefit. Users in households where the kitchen was the innermost room valued the efficient smoke removal. Many viewed time savings as a benefit, since two pots could be used at once. They also valued the cleaner cooking environment, especially in villages where sugarcane root was the primary cooking fuel. Some recognized the link between less indoor cooking smoke and better health (table).

Perceived user benefits of improved stoves in Maharashtra



Women users also perceived drawbacks to using the improved stoves. The problems reported centered mainly on the chimney (leakage and need of frequent cleaning), inappropriate pothole size, inconvenient grates, and greater fuel consumption.

Source: Barnes, Kumar, and Openshaw (forthcoming).

A new generation of manufactured cookstoves addresses many of the problems encountered in the earlier programs. The next chapter examines the potential of these advanced biomass cookstoves to become the "game changers" for international efforts to promote cookstoves with better energy and combustion efficiencies.

Chapter 4. Potential Game Changers: New Approaches and Opportunities

Today there is a new generation of biomass cookstoves manufactured entirely in factories or workshops after having conducted marketing studies, testing of materials, and quality-control assurance during the manufacturing process. For many cookstoves, the process has included significant consumer testing before public introduction. These more advanced biomass cookstoves use energy more efficiently and also pay attention to combustion efficiencies. Along with these cookstoves, some of the effective improved cookstoves—those close in performance to advanced biomass cookstoves, but assembled on-site by qualified installers adhering to standards, including new testing methods—can also contribute to a wide diversity of available cookstove technologies. Coincident with their development, a coalition of groups supporting such cookstoves has developed significantly.

It might now be possible to combine these developments with the new financing models and sources that are becoming available, some of which are linked to addressing climate change. Indeed, there is renewed interest in climate-related funds, such as those of the Global Environment Facility (GEF) and the World Bank's Carbon Finance Unit. The sections that follow describe the promising new developments with respect to advanced biomass cooktoves and new strategies to promote and support their development and deployment.

New Developments for Biomass Cookstoves

The growing consensus within the household energy development community is that better-quality cookstoves are needed to improve indoor air quality, increase fuel efficiency, and obtain stove acceptance over the long term. Unlike burning gas or liquid fuels, the combustion of solid biomass for cooking is a complex process that depends on such factors as fuel variations in energy content, moisture content, and size of pieces to be burned. Another important factor is the cook's skills in managing the cooking process. Taken together, these factors influence the combustion process (Box 8).

Advanced biomass cookstoves with better technological designs feature grates, insulation, induced draft or forced air flow, and more durable materials to provide a cleaner burning, more efficient device. Lower-cost, effective improved cookstoves could also contribute significantly to lowering emissions, improving health, and reducing forest degradation and deforestation. But to meet these requirements, stoves must be carefully designed through testing and performance verification. Systematic investigation of the heat transfer and combustion efficiency of stove design in the laboratory sheds light on which technologies work best, which, in turn, helps to ensure that the stoves disseminated are a significant improvement over traditional cooking methods (Box 9).

Box 8. Better stoves and behavioral change to reduce IAP in China

One of the first community-based trials to assess the links between technology, user knowledge, and behavioral change was conducted in rural China in 2002. The goal was to determine the scope and severity of household air pollution to pilot combined solutions from a multisectoral perspective and evaluate their cultural, socioeconomic, and organizational feasibility. The technology intervention was to improve kitchen layouts and ventilation systems customized for Guizhou, Shaanxi, Gansu, and Inner Mongolia provinces.

In Guizhou, where residents use a steel or cast-iron coal or air-circular stove, the intervention involved closing the upper outlet, which controls the smoke/heat flow via the chimney tract to increase heating utilization, and the lower inlet, which controls the smoke/heat flow for cooking. In Shaanxi, where poorly designed brick-made, coal range and underground stoves are typical, chimneys and an improved tract system for better heat/smoke flow were added. In Gansu, where local people use two-fuel (coal and biomass) range stoves, the focus was on improved chimneys and smoke tracts for heated beds. In Inner Mongolia, ventilation for popular biomass bed stoves is limited to a small window or door. The intervention introduced a partition between the bed and stove, along with an exhaust fan and chimney.

The sampled households were divided into three groups: (i) stove plus behavioral intervention, (ii) behavioral intervention, and (iii) control. About 2,500 households in the first group were provided new stoves with improved ventilation systems on a subsidized basis. Some 200 households from the second group decided to install new stoves at full cost. For the control group in each province, household air pollution was a serious problem. In all four provinces, the first group had larger reductions in particulate matter (PM) and carbon monoxide (CO); but pollutant concentration levels varied significantly between locations, depending on whether the stove was used for cooking or heating—a major consideration for designing cold-climate interventions.

Overall, measurements under household conditions showed that the new stoves and better ventilation techniques resulted in higher efficiency and lower emissions compared to the old stoves. Measurements under controlled conditions revealed an even greater reduction in PM and CO concentrations (13–15 percent), since those operating the stoves were more skilled. The new stoves lowered fuel consumption by 30–50 percent, owing to the improved combustion and ventilation systems. Despite the project's emphasis on health education and behavioral change, these interventions alone did not significantly reduce household air pollution, suggesting the need to couple them with better stoves.

Sources: Baris et al. (2006); Baris and Ezzati (2007).

The new generation of stoves on the horizon will also require new monitoring and evaluation (M&E) approaches to complement previously accepted techniques. Past M&E studies for stove programs have been complicated by the variables needed to measure stove efficiency, durability, and smoke levels. The many diverse variables—ranging from climate, fuel use, and fuel moisture content to kitchen configuration, ventilation, and use of multiple stove types—have led to high measurement variations between households with and without better stoves. Measuring energy efficiency and household air pollution has also proven costly. High expenses, technical equipment challenges, and varying conditions have limited studies to small sample sizes, making it harder to identify the factors linked to efficiency, durability, and smoke removal.

Box 9. Better stoves, fewer emissions

A 2010 study investigating the performance of 50 stove designs compared fuel use and the carbon monoxide (CO) and particulate matter (PM) emissions produced, using the 2003 University of California, Berkeley revised Water Boiling Test Version 3.0.

Compared to the three-stone fire, rocket-type stoves were found to reduce fuel use by one-third, CO emissions by three-fourths, and PM emissions by nearly half. Gasifier stoves, when operating well, averaged a 90-percent improvement, substantially reducing PM. Forced-air stoves with small fans reduced fuel use by an average of 40 percent and emissions by 90 percent. Stoves with poorly-designed combustion chambers did not necessarily reduce—and potentially increased—CO and PM emissions, even though less fuel was used.

Traditional charcoal stoves, which used about the same amount of energy as the three-stone fire to complete a task—not counting the energy lost (up to 70 percent) in making the charcoal—produced up to twice as much CO but four-fifths less PM; rocket-type charcoal stoves reduced this energy consumption by one-third and CO emissions by at least half. Kerosene stoves, operated improperly, emitted higher PM levels than some improved wood stoves, although liquid fuels generally exhibited less energy use and emissions. Finally, well-designed stoves with chimneys removed smoke from the kitchen, while fuel use was generally related directly to how much of the pot was in direct contact with the flame.

This study suggests it is possible to affordably improve stoves over traditional cooking methods. The results can be used as benchmarks for setting international performance standards.

Source: MacCarty, Still, and Ogle (2010).

Previously, laboratory-controlled cooking and kitchen performance tests have usually handled these issues (Smith et al. 2007); and laboratory testing still relies heavily on stove design. Controlled cooking tests are often used to assess model performance. Kitchen performance tests, though less common, are used to compare test results with what actually occurs in households to evaluate program performance. Test results indicate a wide range of exposure levels related mainly to energy efficiency.

This suggests the need for a broadened focus on market development that complements work on the technical design of stoves. More attention needs to be paid to household social characteristics, along with the desirability and affordability of stoves. This will require larger sample sizes than have been conventionally applied for monitoring the better stoves, perhaps complemented by subsamples of physical efficiency and pollution measurements. M&E studies, previously limited mainly to the physical measurements of household pollution and energy efficiency, need to be expanded to measure such consumer-demand features as convenience, price, perceived performance, and local availability.

Most producers of new-generation cookstoves have been in business for only the last 5–10 years, and some are still in the pilot stage of promoting their products (Annexes 3 and 4). According to the manufacturers' numbers, approximately 1 million of these cookstoves have been sold to date, with programs in such countries as China, India, South Africa, Uganda, Honduras, and Guatemala. This suggests a promising start for these programs. Stove costs range widely, from as low as US$15 to as high as US$100–200, with the more expensive cookstoves having higher levels of energy efficiency and fuel combustion. Improved biomass and charcoal cookstoves are less expensive.

These new initiatives for advanced cookstoves still require market testing, improving retail distribution chains, and ensuring that the stoves perform as claimed by the manufacturers as expansion moves forward. The idea of reducing high-quality stove costs through mass production is a promising trend, but we are still early in the learning curve for many of these technologies in terms of both design and dissemination. Currently, most mass-manufactured cookstoves are made in China; thus, expansion of the manufacturing base to other countries would be needed. In addition, such cookstoves would have to pass the tests that slowed previous programs, including satisfying a multitude of cooking styles. This obstacle is not insurmountable, as evidenced by the vast number of people in many diverse cultures that cook with LPG or other modern fuels.

Some of the world’s major manufacturers and an increasing number of foundations and NGOs have become involved in the development of advanced biomass cookstoves. These include the Shell Foundation, Bosch Siemens, Phillips, British Petroleum, and others. Despite affiliation with large manufacturing companies, many of the new initiatives are fairly small and must bear all the product and business-development costs associated with new product and market development. For example, the launch of such products requires investments in market intelligence and development of retail networks. Another feature of market development are required standards that verify the cookstoves perform as publicized by the companies that sell them. Owing to the higher costs of these cookstoves compared to traditional cookstoves, which are built at no cost by most households, some financial support might be needed to help consumers lower or spread out stove costs. The market for advanced biomass cookstoves should be fairly strong once these and other issues that could hinder adoption are addressed. One should also not forget the potential of the lower-cost effective improved cookstoves that meet certain performance standards.

Marketing of the new generation of advanced biomass cookstoves offers many advantages. For example, the cookstoves could be purchased off the shelf. Hence, retailers or development agencies promoting them would not have to worry about developing or designing a stove; rather, such groups could buy market-ready advanced biomass cookstoves, with quality assurance and guarantees. This would make it possible for those interested in supporting advanced biomass cookstoves to focus on developing retailing and promotion strategies, without having to get involved in product design and development, which often is necessary for improved biomass cookstoves.

However, this approach has also led to some unresolved issues. In the case of cookstoves sold without chimneys, for example, the reduction in fuel use corresponds to a reduction in indoor pollution, but it is unclear whether the level of reduction is enough to induce health improvements. In China, most of the traditional improved biomass cookstoves sold to date have had chimneys, which result in a much cleaner indoor environment. But the trade-off is that the pollution contributes to poor outdoor air quality unless some form of installation is made. Thus, scaling up the development of these programs involves surmounting many hurdles; many programs are still small and additional time will be necessary to assess their effectiveness. Nonetheless, there is significant potential for these cookstoves, perhaps along with other less expensive cookstoves, to provide true value to those people still dependent on the traditional use of biomass energy.

Possible New Financing Models

Today, many new financing models are being implemented to support disaggregated forms of renewable energy in developing countries, such as solar home systems (SHSs). Many of these programs started 15 years ago and thus have had many years to refine their financing models and hence offer valuable learning experience. The SHSs and advanced biomass cookstoves share common features. Both are used primarily for household energy services, lasting much longer and offering a much higher quality of energy service than the systems they replace (i.e., SHS versus kerosene for lighting and advanced biomass stove versus open fire for cooking). Both interventions are expensive to purchase, involving large initial outlays unaffordable for the majority of households dependent on kerosene lamps and biomass cooking energy.

However, the operating costs of both SHSs and better biomass cookstoves are fairly low. Each SHS costs about US$200–300, while a new-generation, advanced biomass stove ranges from US$25 to US$70 or more. For example, the Envirofit and Philips cookstoves cost US$25–30, and the Philips blower stove runs about US$70.[6] One difference between SHSs and advanced biomass cookstoves is that, over the past 15 years, SHS promotion strategies have moved from a niche activity to the mainstream for international donors and many countries. But the obstacles now confronting the new advanced biomass cookstoves share many similarities with those faced by SHS in the early years. Thus, it would be good to explore what lessons learned over the years might be relevant for scaling up the adoption of advanced biomass cookstoves.

To understand why the perceptions of these programs have differed, it is important to examine their respective histories. The first SHS projects, established more than a decade ago, were mostly small pilot projects. With limited exceptions, they were oriented mainly to installing systems with hefty subsidies. There was little market development and poor after-sales support. In the early 2000s, renewable energy became popular among development agencies, and serious efforts were made to scale up SHS promotion and marketing through the private sector. The idea was to move SHSs from a pilot phase into the mainstream of development lending. This basically describes the situation of improved and advanced biomass cookstoves today.

[6] An added advantage of blower stoves is their ability to serve as stand-alone, thermo-electric generators and thus be used to run the blower fan, which can significantly boost combustion efficiency.

Most early attempts at SHS mainstreaming involved support for the retailers who sold the systems. The so-called “retailer model” provided companies incentives to sell the SHSs on credit with partial subsidies. Over time, it became clear that these small companies were mainly interested in selling the systems for cash, rather than collecting monthly or bimonthly loans or fees from around the countryside. The one exception was China, where retailers who were provided direct incentives sold more than 400,000 systems in the northwest region of the country (World Bank 2009b). During this period, a similar effort scaled up efforts via private energy service companies (ESCOs), some of which charged fees for service, spreading costs over a longer period.

Today, there is a new approach to promoting SHSs, which has resulted in their adoption on a much larger scale. This approach is followed by such countries as Bangladesh, where close to 500,000 systems have been sold, and Sri Lanka, where SHS sales have reached 60,000 (Govindarajalu, Elahi, and Nagendran 2008). To promote SHSs using this model, three basic groups of actors are required. First, institutions are needed to manage energy funds that can provide financing (World Bank 1999). Generally these institutions also help with technical assistance and the establishment of system standards as a requirement of the loan. Second, microfinance organizations or NGOs are needed to organize demand, provide customer support, and collect loan payments. Third, SHS retailers are required to sell equipment for cash and provide product guarantees. The advantage of this approach is that all of the parties involved have important roles that play to their strengths.

For biomass cookstoves to transition to a new model of product manufacturing and distribution, there might be lessons to be learned from programs supporting SHSs and perhaps even financing available from such programs. Under the right conditions, existing rural development or energy funds in many developing countries could potentially be directed toward advanced biomass cookstoves. These funds, commonly run by local development banks or specialized energy units, have the ability to blend both loans and subsidies and provide them to qualified organizations. They are responsible for setting quality standards because they do not want to lend out money for systems that fail before the loan is collected. The NGOs are responsible for marketing and, in many cases, financing cookstoves over a period of time. They would be pleased to accept technical-assistance money to develop awareness campaigns, a task for which they are well qualified. The manufacturers could then promote their cookstoves both through private retailers and partnerships with NGOs to reach people who otherwise could not afford the upfront costs of these technologies.

As mentioned above, existing funds could be used immediately for improved or advanced biomass cookstoves. This would require some technical assistance to deal with procurement issues, standards, loan terms, and the development of business models. Various existing funds might be ready to accept this challenge; indeed, some have already begun to implement small programs. This is the case in such countries as Mali. The model described above is fairly well accepted and could be used now in some countries. For many other countries, where rural energy funds are not available, other models would have to be developed, possibly building on lessons of successes in other sectors (Box 10).

Box 10. Learning from Bangladesh's water and sanitation program

Bangladesh's sanitation-for-all campaign succeeded in transforming government-partner-community actions into a participatory social movement. The program featured a multi-pronged, awareness-building approach, with media-reinforced messages, directly targeting poor households, community groups, teachers, and students on the benefits of basic hygienic practices.

But integrated approaches and community motivation alone could not have propelled the program forward. Availability of a wide range of low-cost, affordable sanitation hardware designed to reach the poorest of the poor was vital to success. In addition, the program's commercial approach, with its strong entrepreneurial focus, ensured that sanitation products were readily available at the local level. Rather than provide households subsidies for the products disseminated, the program applied community-level peer pressure and influence to achieve a sustained motivational change.

Future cookstove programs can adopt the following lessons from the sanitation program's success:

- A participatory, integrated institutional approach, where the community plays a key role, is effective.
- Capacity building is critical and should involve all stakeholders (e.g., implementers, organizations, and community members).
- Availability of a wide range of product technologies suited to a variety of socioeconomic and local resource conditions helps to reach more households.
- Strong, effective maintenance is essential to ensure continued, appropriate use of the new products.
- Government grants and allocations used to target the poorest of the poor and as incentives for local-government institutions can extend the program's reach and implementation.
- A strong entrepreneurial-development component motivates installation by the community since the new products and services are readily available.
- Awareness-raising activities via government and partner linkages bring about behavioral change, which motivates local people to adopt the new products.

Source: ESMAP (2010).

Other models for scaling up improved or advanced biomass cookstoves might be successful. In one financing approach used in Latin America, for example, renewable-energy options were part of programs that provided social and community block grants. This was used in Guatemala for improved biomass cookstoves (Ahmed et al. 2005). Because these social investment funds provide assistance to whole communities, they can lead to equitable approaches to promoting off-grid renewable energy services. There also are possible ways to partner with both development and health NGOs or government agencies to promote the adoption of advanced biomass cookstoves (Box 11). The model is often influenced by the source of financing, which is the topic of the next section.

Box 11. Reaching the poor through India's prenatal care system

Innovative pilot studies in Haryana and Tamil Nadu, India, known as the Newborn Stove (NBS) initiative, are aimed at testing the feasibility of disseminating advanced biomass stoves via the country's Antenatal Care (ANC) system. The NBS intervention targets the population group most susceptible to the health risks associated with traditional cookstoves: pregnant women in the ANC system and their infant children. Most poor women have access to this free public service, which supports about 10 million births per year.

Conducted by the University of California, Berkeley; Columbia University; Sri Ramachandra University; and the International Clinical Epidemiology Network, India; the NBS pilot studies are investigating the best ways to provide poor women incentives to adopt and use advanced biomass stoves, gathering data on reducing personal exposure to indoor pollution from use of the new stoves, and exploring the acceptability of selected stove types. To increase the potential for reducing personal exposure, only advanced biomass stoves equipped with blowers are used in the trials, each of which covers about 200 pregnancies.

If successful, these studies would provide the needed evidence to establish such stoves as part of India's national ANC system. This would be a highly cost-effective way to address low birth weight, which affects nearly two-fifths of India's newborns, and early childhood pneumonia (Pope et al. 2010). Over time, a national program that targets these mothers could reach the vast majority of poor households—the bottom of India's income pyramid—and thus complement commercial market approaches that initially benefit those at the top.

Source: Kirk R. Smith; University of California, Berkeley.

Potential Financing Sources

International donors have been slow to embrace or support the promotion of better biomass cookstoves, in part, because they do not differentiate them from the old improved cookstoves, which in many cases had problems and often broke down or degraded in less than a year. Thus, it may take time for donors to realize that such programs may be as important as increasing electricity access for rural development and poverty reduction. In this section, we examine some of the existing and potential financing sources that may be applied to promote advanced biomass cookstoves.

Cookstove finance can be divided according to the methods and strategies appropriate to addressing their various program objectives. Program funding types and objectives include:

- Rapid-deployment funding to cookstove project developers to scale up existing financed projects;
- Market development activities to create robust markets for advanced cookstoves in priority countries and regions;
- Pilot programs to assess the technical performance and market viability of high-tech cookstoves that deliver the best local (health) and global (climate) benefits;
- Technical assistance and funding to support cookstove entrepreneurs and manufacturers to foster the quality and quantity of cookstoves in the market and lower costs;

- Policy support to country governments to create enabling policy environments and direct public-sector resources to the problems that cookstoves can address; and
- Humanitarian assistance in disaster and conflict zones to provide cookstoves to distressed populations, such as residents of refugee camps.

The World Bank has implemented a limited number of projects that deal with improved biomass cookstoves (Annex 5); currently, a variety of available financing sources are not being used to support such projects (Annex 6). In fact, it is difficult to estimate the exact amount of financing that has been directed to improved cookstoves because the funding is classified as biomass energy, which includes charcoal and wood production. Nevertheless, it is clear from the figures that financing for improved biomass cookstoves is rather low, probably because of the difficulty in implementing past improved cookstoves programs, which involved custom designs for every country. The new generation of advanced biomass cookstoves, along with new financing, can potentially help to overcome the legacy issues of past programs.

Advanced biomass and effective improved cookstoves are potentially attractive for climate finance, not only because of their contribution to climate-change mitigation;[7] they also can yield major co-benefits in terms of energy access for the poor; improved rural health; and other environmental, agricultural, and economic benefits. Some of the key financing instruments are summarized below, with details presented in Annex 6.

The **Global Environment Facility** (GEF) has several grant mechanisms that can be used for promoting better biomass cookstoves and improving the sustainability of household biomass use. These grants include the Earth Fund (and other private-sector development funds), the Sustainable Forest Management (SFM) program, and the Small Grants Program (GEF 2003, GEF 2007, 2010a). Under the recently approved GEF-5, one focal area identifies improved biomass cookstoves as a priority related to energy efficiency and SFM (GEF 2009). In addition, the GEF's Small Grants Program, which supports the projects of NGOs and community-based organizations, can also support cookstove projects. (Annex 6).

The **Carbon Funds**, administered by the Carbon Finance Unit at the World Bank and the IFC,[8] are another possible financing source for better biomass cookstoves. Cookstove emissions are eligible for funding under the Clean Development Mechanism (CDM) if part of the biomass is non-renewable (GTZ 2010). Moreover, cookstove projects can be credited on the voluntary carbon market (such as the Gold Standard or Voluntary Carbon Standard), which use either their own or CDM methodologies. In addition, the CDM offers methodologies for cookstove projects that incorporate switching from fossil fuels, including reduction in use of non-renewable biomass, and fuel switching to 100-percent renewable energy supplies (Box 12).

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[7] Climate financing sources and instruments discussed in this report do not cover any mechanism for financing the reduction in non-GHG climate forcers, such as black carbon (BC).

[8] Details on a project under preparation are available at www.ifc.org/ifcext/southasia.nsf/Content/ProjectInformation India.

Box 12. Cookstove projects in the carbon market

Projects and programs targeting improved cookstoves and reduction of non-renewable biomass can apply for four methodologies approved under the CDM: (i) AMS-I.C, now under version 18; (ii) AMS-I.E, now under version 3; (iii) AMS-II.G, initially approved in February 2008 and revised in December 2009; and (iv) AMS-I.I, approved in February 2011. In addition, the Gold Standard has approved one methodology applicable in the context of the voluntary market: "Methodology for Improved Cookstoves and Kitchen Regimes" (V. 01, July 2008), which provides a detailed guide on project design and implementation. In September 2010, the Gold Standard published V.02 of this methodology, and V.03 is now under consultation.

As of March 1, 2011, the CDM had 3 registered cookstove projects, with 16 in the pipeline, plus another 11 under the program of activities (PoA). The Gold Standard program had 7 registered improved cookstove projects (3 of which are being issued Voluntary Emissions Reductions [VERs]), 4 validated ones, and 19 in the pipeline.

The accounting, monitoring, and verification requirements of the CDM methodology, which count only the carbon mitigated, are somewhat less onerous than those of the Gold Standard, which use a fossil-fuel baseline (i.e., expected fossil-fuel savings if woody biomass fuel were replaced with the local fossil alternative). The Gold Standard methodology, used in voluntary carbon markets, allows for the inclusion of upstream emissions reductions from charcoal production, as well as CH_4 and N_2O emissions reductions, which the CDM does not. Additionally, CDM-certified credits tradable on the Emissions Trading System (ETS) usually carry a premium over VER credits.

The voluntary market experience that the Gold Standard methodology has provided may lead to new and expanded CDM methodologies for improved cookstoves in the near future.

Sources: http://cdmpipeline.org; https://gs1.apx.com.

The World Bank's Carbon Finance Unit also houses three funds particularly relevant to cookstove programs: the BioCarbon Fund, the Community Development Carbon Fund, and the Forest Carbon Partnership Facility. The first two funds focus on land use–based credits and rural community–based projects, respectively, while the Forest Carbon Partnership Facility is part of the Bank's efforts to address Reduced Emissions from Deforestation and Forest Degradation (REDD); these projects target sustainable local biomass use, making fuel efficiency and fuel stock management the dominant concerns for this sector.[9]

The **Climate Investment Funds** (CIF), which the World Bank plays a major role in coordinating and implementing, are another possible funding source. One of the two CIF, the Strategic Climate Fund, has two programs especially relevant to cookstove initiatives: (i) the Forest Investment Program and (ii) the Scaling Up Renewable Energy Program (Annex 6).

[9] Two major REDD funds fully or partially run by the World Bank—the Forest Carbon Partnership Facility (Carbon Finance Unit) and the Forest Investment Program (Climate Investment Funds)—have already received more than US$700 million in pledged funding for pilot programs in forested developing countries, and implementation is under way. Advanced cookstove programs can be integrated into reduced deforestation country strategies and implementation plans (Annex 6). Virtually all REDD strategies developed by countries in Sub-Saharan Africa contain action steps to make the extraction of wood-based fuel sustainable.

The **International Finance Corporation** (IFC) currently supports many types of efforts to promote market transformation. These include the promotion of markets for new products and in new geographic locations, such as the Lighting Africa program, run jointly with the World Bank with funding from the GEF and other sources (IFC 2009) (Box 13). In addition, the IFC has helped to develop a large number of finance products for businesses and consumers (Annex 6).

Box 13. Lighting Africa: Lessons in market and technology innovation

The Lighting Africa program, jointly-implemented by the IFC and the World Bank, aims to facilitate the commercialization of environmentally-friendly, affordable, high-quality lighting for off-grid rural households. To replace kerosene and other inefficient lighting fuels, Lighting Africa promotes solar-charged, battery-operated LED and fluorescent lighting devices by building an enabling environment and market infrastructure without providing product subsidies. The parallels between the issues this program has tackled and efforts to develop and market improved or advanced biomass stoves are striking.

Based on interaction with world industry leaders in the lighting industry, the Lighting Africa program discovered that major manufacturers lacked information about African markets. To address this gap, Lighting Africa has provided the industry market intelligence. It has facilitated business linkages through its interactive business-to-business website, as well as international and domestic conferences, trade fairs, and workshops. It also has helped to create rigorous testing methods and standards for lighting devices, and is in the process of creating a publicly-recognized certification label. It has conducted consumer-awareness and information campaigns in various countries. In addition, it has provided grant funds for innovations in technology development, marketing, and implementation strategies.

Recognizing the important role of finance, Lighting Africa is working to identify stakeholders' financing needs to assist in developing market-appropriate solutions and financial products, such as providing trade finance and working capital to small and medium enterprise (SME) distributors of off-grid lighting products. Consumer microfinance for purchasers of devices could also help to build market demand by defraying upfront costs. The IFC is poised to develop these financial products.

The Alliance for Improved Cooking has identified a similar set of issues—including M&E, market awareness building, and technology innovation—that must be addressed to move the sale and dissemination of clean cookstoves to a higher level of implementation. A grant facility similar to, or even as part of, the Lighting Africa program could provide NGOs and the private sector a stimulus to promote and sell better stoves.

Source: www.LightingAfrica.org.

To date, the many funds potentially available for financing better biomass cookstoves have been used little for actual projects. Doing so would require a demand for them from both the private sector and governments in developing countries.

New Initiatives and Coalitions

After many years of modest but persistent efforts to deal with household energy issues in developing countries, a new wave of interest has emerged in propelling biomass cookstoves to a higher level on the policy agenda. With mounting concern over climate change, improving the efficiency of traditional cookstoves has received an increasing amount of technical and public attention. There is now an opportunity to form a coalition of agencies with interest in biomass energy problems in developing countries.

Several developments have made this possible. The most obvious new one is the technology itself. Advanced biomass cookstoves offer more convenient ways for development agencies to put biomass cookstoves in their lending or financing programs. In the past, the custom approach to cookstoves development had its merits, but it was difficult to include in programs required to follow strict procurement and other procedures. Also, custom-installed cookstoves could vary in quality, depending on the competence of installation. However, some recent improved stove programs also have dealt with ways to standardize the installation of such cookstoves through such procedures as certifying installers and working with standardized stove parts.

Originally, household energy concerns were given prominence by the UN Food and Agriculture Organization (FAO) and the Energy Sector Management Assistance Program (ESMAP), which formed a household energy unit in the 1980s. For the past 30 years, the German Agency for Technical Cooperation (GTZ) GmbH has jointly implemented programs with national governments and today has two major ones: (i) the Program for Poverty-oriented Basic Energy Services or HERA and (ii) Energizing Development (EnDev), a Dutch-German energy partnership (Box 14).

After a lag, a wider variety of international programs has since become involved. These include those of the World Health Organization, the United Nations Development Programme, and the US Environmental Protection Agency–founded Partnership for Clean Indoor Air (PCIA). In addition, foundations and financiers (e.g., Shell and Morgan Stanley), established private-sector companies (e.g., Bosch-Siemens and Philips) closely tied to major universities (e.g., Berkeley Air Monitoring Group), carbon-project developers (e.g., Impact Carbon and CQuest Capital), and NGOs (e.g., Aprovecho) are now involved with cookstove programs worldwide. Furthermore, a number of national organizations are busy developing or implementing cookstove projects (e.g., SEWA in India and Toyola Energy in Ghana).

The recently launched Global Alliance for Clean Cookstoves (GACC) under the United Nations Foundation (2010) has provided an umbrella for many of the above-mentioned organizations and institutions to work synergistically toward bringing household energy and advanced biomass cookstoves back on the policy agenda of international development agencies and donors. The World Bank has also joined the GACC, as have a number of country governments and other partners.[10]

[10] The GACC is a public-private initiative that aims to save lives, improve livelihoods, empower women, and combat climate change by creating a thriving global market for clean and efficient household cooking solutions. More information is available at www.cleancookstoves.org.

Box 14. Energizing access to modern energy by the poor

Energizing Development or EnDev is an impact-oriented, global-sector initiative of the German Federal Ministry for Economic Cooperation and Development (BMZ) and the Directorate-General for International Cooperation (DGIS) of the Dutch Ministry of Foreign Affairs. In all, 138 million euros have been allocated to support energy access by the poor within a 10-year time frame ending in 2014. The GTZ implements the program, in close cooperation with the Dutch NL Agency.

Since 2005, 6.4 million people have been provided access to clean energy via improved cookstoves, solar home systems, mini-hydropower and biogas systems, grid extension, and densification. To address cooking energy needs, EnDev establishes sustainable markets for energy-efficient cookstoves. Interventions have been implemented in 12 countries worldwide, with a focus on Africa. By mid-2010, 5.2 million people had gained access to modern cooking energy.

Key features of EnDev are its global dimension, focus on capacity development, results-based management, and adherence to rigorous monitoring that traces back each individual household and user. Challenging individual projects and performance-based funding have allowed for fast scale-up of successful activities. A core criterion for all supported activities is long-term sustainability.

Source: GTZ.

Recently, the World Bank launched the Biomass Energy Initiative for Africa (BEIA), which aims to develop the necessary conditions for dealing with regional biomass energy issues. The ultimate goal is to incorporate new initiatives in future lending projects (Box 15).

Box 15. Biomass energy efficiency for Africa grants program

Making charcoal and biomass energy production more sustainable is a key goal of the World Bank-funded Biomass Energy Initiative for Africa (BEIA). Initiated in 2009, the BEIA tests promising approaches to deal with biomass energy that can potentially be incorporated into the World Bank's lending portfolio. It provides small grants to African NGOs, research institutions, universities, and private enterprises—selected via a rigorous proposal review process—to undertake pilot activities related to the development of biomass energy in Sub-Saharan Africa. The program aims to fund innovative ways to address fundamental problems facing Africa's biomass energy sector.

Support focuses on five themes:

1. Enabling market conditions for high-quality and high-performance modern cookstoves (creating the conditions that ease the commercialization of cleaner, more efficient cookstoves to replace traditional biomass-based cookstoves);
2. Modernizing the charcoal industry (improving environmental sustainability and energy efficiency of charcoaling and end use);
3. Demonstrating the feasibility of social biofuels (using small-scale biofuels production systems that supply a local market fuels for cooking, lighting, and power generation);
4. Increasing power capacity with bioelectricity (using biomass to fuel power generation for off-grid or add-on capacity); and
5. Strengthening leadership in biomass energy (promoting higher-level training for technical and professional leaders).

Source: BEIA, World Bank.

Another promising initiative recently launched in India was announced in late 2009 by the Government of India. This approach will take social, technical, and global climate issues into account and will promote global innovation in stove technology, as well as the development of India-specific standards and testing procedures (Box 16).

Box 16. National Biomass Cookstoves Initiative in India

India has announced the National Biomass Cookstoves Initiative (NCI), a large program centered on advanced biomass cookstoves that could reach tens or even hundreds of millions of people who currently use biomass energy to meet their daily cooking needs.

Still under development, the program will focus on:

- Technical issues, including R&D, related to testing and standards;
- Cookstove-delivery procedures;
- Potential programs for fuel processing and supply;
- An innovation contest for next-generation cookstoves; and
- What can be accomplished with community cookstoves.

A new protocol will be adopted to test and qualify cookstoves based on energy efficiency and stove emissions, and testing facilities will be set up prior to qualifying cookstoves. New manufacturers are likely to be involved, and subsidy design may include carbon credits.

The full potential benefits of the NCI were estimated in a recent journal article (Venkataraman et al. 2010).

Source: Indian Institute of Technology and The Energy and Resources Institute (2010).

As part of this initiative, the program team, along with the Government of India, recently announced a partnership with the X PRIZE Foundation to launch a global competition to develop clean-burning cookstoves (Indian Institute of Technology and The Energy and Resources Institute 2010).

As the various initiatives move forward, the main issues to be addressed will include the development of:

- Standards and testing methods;
- Ways to encourage stove adoption;
- Financing techniques to spread out the upfront cost of cookstoves;
- Projects to fill major research gaps;
- Methods for effective awareness raising; and
- Techniques for promoting market-based solutions (including the private sector, NGOs, and microfinance organizations).

The long-term solution might be to garner major financial support for such tasks as health research, field trials, cookstoves testing, training, outreach, and technology design and deployment. Obviously, achieving these goals would require the support of many types of institutions and organizations, including donors and other development agencies.

Chapter 5. A Way Forward

The World Bank Group (WBG) could play a major role in facilitating the success and scale-up of the new initiatives on advanced biomass cookstoves, given its ability to support public and private sectors and bring diverse parties together. In addition, through country dialogue, it could ensure that these endeavors are coordinated with country priorities to maximize potential benefits. There are numerous possible entry points for the WBG in this area, including the support of cookstove technology development and innovation, program scale-up based on experience working with the private sector and financial engineering, and initiatives to fill key knowledge gaps and promote learning and collaboration.

Technology Development

The manufacture of advanced biomass cookstoves began only within the past decade; thus, many of the issues that constrained previous improved stove programs—including better efficiency, less drudgery, and control of indoor air pollution (IAP) levels—are under continuous research and improvement. There is scope for further supporting the technical development of a wide array of cookstove types and facilitating their innovation to meet performance benchmarks or standards.

The problem of cooking with open fires and primitive stoves in developing countries will likely have multiple solutions. Thus, grant competitions might be an appropriate approach to spur innovation. One could encourage the development of a wide variety of low-cost or expensive cookstoves that meet certain minimum standards and expand their marketability, as already initiated by the World Bank in Africa (Box 15) and proposed under India's new cookstove initiative (Box 16). Competitions along the lines of the World Bank's Development Marketplace could provide a starting point.

Widely accepted standards and testing protocols are needed to qualify advanced biomass cookstoves as safe, durable, efficient, and clean burning. Since much of this work will involve the private sector, the IFC, with its ability to provide private companies loans and technical assistance directly, could play a significant role in strengthening emerging cookstove companies and manufacturers, as well as supporting the process of performance-based cookstove certification.[11] A review of and recommendations on accepted standards for advanced biomass cookstoves are needed at the international level. Once certified, these cookstoves could be considered eligible for government financing or partial grants to support dissemination.

In addition, it is necessary to establish monitoring and evaluation (M&E) protocols for both the advanced biomass cookstoves and effective improved cookstoves under conditions of actual stove use. These M&E techniques, in all likelihood, would incorporate a wider range of

[11] A four-star rating system could be developed for Safety, Efficiency, Emissions, and Durability (SEED), based on a country's typical cooking patterns.

assessment techniques that are both qualitative and quantitative in nature and much larger sample sizes to assess stove adoption and performance under a wider range of cooking practices for larger populations. This would help to address the technical issues of cookstove performance over time. Performance-based financing schemes then could be designed around them with higher incentives for the better performing products. The goal would be to facilitate the adoption of better stoves and the promotion of businesses for designing, producing, and marketing stoves.

Program Scale-up

Are programs to promote advanced biomass cookstoves and effective improved cookstoves feasible on a larger scale? There is no guarantee that current efforts can be sufficiently scaled up to cover all people in developing countries who use primitive cookstoves and open fires. But these new efforts have many promising features. Unlike previous efforts to promote improved stoves, the advanced biomass cookstoves are mostly driven by private-sector interest in developing a commercially-oriented business (Annexes 3 and 4). Thus, they are meant to be available off the shelf and are claimed to be safer, more durable, efficient, and clean burning. If manufactured and deployed on a large scale, their costs could be reduced.

Based on lessons from previous efforts to promote better cookstoves through the WBG and other more recent experiences, a number of fundamental issues need to be addressed to enable the market for scaled-up cookstove deployment (World Bank 2009a, 2010; ESMAP 2010). Because few national institutions promote cookstove programs, a national coordinating agency responsible for such programs would be required. Although the role of such an agency would vary by country, certain essential responsibilities would be common to all.

Given that cookstoves with reliable advanced performance are relatively expensive, ways must be developed to finance their initial costs and certain added expenses involved in market development. Existing loan funds administered by traditional financial groups generally have not been used to finance biomass cookstoves; in cases where they have, funds have often been directed to projects with little support for marketing or commercial development. The financial engineering required to support cookstove programs can be adapted from experiences both within and outside the WBG, including those of the energy funds, microfinance, social funds, risk guarantees, and output-based aid (OBA). The successful World Bank–financed solar home systems (SHSs) project in Bangladesh, for example, provides useful lessons in financial intermediation for small-scale energy projects. The financing and subsidies involved in such programs are complex since the products are generally sold via markets by the private sector. But such programs as Lighting Africa—although they promote fairly low-cost appliances with obvious benefits—have learned to address similar issues (Box 13). Learning from Lighting Africa has special merit, given Sub-Saharan Africa’s continued dependence on biomass cooking.

Generally, the most successful cookstove programs have not provided direct subsidies for the stoves; rather, indirect subsidies have been directed toward technical design, capacity development, M&E, and cookstove promotion. One exception, however, has been using community social funds to purchase cookstoves for entire communities; this approach also might be applicable to certain groups, such as pregnant women involved in neo-natal care programs. There might also be a role for vouchers or some form of rebate that provides increasing subsidies, based on the smoke removal or energy efficiency of stove products. It would be necessary to evaluate the balance between loans and grants for promoting better cookstoves in developing countries, taking both cost and affordability into consideration.

Mainstreaming the advanced biomass cookstove programs broadly requires that the role of climate-finance instruments, including carbon finance, be further explored. Financing through the CDM and voluntary markets has already been demonstrated (Box 12); however, using "transformational" financing instruments under the Climate Investment Funds (CIF) needs to be developed.

Knowledge Gaps and Potential Partnerships

Both technology development and program scale-up involve critical knowledge gaps. These include, but are not restricted to, rigorous field testing of stoves to support the development of standards and certification criteria; better understanding of the relationship between key health end points and exposure levels; and assessment of cookstove efficiency vis-à-vis emissions and fuel use. WBG support to fill these gaps would complement other initiatives, such as the World Health Organization–led effort on developing air quality guidelines for indoor air pollution.

Support is also needed for cookstove awareness raising and publicity, which could be dovetailed with other programs that promote the concept of clean and healthy living, such as the campaigns linked to better sanitation. Based on the latest research and information, such activities, designed to complement scale-up efforts, would highlight the adverse impacts of primitive stoves and open fires on human health and the environment and opportunities to address them with the new generation of better stoves. However, it is most important that consumers are made aware of and perceive a significant improvement in the cookstoves available for purchase compared to those they currently use. Grants could be given to NGOs to promote cookstove adoption among poorer populations as a part of clean and healthy living. Such a strategy would require cooperation among governments, the private sector, and NGOs qualified to support program dissemination. This effort could be expanded to support greater South-South exchanges and collaboration (e.g., Africa could learn from Asia's experience and the private sector could expand into newer markets). The role of partners and collaborators would be essential not only for spreading the message about the new generation of cookstoves, but also for knowledge management (e.g., intervention studies on stove performance and certification criteria). The United Nations Foundation–led Global Alliance for Clean Cookstoves offers an umbrella under which various working groups will function,[12] providing a good platform to partner with diverse stakeholders, ranging from academia to private- and public-

[12] Working groups have been established on standards and testing, technology and fuels, health, climate research, reaching consumers, finance and investment, M&E, carbon finance, and humanitarian issues.

sector entities. The creation of these working groups demonstrates the broad agenda that needs to be covered to develop and deploy the new generation of cookstoves at scale. The agenda for the World Bank mentioned here is only a part of the puzzle. There are many complementary activities for which other actors are better suited.

Chapter 6. Conclusion

The provision of clean and affordable household energy is a part of scaling up energy access for the poor. However, the problem of emissions from biomass-based cooking remains a major challenge, with approximately 2 million premature deaths (mostly women and children) attributed to it annually. Today, there is a new potential to promote advanced biomass cookstoves and affordable, effective improved cookstoves that burn fuel cleanly and efficiently, as part of the access agenda. The building blocks are falling into place. A new generation of advanced biomass cookstoves has been supported by a consortium of established private-sector organizations and donors; at the same time, less expensive, effective improved cookstoves that meet performance standards are also an option.

The growing consensus is that technical assistance is needed to develop standards and facilitate business development. Microfinance organizations, private companies, governments, and NGOs already promote advanced or effective improved cookstoves in many countries, but need support to scale up. Some stove manufacturers already offer money-back guarantees for their cookstoves, and retail distribution chains are being developed. With the advent of funds affiliated with climate-change mitigation, potential avenues for financing new initiatives are opening up. Other financing models (e.g., energy funds), for which there is sufficient accumulated experience, are applicable to scaling up stove programs. Finally, a new international coalition is forming around the issue of promoting advanced biomass cookstoves and alleviating indoor air pollution.

The issue of addressing the household (biomass) energy challenge is highlighted in the new World Bank Group (WBG) energy and environmental strategies, the latest World Development Report,[13] and the WBG Strategic Framework on Development and Climate Change. A point of entry for the World Bank is the IDA 16 consensus on mainstreaming gender and climate change in development assistance. The social and economic consequences of reducing the hours women spend collecting biomass fuel, improving their health, and freeing up their time for more beneficial activities might well result in raising the living standards of an entire generation of children and households. At the global level, there is likely to be a reduction in greenhouse gases and other climate forcers attributed to biomass cooking. Thus, in the context of changing strategies or "game changers," as characterized in this report, it makes sense for the international donor community to actively engage on the issue of clean household cooking as a topic of concern.

[13] World Bank, *World Development Report 2010: Development and Climate Change* (Washington, DC, 2010).

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Annex 1. Comparative Cooking Costs and Interfuel Substitution

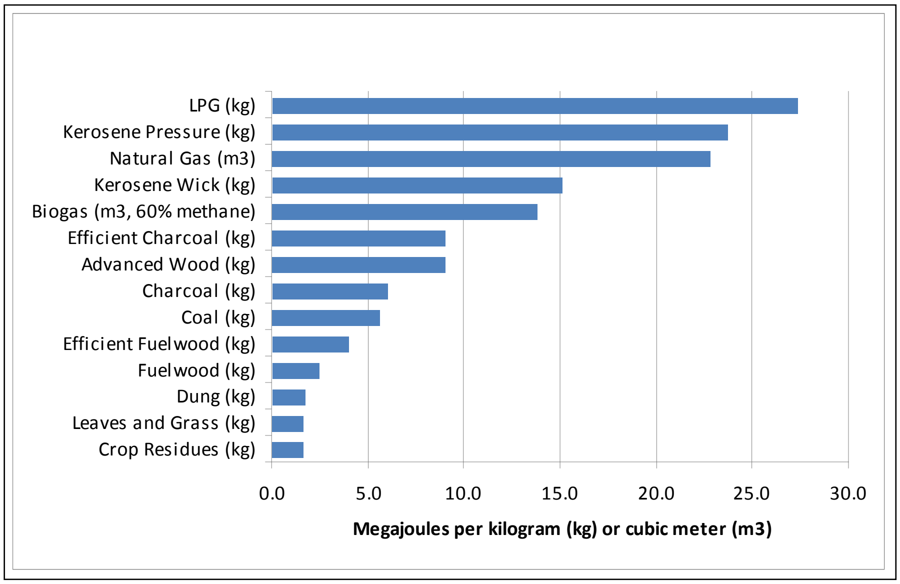
The interlinked problems of biomass energy collection, use of traditional biomass stoves, and resulting indoor pollution and its consequences for human health remain invisible to major policy makers in many developing countries. Most fail to factor the time and energy women spend collecting biomass supplies into the costs of using biofuels; therefore, women's expenditure of time and energy is often not equated with value or money. For most women in developing countries, the biomass energy syndrome means a life of poor health burdened by unpaid work and drudgery. In addition, the resulting environmental pressure often leads to degradation of nearby forests and community land.

There are several ways to deal with the problems caused by the traditional use of biomass energy in developing countries. The solutions include adjusting policies so that people can switch to liquid fuels for cooking, adopt more efficient biomass stoves, and provide means to better ventilation of the kitchen or cooking space. Such measures can significantly reduce the pressure on local biomass resources; diminish IAP levels in people's homes, leading to improved health; and free women from the drudgery and time spent collecting biomass fuels so their time can be used in more beneficial ways. As a result, it is important to examine both the comparative cooking costs and the possibilities of interfuel substitution that would entail cooking with commercial fuels, such as LPG or kerosene.

The cooking efficiency of both improved biomass stoves and commercial fuels can be illustrated by examining the delivery of heat for cooking by various combinations of fuels and stoves. LPG and other liquid fuels clearly deliver the highest end-use heat for cooking compared to all other fuel and stove combinations (Figure A1-1). This is both a function of the density of the fuel and the efficiency with which the heat is transferred to the cooking task. By contrast, straw, dung, leaves, and grass—the least liked fuels by the people who use them—are at the bottom of the chart. The conclusion is that there are basically two ways to improve efficiency of heat delivery for cooking: the use of better stoves and moving from solid to liquid fuels.

The transition to better stoves, along with efforts to promote petroleum cooking fuels, can provide many benefits to households dependent on the inefficient use of traditional cooking fuels. They include avoided health costs associated with the use of unventilated biomass stoves, which offer society an economic benefit. The avoided illnesses and deaths that might be attributed to the use of improved stoves or petroleum cooking fuels may be significant. The costs involved in treating illnesses caused by IAP, which must be borne by public health facilities, may also be significant. The conclusion is that the unvalued time spent collecting fuelwood could easily pay for an improved stove that saves fuel and thus collection time, along with any expense for purchased biomass. Although more costly, the transition to LPG for cooking would have even greater benefits than adopting an improved biomass cookstove.

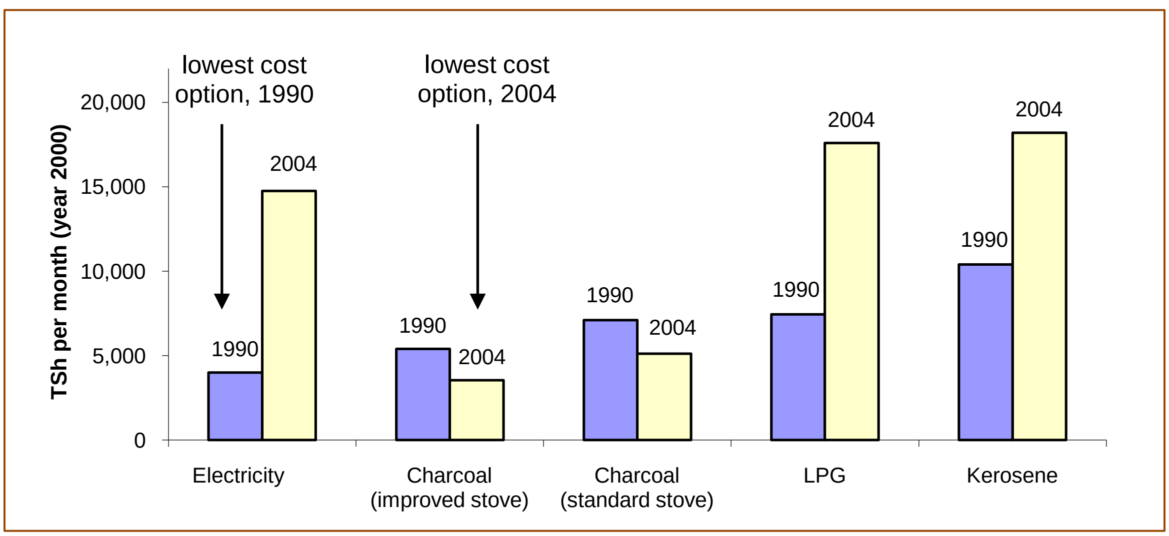
Figure A1-1. The Energy Transition for Cooking



Source: O'Sullivan and Barnes (2007).

The efficiency of using various types of cooking devices is important, but it does not help to explain either the economic benefits or the affordability of the various options. Yet such factors are quite important to people's choices of cooking fuels. Affordability is a particularly important issue for those living on $1–2 a day. In Dar es Salaam, Tanzania, for example, the cost of electricity, LPG, and kerosene increased substantially between 1990 and 2004, while the cost of charcoal decreased over the same period, leading to a greater demand for charcoal (Figure A1-2).

Figure A1-2. Monthly Cooking Costs in Dar es Salaam, Tanzania (1990 and 2004)



Sources: Hosier and Kipondya (1993); Ghanadan (2004).

One can further analyze the effect of economic impacts by calculating and comparing the cooking costs. This analysis compares the costs of various stove types, using the following method. First, the value of the fuel used for cooking is calculated. For purchased fuels, the quantity of the fuel typically used per month is multiplied by the fuel price to give the monthly cooking costs. For collected fuels, two ways are used to establish the value of the fuel collected. If there is a local market for wood or other biomass fuels, a market price can be used. If there is no local market, then the average fuel collection time per month is multiplied by the local agricultural wage rate. This method is legitimate because this wage rate is generally established by a market and essentially reflects the value of time for agricultural workers, most of whom collect biomass fuels. It is also necessary to estimate stove costs. This is done by dividing the stove price by its average lifetime. Thus, the total cooking cost is estimated by summing the fuel cash cost, the value of fuel collection time, and the stove costs.

One caveat in this analysis is that the comparative costs are hypothetical because they assume that families cook exclusively with one fuel. Typical international prices were used for both fuels and stoves; and world market prices and average fuel consumption levels were used, as defined by many international household energy surveys. Thus, the figures do not relate to any one country but offer perspective on comparative cooking costs in developing countries using some typical values of both fuel and stove costs. Obviously, in any one country, the values could change significantly depending on the local prices of both the fuels and stoves.

The price of commercial fuels was obtained by examining international retail prices and eliminating taxes and subsidies. Thus, these could be considered as shadow prices. For biomass fuels, which vary considerably by country, based on local availability, we used our more than 50 years of household energy experience to arrive at what seemed a reasonable price and collection time. It should be cautioned that these figures are based on international prices for commercial fuels and country-specific processes for wood and charcoal. Thus, the comparisons are meant to show the range of cooking costs rather than precise estimates for any particular fuel.

Recent prices for Malawi are US$0.057 per kg for fuelwood and $0.192 per kg for charcoal. Compared to other countries, these prices are a bit high, owing to high petroleum prices. Therefore, we adjusted them lower to correspond to other country-level data. But there is wide variation, which would affect the results, making biomass energy a bit more expensive. However, small differences in price would not have much effect on the overall patterns. For Kenya, a recent survey estimated the cost of purchased wood at 3.5 Kenya shillings per kg (about 4¢ per kg). For charcoal, the price was 8.8 Kenya shillings per kg (about 11¢ per kg). In research not presented here, we also calculated the end-use cost for cooking to confirm that our assumptions were reasonable (Table A1-1).

Table A1-1. Commercial Fuel Prices in Selected Markets, 2010

Commercial fuel	Price/ gal	Price/ kg	Kg/ month	Cost/ month
Kerosene (world market price, 2010)	2.80	0.92	15.00	13.80
LPG (world market price, 2010)	2.50	1.20	13.00	15.60
Charcoal (Malawi and Kenya average)	--	0.13	73.58	9.57
Wood (Malawi and Kenya average)	--	0.04	150.00	6.43

Source: Own estimates.

The price of kerosene would probably have been higher if exclusive to cooking; however, based on experience, we took the average for people using both wick and pressure stoves. Fuel use per month varies significantly by country, but these figures are accepted as about average for most countries that have fairly normal pricing policies. Using the so-called rule of thumb developed for household cooking over the years, we modified the figures as needed. For example, a recent survey in Kenya found that household fuelwood consumption was about 160 kg per month, and charcoal use about 50 kg per month. These figures are fairly close to those presented below (Table A1-2).

Table A1-2. Cooking Price and Average Monthly Consumption

Stove type	Cash fuel price/kg	Average stove efficiency (%)	Fuel use per family (kg/month)
Traditional open fire	0	0.15	150
New-generation single pot	0	0.30	75
New-generation two-pot with chimney	0	0.30	75
Artisan improved	0	0.25	90
Biogas system	0	0.60	NA
LPG	1.20	0.60	13
Kerosene (pressure)	0.92	0.55	15
Kerosene (wick)	0.92	0.35	15
Charcoal (improved)	0.13	0.30	55
Charcoal (traditional)	0.13	0.20	74
Traditional open fire (urban)	0.04	0.15	150

Sources: O'Sullivan and Barnes (2007); Barnes, Krutilla, and Hyde (2005); own estimates.
Note: Fuel use is for an average family of 5.

Table A1-3 shows the monthly value of fuel collection. In India, the agricultural wage rate in 2005 was about Rs. 33 for women and about Rs. 48 for men. This is approximately 1 dollar a day, which is similar to the figures used for poverty-level estimates; thus we used 1 dollar a day, divided by 8 hours. For biogas, we estimated that fuel collection costs are zero, even though dung and other feedstock must be collected and put into the digester. However, we reasoned that fuel-collection costs are offset by improved fertilizer (i.e., dung would otherwise have been collected for fertilizer or fuel use). We did not include information on dung since its low energy content limits its use to mainly slow cooking and warming of food.

Table A1-3. Value of Fuel Collection per Month

Fuel collected, stove type	Collection hours/ month	Agricultural wage rate, India (US$/hour)	Value of collection (US$/month)
Wood, open fire	30	0.125	3.75
Wood, new generation	15	0.125	1.88
Wood, artisan	20	0.125	2.50
Biogas (dung and other feedstock), biodigester	0		

It is particularly important to recognize that it is not only the levelized costs of stoves and fuels that are an issue, but also the pressures of fuel and stove purchases when families are under economic stress.

The value of stoves is rather straightforward compared to other aspects of comparative cooking costs. The retail cost of the stoves is simply divided by the life of the stove to arrive at a monthly cost.[14] Based on our experience, we estimated the cost of the artisan and charcoal stoves. The costs of next-generation stoves are available for various stove types, and we used the costs of the rocket wood stoves. Depending on the model purchased, the price of these stoves can be higher or lower, so we decided to use a price that was neither in the lower nor the top part of this price range. Biogas systems come in various sizes and shapes as well. Since we were not valuing the collection cost of the fuels, we decided to use an average cost for a relatively high-quality system that would not be prone to breaking down over the life span of the system. We did not include maintenance costs in the calculations since dividing them by months of service would add little to the overall stove cost. Similarly, we did not include replacement parts and maintenance costs for kerosene stoves (Table A1-4).

[14] We have not discounted the value of the stoves because of the difficulties that would result from the differing life spans of the stoves; however, the differences would be quite small. This example is for illustrative purposes only.

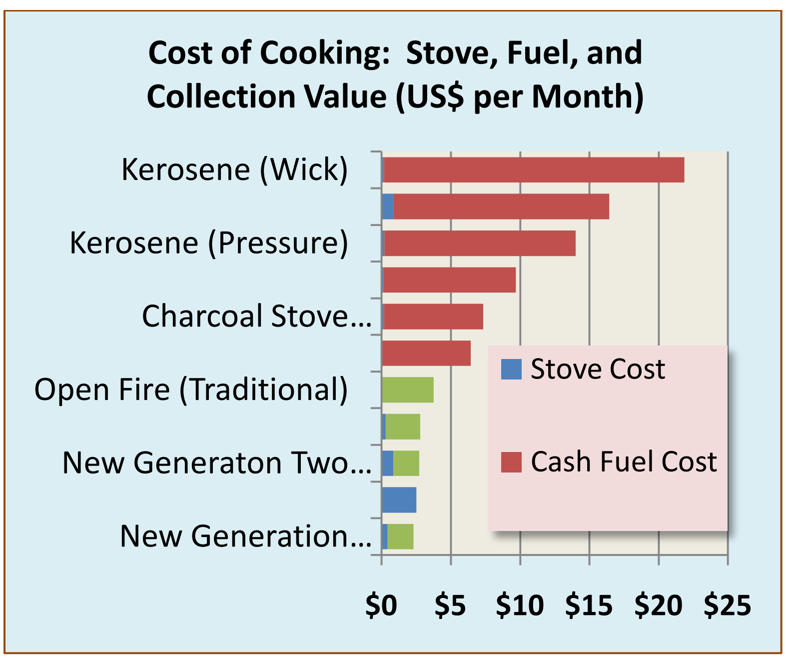
Table A1-4. Typical Stove Costs in Developing Countries

Stove type	Stove cost (US$)	Life of stove (years)	Cash stove cost (US$/month)
Traditional open fire	0	na	0.00
Traditional charcoal	3	2	0.13
Improved charcoal	6	3	0.17
Kerosene wick	6	3	0.17
Kerosene pressure	7	3	0.19
Artisan improved	5	1.5	0.28
New generation single-pot	25	5	0.42
LPG stove plus cylinder	100	10	0.83
New generation two-pot and chimney	50	5	0.83
Biogas system	300	10	2.50

Sources: Based on Kenya charcoal stoves, Envirofit International stove, LPG stoves in India, SNV-promoted biogas systems, and others.

With the above assumptions, it is possible to construct a profile of comparative cooking costs. From these estimates, it becomes clear why people continue to use biomass fuels in developing countries. Generally, biomass fuels are less expensive than petroleum-based fuels. In addition, the cost of a traditional charcoal stove and fuel use is about the same as for LPG, but this is not an unusual pattern for urban areas in developing countries. Charcoal prices often follow those of petroleum once adjusted for cooking efficiencies. It should be noted that cooking exclusively with a kerosene wick stove is uncommon—the stove is used mainly for simmering and slow cooking—which might explain its exorbitant cash fuel cost (Figure A1-3).

Figure A1-3. Profile of Comparative Cooking Costs



Interestingly, after valuing fuel collection time, cooking with an open fire is the most expensive form of cooking with wood. Once the price of an improved stove is spread over its lifetime, the actual stove costs are quite low and completely overshadowed by the value of saved biomass or reduced collection time. This might suggest that, in addition to the value of convenience and cultural cooking practices, a key to promoting improved stoves is to spread out the relatively unaffordable initial purchase costs of the stove. Once this is done, the new manufactured wood stove incurs the lowest expenses for cooking compared to all other stove and fuel combinations. In fact, the cost savings compared to an open fire can be as high as 40 percent. These estimates of cooking costs are for illustrative purposes only because it is expected that the cost of cooking will vary significantly between countries due to differences in policies to tax or subsidize commercial fuels, the local price of wood, and the extent of average fuel collection time.

Annex 2. Black Carbon, Climate Change, and Traditional Cookstoves

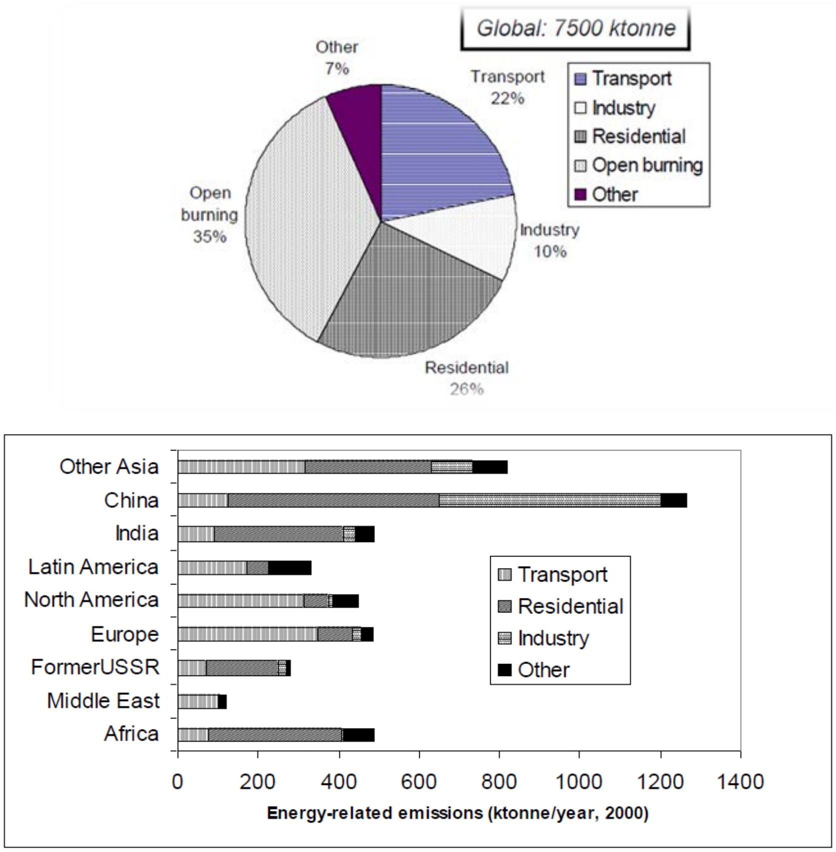
Black carbon (BC) is an aerosol—a fine, solid particle dispersed in the air—made of elemental carbon produced via incomplete combustion, which has both local (health) and global (climate change) consequences. A major component of soot, BC is known to have significant adverse health effects when inhaled. It is also recognized as one of the principal agents of global warming. Climate science now views BC as the second or third largest warming agent after CO_2, alongside methane (CH_4). BC's global warming effect is estimated at 27–55 percent that of CO_2 (Ramanathan and Carmichael 2008). Thus, addressing BC emissions is a potentially good example of delivering co-benefits from environmental policies.

BC warms the atmosphere differently from greenhouse gases (GHGs). It is highly effective in absorbing energy from the sun, which the particles then convey to the atmosphere. Upon deposition on ice and snow, BC accelerates melting and darkens the surface. By reducing the reflectivity of the earth's surface, it warms the climate. This effect increases the likelihood that cookstoves could mostly contribute to global warming, especially in areas close to ice and snow accumulations. In the Himalayas, for example, there is evidence that BC from cookstoves is having a significant effect on accelerating the melting of glaciers, with implications for regional water supplies. Regions high in emissions from BC and related aerosols can suffer from extensive brown haze that can affect temperature and precipitation. In Asia, for example, early evidence suggests that large BC emissions have caused shifts in India's monsoon and China's rainfall patterns.

The lifetime of BC particles in the atmosphere is 1–2 weeks on average, compared to centuries or millennia for CO_2. Although BC does not accumulate, it is constantly replenished by human and natural activities, including the burning of agricultural land and forests and use of biomass for fuel, coal in households and industry, and diesel for transport and stationary power generation. Traditional cookstoves and open hearths emit large amounts of fine particulate matter (PM)—of which BC is a part—causing severe IAP, leading to adverse health impacts, particularly for women and young children. Global inventories indicate residential sources account for nearly one-fourth of BC emissions, mainly from cookstoves and stone hearths using solid fuels (Bond et al. 2004; Bond et al. 2007; Bond 2010) (Figure A2-1).

Biomass fires also produce large quantities of organic carbon (OC) particles, a cooling agent that tends to offset BC's warming effect (Box 6). The scientific understanding of how BC and OC interact with climate is significantly less than for CO_2, and much research is being conducted in this challenging area. Questions that need more robust answers include the ratio of BC and OC emissions from various sources, their interaction with clouds, changes in BC chemistry after particles are emitted, and BC transport from points of production to the wider atmosphere. To assess the effect of BC and OC combinations on global warming, emissions need to be considered within global climate models that calculate the interaction of all these factors with other climate variables. To date, climate modeling has not determined with a high degree of certainty the net impact of reducing BC and OC emissions on global warming.

Figure A2-1. Global Emissions of Black Carbon by Sources and Regions



Source: Bond (2010).

It should be stressed that the results from global climate models are highly dependent on the ratio of OC to BC that is assumed; and since that ratio is likely to vary greatly between locations, combustion devices, and types of biomass used as fuel, it is possible that field measurements will find regional differences in the net warming influence of OC and BC emissions from biomass burning. In contrast to the uncertainty about the effect of aerosols on net global warming from reduced use of biomass fuels, climate modeling shows that it is highly likely that less use of diesel and coal reduces global warming because of the high proportion of BC (which is warming) relative to OC (which is cooling).

Cookstoves co-emit other products of incomplete combustion (PIC) that also contribute to global warming, including nitrous oxide (N_2O) and carbon monoxide (CO) (Smith et al. 2000b; MacCarty et al. 2007). In addition, emissions from charcoal stoves include methane (CH_4), which has a high Global Warming Potential (GWP); if the upstream emissions from charcoal production are considered, the climate impacts become significantly higher.[15] Reduction in non-

[15] It has been shown that, under conditions of sustainability (i.e., complete CO_2 sequestration), emissions of other pollutants during charcoal production and use amount to more than 2,600 g of carbon (CO_2 equivalent; 20-year GWP) from non-CO_2 GHGs for each kilogram of charcoal; in comparison, the emissions range of non-CO_2 GHGs for each kilogram of firewood is 200–400 g (Bailis, Ezzati, and Kammen 2003).

CO_2 GHGs and PICs, including OC and BC, is also important, given that it is the most readily demonstrable climate benefit of introducing better cookstoves. Under accepted, voluntary-market emissions-reduction methodologies and potential BC emission-reduction initiatives, the reduction of non-CO_2 GHGs and PICs may be of critical importance and a possible source of monetizable revenue.

MacCarty et al. (2007) have conducted the most comprehensive study incorporating the GWP of non-CO_2 GHGs and PICs, including BC and OC. While providing appropriate disclaimers for the arbitrariness of the task selected (boiling a liter of water and simmering for 30 minutes), the laboratory-based nature of the tests, measurement of emissions, and calculation of GWP for non-standard PICs provides a valuable study comparing cookstoves.

The study shows that the emissions and thus the climate impacts vary greatly between cookstove types. Three-stone fires have 2.5 times the GWP as rocket or fan stoves and nearly double the GWP of gasifier stoves. Fan stoves consume more fuel and thus release more CO_2 than some other improved cookstoves, but with a dramatic PM reduction. Gasifier stoves are not terribly efficient, releasing more CH_4 than fan stoves, yet also achieve a dramatic reduction in PM emissions, with significant repercussions for BC's impact on human health and climate.

Table A2-1. FAO Projections of Woodfuel Consumption in Developing Regions to 2030

Woodfuel type	1970	1980	1990	2000	2010	2020	2030
Fuelwood (million m^3)							
South Asia	234.5	286.6	336.4	359.9	372.5	361.5	338.6
Southeast Asia	294.6	263.1	221.7	178.0	139.1	107.5	81.3
East Asia	293.4	311.4	282.5	224.3	186.3	155.4	127.1
Africa	261.1	305.1	364.6	440.0	485.7	526.0	544.8
South America	88.6	92.0	96.4	100.2	107.1	114.9	122.0
World	1,444.7	1,572.7	1,611.6	1,616.2	1,591.3	1,558.3	1,501.6
Charcoal (million tons)							
South Africa	1.3	1.6	1.9	2.1	2.2	2.4	2.5
Southeast Asia	0.8	1.2	1.4	1.6	1.9	2.1	2.3
East Asia	2.1	2.3	2.3	2.2	2.1	2.0	1.8
Africa	8.1	11.0	16.1	23.0	30.2	38.4	46.1
South America	7.2	9.0	12.1	14.4	16.7	18.6	20.0
World	21.2	27.0	35.8	45.8	55.8	66.3	75.6

Source: Broadhead, Bahdon, and Whiteman (2001).

Biomass fuel used for household energy also contributes to forest degradation and possibly deforestation if biomass is harvested unsustainably. The UN Food and Agriculture Organization (FAO) has estimated that woodfuel consumption in Africa and Latin America, part of which may be non-renewable, will continue to rise rapidly in the coming decades (Broadhead, Bahdon, and Whiteman 2001; Arnold et al. 2003) (Table A2-1).

Annex 3. Overview of Selected Biomass Cookstove Programs Recently Implemented

Promotion in Asia, Latin America, and Worldwide

Attribute	New Lao Stove (NLS) Program, Cambodia	Rocket and Malena Stoves, EnDev Bolivia	ONIL Stove and Chimney Wood Stove, Nicaragua and Guatemala	Oorja Stove Program, India	Envirofit International Cook Stove Program, India	StoveTec Improved Cook Stove Program, Global
Fuel type	Charcoal	Wood	Wood	Biomass pellets	Wood	Wood and wood-charcoal
Combustion efficiency	Low	Intermediate	Intermediate	High	Intermediate	Intermediate
Chimney	Not Applicable	Yes	Yes	No	Optional	No
Implementing agency and main partners	GERES, the European Commission.	GTZ in cooperation with Energy Ministry, prefectures, municipalities, stove installers, and NGOs; funded by DGIS (Dutch government) and BMZ (German government).	HELPS International, Shell Foundation, U.S. EPA, and BANRURAL.	BP Energy India Private Ltd., First Energy, and Indian Institute of Science.	Envirofit International, Envirofit India, Shell Foundation, Grameen Koota, Oak Ridge National Laboratory, Colorado State University, Aprovecho Research Center.	StoveTec, Aprovecho Research Center and various donors, NGOs, and government agencies.
Duration	1998–2006	2006–2013	1999–present	2006–present	2007–present	2009–present
Achievement	800,000 stoves produced and sold to about 300,000 households; 31 production centers established, including 5 that produce NLS stove exclusively.	29,249 improved stoves (both Rocket and Malena types) sold across Bolivia.	82,000 ONIL stoves distributed.	445,000 stoves sold; 32,000 tons of biomass pellets sold.	More than 100,000 cookstoves sold by Envirofit.	120 projects completed in 50 countries; since 2009, 155,000 stoves sold, 75% of which were sold to Envirofit International.

Promotion in Asia, Latin America, and Worldwide (Continued)

Attribute	New Lao Stove (NLS) Program, Cambodia	Rocket and Malena Stoves, EnDev Bolivia	ONIL Stove and Chimney Wood Stove, Nicaragua and Guatemala	Oorja Stove Program, India	Envirofit International Cook Stove Program, India	StoveTec Improved Cook Stove Program, Global
Technology	Updraft combustion stove with a grate that uses charcoal.	Rocket Stove: semi-industrial metal stove with a ceramic burning chamber; metal stoves for peri-urban areas. Malena Stove: mud adobe two-pot chimney stove with very good performance and quality control (for poorer rural families); made of unfired mud/clay bricks mixed with straw and dung. Metal chimney and grate provided by the project at no cost.	Rocket-type, woodfuel chimney stove.	FirstEnergy "Oorja™" Stove (originally developed by BP). Requires pelletized fuel and electrical power for its fan. Pellets made of agricultural waste. Chamber for burning pellets; mini-fan (powered by rechargeable batteries and controlled by a regulator). Increased combustion efficiency and no smoke generated.	Legacy ceramic stoves and new G-series stoves (made of metal with a 5-year warranty). Metal shelf in front of combustion chamber to support fuelwood.	Wood and wood-charcoal stoves with metal combustion chamber that has a refractive ceramic liner. Metal shelf in front of combustion chamber to support fuelwood.
Approach	Training a group of cookstove producers; establishing association of producers; dissemination of stoves.	Dissemination via (i) commercial approach (trains professional producers who build stoves for a fee) and (ii) self-build approach (NGO technicians and promoters trained and paid to train households to build stoves) (partially successful, as special skills and experience needed to ensure efficiency and quality).	Mass production and distribution of stoves.	Company functions as commercial stove-producing enterprise. Entrepreneurs trained in villages via product training and basic business management; carry out sales and distribution. Service engineers and service centers on company rolls. Currently, sales are 55% urban areas and 45% rural ones.	High-volume manufacturing in China and India; stoves sold through well-established enterprises. Local retailers, already in the business of selling stoves, have an additional product to add to their range of goods.	Mass-produced wood and wood-charcoal stoves; factory established in China; micro-entrepreneurs and independent sales representatives trained. Regional distribution hubs set up with partners. Most sales to distributors (e.g., companies, government agencies, and NGOs).

Promotion in Asia, Latin America, and Worldwide (Continued)

Attribute	New Lao Stove (NLS) Program, Cambodia	Rocket and Malena Stoves, EnDev Bolivia	ONIL Stove and Chimney Wood Stove, Nicaragua and Guatemala	Oorja Stove Program, India	Envirofit International Cook Stove Program, India	StoveTec Improved Cook Stove Program, Global
Financing and subsidies/ pricing	Selling price of $2.3–4; a 30% subsidy offered to producers, in the form of a loan or grant. Carbon finance covers the "soft" costs, including marketing, research and development, training producers, quality control and assurance, and standardization.	Retail price range for both stoves of $30–40. Stove producers supported with a decreasing subsidy rate, from $26 in 2005 to $15 in 2007. Complete subsidy withdrawal, as originally planned, hampered by increasing metal prices; by mid-2008, a loan scheme put in place to complement subsidy in the short term, eventually substituting it altogether in the long term.	In Mexico, stove cost is $150 (stove, demonstration, training of assembly and use, and follow-up visit). In Guatemala, stove cost is $100 (includes same as above); for an extra $15, stove delivered to community anywhere in the country in minimum quantities of 50. HELPS community development program purchases stoves and other products at full price from ONIL Products division. ONIL program currently seeks carbon-credit funds via CDM, and is in the process of validation and registration; 100% of cost borne by customers. HELPS International to use microfinance to help families access loans to pay for stoves; income from carbon finance key to overcome this and other barriers.	Stove cost range of $24–37. Pellets 0.1 cents per kg. No subsidies offered.	Price range of $19–31. 100% of cost borne by customers; according to Envirofit, India, retail market sufficiently developed to support a non-subsidized product. Envirofit works with local government, which subsidizes part of the cost for the poor (usually sells it at 10% of the cost); currently conducting negotiations with key carbon finance players.	Retail price of $8–10 for wood stove and $10–12 for wood-charcoal stove. Subsidies offered by some distributors.

Promotion in Asia, Latin America, and Worldwide (Continued)

Attribute	New Lao Stove (NLS) Program, Cambodia	Rocket and Malena Stoves, EnDev Bolivia	ONIL Stove and Chimney Wood Stove, Nicaragua and Guatemala	Oorja Stove Program, India	Envirofit International Cook Stove Program, India	StoveTec Improved Cook Stove Program, Global
Market development	Included diagnostic study to determine operational strategy and identify basic project components: choice of pilot area, resources to put in place, and technological work to be done. GERES faced problem of tendency toward NLS market saturation, noted by producers. NLS market needs to be better understood and investigated to avoid saturation. Stoves more suited to rural conditions should also be offered.	Project faced difficulties due to direct competition with subsidized LPG and increasing metal prices.	ONIL stoves initially designed by interviewing 60 women in Guatemalan highlands to better understand their cooking needs and preferred pot sizes and materials to devise a solution of which the women approved. Prototypes field-tested and modified before the women accepted the stoves, after which commercialization began.	Main monitoring and market development mechanisms: company's financial results, sales numbers, and marketing surveys; company also worked with universities and institutions to share knowledge and have third-party evaluations.	Envirofit India regularly conducts extensive market monitoring before and after entering a particular region; surveys done in coordination with partner groups (e.g., Grameen Koota), externally (e.g. MART, an expert in conducting surveys of rural Indian populations, and Berkeley Air Monitoring Group, which conducts independent verifications of Envirofit cookstoves in the field), and internally (e.g., Envirofit sales team members talking to customers at promotional events).	StoveTec develops a network of partners (e.g., Trees Water People in Haiti, GTZ ProBeg in Africa and Asia, World Vision Australia in Ethiopia) that have the knowledge and familiarity with local tastes and preferences in various countries.

Promotion in Asia, Latin America, and Worldwide (Continued)

Attribute	New Lao Stove (NLS) Program, Cambodia	Rocket and Malena Stoves, EnDev Bolivia	ONIL Stove and Chimney Wood Stove, Nicaragua and Guatemala	Oorja Stove Program, India	Envirofit International Cook Stove Program, India	StoveTec Improved Cook Stove Program, Global
Improved stove identification and development	GERES set up a quality seal system; it demands and enforces the agreed quality standard with producers. GERES Cambodia has developed a test protocol adapted for the NLS. It is improving the stove in permanent liaison with a pilot producer. Parallel to introducing the stove in a real-life situation, one or more pilot producers are chosen to carry out final stove production tests, technique validation, and selection among a range of stoves.	Implementers used continuous direct feedback from households and installers. Stoves adapted for local development and various environments and fuels (e.g., wood, dung, or lama dung).	Continuous feedback from the field helped in making modifications based on laboratory testing and analysis, as well as cost/benefit ratio of the modifications. Thanks to feedback, other products have been created to meet household needs (e.g., Nixtamal stove [large pot boiler], institutional stove [similar to Nixtamal but with chimney for indoor use], ONIL Cooker [retained heat cooker], basic solar lighting [to replace light from the open fire], and ONIL Water Filter [in some regions of Guatemala, 40% of firewood is used to boil water]).	Technology developed via a collaborative partnership with the Indian Institute of Science. Initial laboratory testing followed by extensive consumer testing with prototypes; based on feedback, final products were developed.	"Voice-of-the-customer" driven design traits and concepts infused into product development process. Focus groups conducted to obtain information on perceptions of prototype and production designs.	Identification of improved stoves goes through the following channels: field tests in India, where 120 women cook meals; cooking tests in a laboratory; daily monitoring of fuel use and IAP; and recent field tests in Uganda by Columbia University.

Promotion in Asia, Latin America, and Worldwide (Continued)

Attribute	New Lao Stove (NLS) Program, Cambodia	Rocket and Malena Stoves, EnDev Bolivia	ONIL Stove and Chimney Wood Stove, Nicaragua and Guatemala	Oorja Stove Program, India	Envirofit International Cook Stove Program, India	StoveTec Improved Cook Stove Program, Global
Communication/ promotion	Classic advertising campaigns for consumer products (e.g., washing powder). Project used video clips, posters, cartoons, and demonstrations. Advertising campaigns unusually effective in disseminating NLS. Campaign created visual identity for stove, which became known to a maximum number of potential users.	Channels included village events, radio programs, leaflets, manuals, posters (operation and maintenance), and demonstration stove build outs engaging communities at the beginning of the project.	Stoves marketed via other NGOs, local associations, farm owners, socially responsible businesses, municipal and federal government programs, community distributors, or direct sales. Communication channels: radio, newspapers, billboards, rural schools, urban buses, stands at events, and market-day events involving rural communities and community distributors.	Demonstrations, posters; press, TV and radio ads, van campaigns, and wall paintings in villages.	Stove demonstrations; TV ads; talk shows; display vans; and working with government officials, women, and wage earners.	Stove demonstrations, TV ads, and talk shows.

Promotion in Asia, Latin America, and Worldwide (Continued)

Attribute	New Lao Stove (NLS) Program, Cambodia	Rocket and Malena Stoves, EnDev Bolivia	ONIL Stove and Chimney Wood Stove, Nicaragua and Guatemala	Oorja Stove Program, India	Envirofit International Cook Stove Program, India	StoveTec Improved Cook Stove Program, Global
Local perceptions	NLS popularity due to the ability to recoup the stove price within six months because of fuel savings.	For both stoves, customers reported less eye irritation and coughing and cleaner kitchens. Malena stoves tended to have higher acceptance than rocket stoves.	Program evaluation showed stove acceptance (after several years) varies with acquisition type, follow-up by implementing organization, and spare-parts availability. A main challenge: the ONIL stove "competes" against cell phones and Coke.	Users report such main benefits as convenience, fast cooking, fast heating (of water), and time savings. Health benefits not among top priorities, according to company employees.	Three-quarters of cooks in a USAID study said Envirofit stoves would be an improvement over their existing appliance; over 70% of respondents associated the Envirofit stove with convenience and fuel savings.	Users give StoveTec credit for using less wood, but the main factors are the time spent cooking food and design.

Promotion in Africa and Haiti

Attribute	Uganda Stove Manufacturers Program	Mirt Stove, Ethiopia	Jiko Kisasa Stove, Kenya	Recho Mirak Stove, Haiti
Fuel type	Separate models for charcoal and wood	Wood	Wood	Charcoal
Combustion efficiency	Low	Intermediate	Intermediate	Low
Chimney	No	No	No	No
Implementing agency and main partners	Uganda Stove Manufacturers, Ltd. (Ugastove), U.S. EPA, JP Morgan Climate Care, and CEIHD/Impact Carbon.	GTZ, Shell Foundation, Ethiopian Ministry of Agriculture, and Netherlands Directorate-General of Development Cooperation (DGIS).	GTZ, Department of Agriculture of the Government of Kenya, German Federal Ministry for Economic Cooperation and Development (BMZ), and Netherlands Directorate-General of Development Cooperation (DGIS).	ESMAP/World Bank
Duration	2007–28	1998–08	2005–12	2007–09
Achievement	60,000 stoves sold; Ugastove now manufactures some 70 stoves per day.	458 Mirt stove producers trained, 251,000 stoves sold in Ethiopia (Tigray, Amhara, and Ormiya regions), and 339 entrepreneurs supported and established.	By December 2009, 775,000 stoves sold with 3.5 million people having benefited (by June 2009, some 380,000 stoves had been sold); the doubling of the number of stoves sold shows the significant scale-up effect. Average monthly production of 337 Jiko Kisasa liners per producer and average monthly income of $200–400.	144 artisans trained and 120 certified for stoves production; 23 traders and 49 artisans trained in business and accounting. Documented production of more than 8,000 improved stoves. More than 10,000 quality labels distributed to qualified stove manufacturers. Some 20,000 improved charcoal stoves sold.
Technology	Three types of improved fuel-efficient stoves marketed: (i) charcoal stoves for domestic and restaurant use, (ii) residential wood stoves, and (iii) institutional wood stoves.	High-mass stove made of cement and volcanic ash; produced to cook Ethiopian bread (*injera*).	Stoves promoted included portable wood-burning Jiko Kisasa, made of scrap metal and ceramics; inbuilt Jiko Kisasa with 1–2 potholes; rocket stoves with 1–2 potholes; and institutional rocket stoves, baking ovens, and soil sterilizers.	Improved stove with a closed combustion chamber; offers a 40% reduction in charcoal consumption, which reduces the cost of input materials.

Promotion in Africa and Haiti (Continued)

Attribute	Uganda Stove Manufacturers Program	Mirt Stove, Ethiopia	Jiko Kisasa Stove, Kenya	Recho Mirak Stove, Haiti
Approach	Producing and selling stoves on a commercial basis.	Training producers and supporting entrepreneurs.	Capacity building in all aspects of stove commercialization. Expanding broad local knowledge, experience, and resources through work with local administration and community-based organizations and groups. Support for establishment of a Stove Dealers' Association to take over stove activities after project phase-out. Major skills-transfer effort to the Association so it can realize its position and responsibilities as a national entity.	Facilitating modernization of the distribution supply chain; training of craftspersons to enable them to improve production capability, create small enterprises, and develop management and business skills; fostering of business relationships between raw materials suppliers and craftspersons that produce stoves; and offering business support services to assist in stove sales and promote the implementation of successful business models.
Financing and subsidies/pricing	Price of the household charcoal stove is US$11; the household wood stove costs $15. No subsidies offered. Carbon finance covered soft costs (e.g., training staff, marketing and sales, and credit facilities).	Selling price is US$2–4, with a coupon-based subsidy system; in Amhara and Oromia, the product did well without any subsidies. Average subsidy about 24% of stove cost; subsidy valid for a limited time and for a certain number of stoves.	Prices vary from US$1.5–3 for Jiko Kisasa, $2.5–3 for one-pot Rocket Mud Stove, and $3–6.5 for two-pot Rocket Mud Stove. No direct subsidies; indirect subsidies offered in terms of capacity building of and support to stove producers, builders, installers, and contractors with regard to technical and entrepreneurial skills, organizational development, and workshop equipment.	Price is about US$3–4, twice the price of the traditional charcoal stove.

Promotion in Africa and Haiti (Continued)

Attribute	Uganda Stove Manufacturers Program	Mirt Stove, Ethiopia	Jiko Kisasa Stove, Kenya	Recho Mirak Stove, Haiti
Market development	Commercialization approach emphasized from program start; market development component ensures wider and sustainable markets; but mechanism for developing and sustaining markets has not been fully implemented. Major barrier is lack of sufficient funds to reach out to all market segments. Well-researched marketing plan designed with Partnership for Clean Indoor Air (PCIA) funding. Market plan further refined with support from Accenture Development Partners (ADP), but some recommendations are yet to be implemented for reasons related to limited funding.	Business and technical-skills training aim to establish a nationwide network of Mirt stove producers; institutional strengthening and capacity building for partner organizations.	Capacity building of and support to stove producers, builders, installers, and contractors on technical and entrepreneurial skills, organizational development, and workshop equipment; stoves promotion through recruitment and training of stove marketing groups and developing entrepreneurship skills of all stove dealers; public awareness raising on improved stoves and hence opening up stoves market; promotion of income generation through stove production and productive use of cooking devices.	Training artisans to produce the improved charcoal stoves, enabling them to develop the market chain, and encouraging them to form cooperatives (this activity faced a number of hurdles as artisans preferred to work on their own). Project faced problems convincing artisans to start producing the stoves as they saw no demand for them.

Promotion in Africa and Haiti (Continued)

Attribute	Uganda Stove Manufacturers Program	Mirt Stove, Ethiopia	Jiko Kisasa Stove, Kenya	Recho Mirak Stove, Haiti
Improved stove identification and development	Focus-group discussions regularly conducted to establish customer preferences. In 2006 and 2007, technical designs improved to achieve high-efficiency levels with expert help from the Centre for Entrepreneurship in International Health and Development (CEIHD), based at the University of California, Berkeley, with financial support of the PCIA.	Stove adoption-rate studies carried out in all regions, followed by product testing and design modification. Based on continuous research and development, new stove models developed, using alternative and cheaper raw materials.	To address quality control and better stove identification, the GTZ project established Kenaisa, a stove association linked to the Kenyan Bureau of Standards, to assume responsibility for quality control and support of stove producer businesses.	Branding effort featured an Eco-Label (QEEL) quality-control seal, serving as visual reminder of Mirak stove's benefits and guaranteed energy efficiency. Financing quality-control system ensured compliance of stoves produced with norms defined under QEEL. Regulatory and support measures identified to promote the sale of energy-efficient stoves and discourage the dissemination of inefficient traditional stoves. M&E of chain of production, sale; specific project component to provide data to correct or fine-tune ongoing operations and document process for possible replication. Government institutions often could not oversee quality of stoves sold or enforce standards established by the project. Office for Mines and Energy has only recently acquired equipment for efficiency testing of fuel and stoves.

Promotion in Africa and Haiti (Continued)

Attribute	Uganda Stove Manufacturers Program	Mirt Stove, Ethiopia	Jiko Kisasa Stove, Kenya	Recho Mirak Stove, Haiti
Communication/ promotion	Infomercials, radio programs, group demonstrations, and door-to-door advertisements.	Awareness raising and promotion campaign carried out by Shell Foundation included coupon sales, cooking demonstrations, TV ads, radio commercials, and billboards. TV commercials effective in urban areas, while radio commercials effective in rural areas.	Promotion through recruitment and training of stoves marketing groups and building entrepreneurship skills of all stove dealers; marketing groups and individual entrepreneurs carried out market and cooking demonstrations, stove campaigns, consumer education, trade fairs, and other exhibitions; GTZ produced promotional materials, including flyers, pamphlets, t-shirts, posters, and print (e.g., stove bulletin) and mass-media materials.	Public-awareness campaign launched to educate consumers on stoves' economic, health, and environmental benefits. Campaign included efforts in model recognition, public demonstrations, brochure distribution, radio and TV ads, and newspaper articles. Communications company, Mediacom, prepared and placed ads with 2 TV and 5 radio stations over an 8-month period; prepared 2,000 promotional stickers and many informational brochures; and enlisted a well-liked spokesperson for media ads (incurring added costs).
Local perceptions	Users preferred the lower fuel consumption, ease of lighting, ability to simmer, lower heat radiation, and stability, some of which attributes were unique to Ugastove charcoal and wood stoves.	Popular with and well-adopted by consumers across all regions. Consumers often cited their preference for the stove's fuel economy and reduced smoke for better health and convenience. Fuel economy as a major reason for purchasing was ranked first by majority of consumers in all regions.	Women interviewed cited time gained from faster cooking and money saved from less firewood use. Time surplus used for farming, income-generating activities, girls' education, and women's participation in community life. Money saved used to buy daily items. Health improvements due to reduced smoke emissions and fewer accidental burns of children considered improvement of living conditions.	Investigators, who periodically meet 100 test subjects, report positive comments from these stove users. Once consumers jump the hurdle of the higher stove price, they are satisfied with visibly higher performance of the newer model. If they do, given the savings in charcoal purchases, it is estimated that less than a month is needed to recover the additional investment.

Annex 4. Description of Selected Cookstove Programs

Envirofit International's Family of Rocket Stoves

Envirofit International's family of rocket stoves is developed by Envirofit International in partnership with the Engines and Energy Conversion Laboratory at Colorado State University and the Materials Science and Technology Division at Oak Ridge National Laboratory. After a period of research and design, the manufacturing program was started in 2007 with the help of various foundations. The program can be considered in the initial stages of scaling up activities; to date, more than 100,000 stoves have been sold in India, with target sales of over 10 million. The basic stove without a chimney costs about US$30 (see photo below). Envirofit has begun to work with microfinance organizations to make the stoves more affordable to consumers. The development of this stove was made possible by a partnership with the Shell Foundation.

According to the manufacturer, the Envirofit cookstoves are designed to burn traditional fuels like wood and other biomass materials. They are designed to reduce fuel use by 60 percent, CO_2 emissions by 60 percent, and black carbon (BC) by 40 percent. Using this stove, energy savings would equal 800 kg of wood per year. The design was developed using advanced Computational Fluid Dynamics, heat transfer modeling, and robust emissions and durability testing to optimize the geometry and materials. The program is not restricted to the laboratory. Envirofit has worked with customers across the world to assess their needs for a good general cookstove. The stoves have been designed for an attractive appearance, ease of use, and extended durability. As a result, Envirofit has developed a patented design that makes the stoves clean burning, efficient, lightweight, durable, and affordable. Recently, an improved charcoal stove was developed to be sold initially in Africa.

The Envirofit program description is available at www.envirofit.org.

Aprovecho's StoveTec

The Aprovecho Research Center, through its StoveTec spin-off organization, has designed the StoveTec stove, a model that incorporates all the proven features learned through Aprovecho's many years of stoves program experience (120 projects in 50 countries). Since 2007, the StoveTec design has been manufactured in China by Shangou Stove Manufacturers, which has the capacity to produce durable stoves in mass quantity at affordable prices. Only within the past year has StoveTec started to market the stove, and dissemination has just begun. Currently, the company is searching for retailers interested in purchasing stoves in quantity. The approach is to establish regional distribution hubs with partners around the world to ensure the availability of its products and build awareness among stove users in those countries. According to the manufacturer, about 150,000 stoves have been sold at the retail price of about US$10 per stove.

The StoveTec stove is made of sheet metal with a line of ceramic clay. This clay ensures efficient heat capture and transfer. The top part of the stove is a cast-iron disc on which pots can stand (see photo at right). The stove also comes with a pot skirt, which encircles the pot to ensure even better heat transfer. The rocket-stove design originally used for the stove ensures that combustion occurs in the space directly above the fire, which ensures that much less smoke is emitted.

Compared to cooking on an open fire, the StoveTec stove has the advantage of using 40–50 percent less wood or charcoal, cutting down cooking time by about half, and thus emitting 50–75 percent less smoke. It is estimated that each stove would prevent the release of about 1.5 tons of greenhouse gases (GHGs) into the atmosphere each year. The stoves are both sturdy and portable.

The StoveTec program description is available at www.stovetec.net.

HELPS ONIL Wood Stove

HELPS International, an international nonprofit organization, was originally founded to provide medical care to the poor in Central America. Doctors involved in that program who treated a high number of burn cases related to traditional stove use in Guatemala initiated an effort to develop energy-efficient improved stoves that would prevent burns and remove smoke to improve health.

For the past decade, the company has promoted various stove designs, but it is only within the last 5 years that it has begun to expand and upgrade its manufacturing capacity. The ONIL stove is rather expensive, costing more than US$100. People living in peri-urban areas and those relatively well off comprise the main market. Except for programs sponsored by HELPS International, consumers are expected to pay full price.

The ONIL stove is designed to burn wood. It has a rocket-style design with an advanced combustion chamber, along with a chimney to remove smoke from the house or kitchen. The inside of the stove is made of high insulating material, reflecting heat back into the stove rather than absorbing it. Since the opening for fuel is small, wood must be cut into smaller pieces before being fed through the opening. According to the manufacturer, the ONIL stove reduces wood use by 64 percent per month, and all models have a chimney to vent smoke from the main living areas. The "step" in front of the fuel entrance allows sufficient air flow to cause complete combustion (see photo at right). The height from fire-bed to heating surface is long enough to allow near-complete combustion before the smoke is vented through the chimney to the outdoors. With proper maintenance, the ONIL stove has a 10-year life span. Currently, the company is exploring ways to use carbon finance to lower stove costs.

To date, more than 80,000 stoves have been sold in Guatemala, Honduras, and Mexico, demonstrating market demand. The company also offers such products as the Nixtamal stove (a large pot boiler), an institutional stove, the ONIL cooker (retained heat cooker), a basic solar lighting system (to replace light from the open fire), and the ONIL water filter.

Details on the ONIL stove program are available at www.onilstove.com.

GERES Charcoal Stove

Since 1994, GERES has worked in Cambodia to develop energy-efficient solutions designed to conserve the environment and improve living conditions for the Cambodian people. In 1999, GERES introduced the New Lao Stove (NLS), supported by trainers from Thailand where the stove was earlier marketed under the name "Thai Bucket." After training, a group of already operating cookstove producers conducted initial comparative tests with the competing traditional model, known as the "Traditional Lao Stove." The innovative GERES charcoal stove, rather than the stove design, is the successful institutional model for selling the stoves.

Sales of the NLS in Cambodia from mid-2003 to early 2010 reached close to one million units, well ahead of projections. For this work, GERES-Cambodia received the 2006 Ashden Award for Sustainable Energy. According to the manufacturer, the NLS can save a considerable quantity of charcoal compared to traditional stoves. Due to the proven ability of the NLS to reduce CO_2 emissions, GERES-Cambodia was the first project developer in the world to put forward an improved cookstove project to trade on the carbon market in 2006. The price of the stove is US$2–4. The NLS technical design is an updraft combustion stove with a grate (see photo at left).

The process of achieving these results is important to understanding ways to promote improved biomass stoves. However, it should be understood that the main stove promoted under the GERES program is a charcoal stove, and there has been more success selling charcoal stoves around the world because the fuel is purchased in the market. The GERES approach may be summarized as setting up a local supply chain, selecting a trial area, and training producers to produce stoves initially for this area and then nationwide. The goal of the approach is to convert traditional stove makers into improved stove makers and to turn customers into consumers of improved charcoal stoves. Women comprise a large share of the entire supply chain (e.g., managing retail shops and conducting stove demonstrations).

During the first program year, GERES conducted an assessment of the pilot province, which demonstrated the importance of household cooking as the lead share of wood-energy consumption. Research and development work validated the first fuel-efficient stove models. The second year was devoted to testing methods of dissemination and their potential for the various selected stove models. In the third and fourth years, the project facilitated the establishment of a national network, ensured the sustainability of the process, and prepared for a second phase scaled up to nationwide distribution. One problematic aspect that evolved in the course of implementation was the choice of decentralized production at small units. Having multiple, widely scattered producers made it difficult to control the stove quality. Subsequently, some 31 production centers were consolidated into 5 centers that produce only the NLS.

The NLS description is available at www.geres.eu.

Mirt Stove in Ethiopian Cookstove Program

The Mirt stove has been disseminated under the GTZ GmbH-implemented Ethiopian Cookstove Program together with national partners, the Ministry of Agriculture, and the Ministry of Energy. The program is currently funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) and the Netherlands Directorate-General of Development Cooperation (DGIS), with previous funding by the World Bank and Shell Foundation. The first design and testing of Mirt was completed under the World Bank-funded Cooking Efficiency Improvement and New Fuels Marketing Project (CEINFMP), which ended in 1995. Two years later, the GTZ began to support the continuation and scaling up of the project to various regions of Ethiopia. With support from the Ministry of Agriculture, the Project Household Energy/Protection of Natural Resources (HHE/PNR) began support of the commercial dissemination process in 1998.

Designed for baking Ethiopian bread (*injera*) in households that use biomass cooking fuels, the Mirt stove was optimized and further tested by Aprovecho. The Mirt stove is made of cement and volcanic ash, with a life span of at least 5 years. It offers fuel reduction of up to 59 percent. While the standard Mirt showed a 30-percent reduction in particulate matter (PM) compared with the open fire, the newly developed model of Aprovecho showed a PM reduction of almost 50 percent. Since 1995, when stove dissemination started, more than 300,000 pieces were sold throughout Ethiopia. Large-scale dissemination was supported by media advertisements and cooking demonstrations. The sale price ranges from US$2.94 to $4.12.

Unlike other charcoal and kerosene cookstoves, Mirt is a massive stove since it was designed to cook injera (bread), which is large in size (see photo at left). This requires that the parts be produced at private production sites and afterwards assembled at the customer's house, making it difficult to sell Mirt as an off-the-shelf item. These stove features have remained a major obstacle for wide-scale dissemination, highlighting the importance of creating market infrastructure. Furthermore, difficulty in obtaining some raw materials, such as cement, has, to a large extent, confined dissemination efforts to urban and peri-urban areas.

In 2008, the GTZ also started to support development of the design and adoption of a cookstove, called Tikikil, which uses both wood and charcoal. Employment generation is a main outcome of the project, and women constitute 36 percent of the total number of producers.

Details on the Mirt stove are found at www.hedon.info/docs/EthiopiaScalingUpApproach.pdf.

Uganda Stove Manufactures, Ltd. Charcoal Ugastove

The Uganda Stove Manufacturers, Ltd., known as Ugastove, is a charcoal stove–producing company. Initiated as a family business, Ugastove was able to utilize carbon funds to finance its startup stoves business. The Ugastove project grew out of a U.S. Environmental Protection Agency (EPA) grant to commercialize the stove; this grant financing was used to construct a local manufacturing shop to develop the design of the stove and air and carbon monitoring system and to conduct market research.

Carbon financing, provided by JP Morgan Climate Care, based in Nairobi and London, began in 2007 and is expected to run until 2028, with a review conducted every other year. Ugastove still needs to improve its sales and financing to ensure profitable operations.

Today the Ugastove project works in partnership with Impact Carbon (formerly the Centre for Entrepreneurship in International Health and Development), based in San Francisco. Logistical support was provided by the PCIA and GTZ-supported Promotion of Renewable Energy and Energy Efficiency Program (formerly the Energy Advisory Project).

Ugastove has concentrated its marketing and dissemination efforts in Kampala, where charcoal is used by a majority of the population, with limited extension in other urban areas. Ugastove reported that nearly 60,000 stoves were sold since 2005. It has developed several stove types: charcoal stoves for domestic use, priced at US$11; an improved fuel-efficient, residential wood stove (not yet marketed), priced at $15; and a fuel-efficient, institutional wood stove.[16] These stoves are not subsidized, but the company has access to carbon finance for marketing, training, and other soft costs.

Technically the stoves are similar to the less expensive improved Jiko stoves common in many urban areas of Africa (see photo at left). However, the stoves have more substantial fuel efficiency. According to the manufacturer, they can achieve a US$130 reduction in household fuel costs over three years.

A description of Ugastove is available at www.ugastove.com.

[16] Sold mainly to schools, armed forces units, and other urban institutions to replace traditional wood fires.

GTZ-implemented Household Stove Deployment Program in Kenya

The Promotion of Private Sector Development in Agriculture, implemented by the GTZ in partnership with the Government of Kenya's Department of Agriculture, was funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) and the Netherlands Directorate-General of Development Cooperation (DGIS). The target groups were Kenya's rural and urban households in Transmara and Western and Central cluster; stove producers, installers, and dealers; and social institutions and productive users (e.g., restaurants).

Various models were brought into the market. The Jiko Kisasa stove is made of ceramic and metal (see photo at left). It has a firewood savings potential of 40 percent, while the Rocket Mud Stove (RMS) has a savings potential of 60 percent. The price of Jiko Kisasa varies from US$1.5 to $3, while the RMS ranges from $2.5 to $3. Over the life of the project, about 1 million households purchased the stoves.

A major project goal was to promote the adoption of energy-saving devices among social institutions, including schools, hospitals, and colleges. This was achieved via sensitization meetings held with the heads of such institutions and linking these institutions with trained stove technicians and potential financing institutions. In addition, cooperation was sought with school feeding programs to include improved stoves in their work.

In addition, mainstreaming of HIV/AIDS groups into stove activities for HIV-positive people was carried out. Such groups were provided equipment (stoves and/or production materials) and skills training for capacity building.

The project description is available at www.hedon.info/docs/BP57_FeldmannEtAl.pdf.

Recho Mirak in Haiti

The World Bank–supported Miracle Stove project in Haiti was a direct response to findings of the 2005 study carried out by the Government of Haiti and funded by the Energy Sector Management Assistance Program (ESMAP) and the Ministry of the Environment.[17] The study goal was to develop a new household energy strategy that included the promotion of local production and dissemination of improved charcoal stoves.

As a result of the project, 144 artisans were trained and 120 certified to produce the improved charcoal stoves. In addition, 23 traders and 49 artisans received training in business and accounting. The production of more than 8,000 improved stoves has been reported and documented. More than 10,000 quality labels have been distributed to qualified stove manufacturers. In all, some 20,000 improved charcoal stoves were sold.

Traditionally, the small, three-legged charcoal stoves used for cooking have been made out of scrap metal. To benefit from the same raw materials and skills set of the stove makers, it was decided to utilize the same basic resources and technique to manufacture the improved Recho Mirak stove (see photo above left). This "miracle stove" has a closed combustion chamber, and offers a 40-percent reduction in charcoal consumption, which has the advantage of reducing the cost of input materials. However, the stove requires 30 percent more metal than its traditional counterpart. Given the export market for used sheet metal, it became more difficult for artisans to find the used metal they needed as the project pushed to increase stove production.

A main project lesson is the need for a stove design that uses locally available raw materials. The project attempted to resolve the sheet-metal shortage issue by involving local providers from the formal sector, proposing that they produce and sell stove-making kits from which the artisans would manufacture the improved stoves. Had this worked, it could have eliminated the raw-materials shortage and, in turn, increased ease of production for the manufacturer, increased the volume of stoves generated, and reduced the unit price. Unfortunately, no local suppliers expressed interest in getting involved.

[17] The study is entitled "Strategy To Alleviate the Pressure of Fuel Demand on National Wood Fuel Resources."

Annex 5. Existing World Bank Financing of Improved Stove Projects

Project Name	Country	Year Initiated	Total Cost (US$M)	World Bank Finance (US$M)	Total Biomass Energy (US$M)	Issues in Appraisal Document*
Energy Services Delivery Project	Benin	2004	95.7	45	6.2	FP, CP, and IS
Increased Access to Modern Energy Project	Benin	2009	178.5	72	5.5	FP and IS
Energy Access Project	Burkina Faso	2007	41	41	6.7	IS
Community-based Ecosystem Management Project	Chad	2005	94.45	39.76	2.5	IS
Energy Access Project	Ethiopia	2002	216.2	132.7	30.9	FP and IS
Household Energy and Universal Access Project	Mali	2003	53.35	35.65	11.2	FP, CP, IS, and IAP
Second Adaptable Program Loan for the Energy Development and Access Project	Mozambique	2010	80	80	14.3	CP and IS
Urgent Electricity Rehabilitation Project	Rwanda	2004	31.3	25	0.9	IS
Sustainable Energy Development Project	Rwanda	2009	8.3	0	3.95	CP and IS
Electricity Services for Rural Areas Project	Senegal	2004	71.7	29.9	4.6	FP, CP, IS, and IAP
Sustainable and Participatory Energy Management	Senegal	2009	11	10	11	FP, CP, and IS
Power Development Project	Nepal	2003	133.4	50.4	1	IS
Integrated Energy Services Project	Mexico	2007	98.49	15	1.22	IS

Source: World Bank Project Appraisal Documents.

* FP = fuelwood projection, CP = charcoal production, IS = improved stoves, and IAP = indoor air pollution.

Annex 6. Potential Financing Sources for Better Cookstoves

The World Bank Group (WBG) has at its disposal a number of potential avenues and mechanisms to fund and implement initiatives on better stoves. To finance both the new advanced manufactured stoves and the effective improved stoves, four funding sources could be tapped: (i) GEF grant funding, including its Small Grants Program, which can supplement World Bank or IFC-supported projects; (ii) carbon market funding; (iii) Climate Investment Funds; and (iv) IFC-led, private-sector and market development funding.[18] Presently, however, little financing is dedicated to advanced stoves programs by either the World Bank or the IFC (Annex 5).

Global Environment Facility

The GEF has several grant mechanisms for promoting better biomass stoves and improving the sustainability of household biomass use: (i) the Earth Fund (and other private-sector development funds), (ii) the Sustainable Forest Management program, and (iii) the Small Grants Program (GEF 2010b).

The Earth Fund

The Earth Fund resulted from the GEF 2006 private-sector strategy, which advocated the establishment of a pilot public-private partnership initiative to enhance GEF engagement with the private sector. This US$50 million program, approved in May 2008 as the GEF Earth Fund, established the IFC as both an implementing partner and co-financier. The financing for this fund under GEF-4 has largely been completed. However, the recently approved GEF-5 replenishment designated $80 million in resources for private-sector development, and some of this grant money may be allocated to replenish the Earth Fund. One focal area under GEF-5 identifies improved biomass stoves as a priority related to energy efficiency and sustainable forest management (GEF 2009). It is expected that the GEF-5 private-sector strategy and business plan will be reviewed and allocated in November 2010; with the right support, it might be possible to include advanced biomass cookstoves as one of the eligible funding areas. Since the Earth Fund is allocated under the IFC and other organizations, those entities would need to establish advanced biomass cookstoves as an area of interest.

Sustainable Forest Management

Through its Sustainable Forest Management (SFM) and sustainable land management programs, the GEF should be able to support cookstoves activities. The regional focus of the SFM program includes areas with large swaths of intact tropical forests, such as Amazonia, the Congo Basin, and Papua New Guinea/Indonesia (GEF 2007). The operational program on sustainable land management includes "catalytic or incremental funding for…activities complementary to development and poverty alleviation related activities," including the "establishment of

[18] Potential funding is also available through the UN-REDD, which works in close coordination with the GEF, Carbon Funds, and Climate Investment Funds.

community woodlots to provide fuelwood as an alternative source to natural forests and woodland" (GEF 2003). The GEF has developed a targeted US$250 million program under the GEF-5 replenishment for REDD+ interventions that links to greater efforts targeting sustainable forest management (SFM). The envelope "will be operated as an incentive mechanism for developing countries to invest significant fractions of their allocations from biodiversity, climate change, and land degradation for more comprehensive SFM/REDD+ projects and programs." The GEF is also working closely with the multilateral REDD mechanisms, UN-REDD, the Forest Carbon Partnership Facility, and the Forest Investment Program.

Small Grants Program

With a presence in 122 countries and more than 12,000 grants awarded worldwide, the Small Grants Program supports the projects of NGOs and community-based organizations in developing countries that demonstrate how community action can maintain the fine balance between human needs and environmental imperatives.

As part of its broader mandate to promote environmental protection and sustainable livelihoods, the GEF has supported advanced cookstove projects under the Small Grants Program. For example, a 2001 project in Vietnam contributed to reducing the need to use firewood and charcoal for cooking by introducing locally manufactured, higher-efficiency stoves (GEF 2010a). The NGOs and other organizations must apply for the small grants, which generally are disbursed through the United Nations Development Programme.

Carbon Funds

The Clean Development Mechanism (CDM), the primary vehicle of carbon market support for emissions reductions in developing countries, has expanded its methodologies for qualifying cookstoves projects. In addition, the Carbon Finance Unit at the World Bank administers several funds relevant to stoves programs. Furthermore, the Strategic Climate Fund, one of the two Climate Investment Funds (CIF), has two funding mechanisms that will likely mesh well with cookstove initiatives.

Clean Development Mechanism

Until recently, cookstove emissions were ineligible for CDM project funding since renewable biomass energy was not considered to have an impact on the buildup of greenhouse gases (GHGs). Recently, however, the CDM and voluntary carbon markets approved new methodologies for qualifying stoves projects that reduce unsustainable biomass used for household energy. Cookstove emissions are eligible for project funding under the CDM if part of the biomass is non-renewable. Moreover, cookstove projects can be credited on the voluntary carbon market with various standards (e.g., Gold Standard or Voluntary Carbon Standard), which use either their own or CDM methodologies. In addition, the CDM offers methodologies for cookstove projects that incorporate fuel switching (away from fossil fuels), including AMS-II.G (reduction of use of non-renewable biomass), AMS-I.E (fuel switch to 100-percent renewable-energy supplies), AMS-I.I (biogas/biomass thermal applications for household/small users), and AMS-I.C (thermal energy production with or without electricity).

As of March 1, 2011, 3 cookstove projects were registered under the CDM, with 16 in the pipeline (UNEP Risoe Center).[19] The recently approved program of activities (PoA) approach has spurred interest from a number of project developers. Currently, 11 such PoAs are under preparation (one program is multi-country); 14 countries are represented, the majority of which are located in Sub-Saharan Africa (Burundi, Kenya, Nigeria, Rwanda, South Africa, Sudan, Tanzania, Togo, Uganda, and Zambia). Although the trend is small, increasing signals from both policy changes and newly approved projects illustrate the potential for expanded CDM and voluntary market crediting for cookstove projects in the future (Box 12).

Although the voluntary carbon markets represent a small fraction of overall carbon trading, they are an important niche for stoves projects, having established a project pipeline in Sub-Saharan Africa. As of March 1, 2011, the Gold Standard program had 7 registered improved cookstove projects (of which 3 are being issued Voluntary Emissions Reductions), 4 validated ones, and 19 in the pipeline. Accumulated project experience, new partners, and market exposure for better stoves can provide models for developing WBG-supported national and regional programs in those countries.

Carbon Finance Unit

The World Bank's Carbon Finance Unit houses three funds with particular relevance to cookstoves programs: (i) the BioCarbon Fund, (ii) the Community Development Carbon Fund, and (iii) the Forest Carbon Partnership Facility. The first two funds focus on land use–based credits and rural community–based projects, respectively. The Forest Carbon Partnership Facility is part of the Bank's efforts to address Reduced Emissions from Deforestation and Forest Degradation (REDD).

To receive certified or verified carbon credits, there must be assurance that the project activity and therefore the emission reductions would not have occurred without the carbon funding. Consequently, projects must plan ahead and apply for carbon credits at the outset, and meet rigorous planning, monitoring, and verification requirements.

The BioCarbon Fund (BioCF) has provided the World Bank valuable experience in designing, implementing, and verifying projects that develop emission reduction credits from land-use change. Although current financing for the BioCF has been fully committed, it is possible that stoves could be incorporated into future BioCF funding rounds. Projects that follow the methodologies used by the BioCF include plantation biomass projects that grow fuel for wood or charcoal cookstoves and displace unsustainably harvested forest wood or fossil

[19] The CDM/JI Pipeline Analysis and Database is available at http://cdmpipeline.org/.

fuels; projects focused on energy-efficient advanced stoves to replace less efficient hearths and stoves follow the small-scale, energy-efficiency methodologies recently approved by the CDM.[20]

The Community Development Carbon Fund (CDCF) provides capital to purchase carbon credits generated by projects that focus on community development activities. Capitalized at US$128 million, the CDCF has signed emission reductions purchase agreements (ERPAs) for 29 projects. These projects did not include cookstoves per se; however, "improved access to energy for heating and/or cooking" is one of four "key community benefit outcomes," suggesting that cookstove projects would fit well into future CDCF portfolios (Sen 2009).

The Forest Carbon Partnership Facility (FCPF) projects aim to address the drivers of deforestation. These REDD schemes, now being developed through the UN climate-change negotiations, have significant potential to provide near-term revenue for cookstove projects. REDD projects will target sustainable local biomass use, making fuel efficiency and fuel stock management the dominant concerns for this sector.[21]

Climate Investment Funds

The World Bank plays a major role in coordinating and implementing the Climate Investment Funds (CIF). One of the two CIF, the Strategic Climate Fund, contains two programs whose funding mechanisms will likely mesh well with cookstove initiatives: (i) the Forest Investment Program (FIP) and (ii) the Scaling Up Renewable Energy Program (SREP).

The FIP has already garnered US$558 million in pledges for countries to implement REDD activities. Among them, the FIP design document calls for "a dedicated grant mechanism to be established to provide grants to indigenous peoples and local communities in pilots to support their participation in the development of FIP investment strategies, programs, and projects" (CIF 2010a). The mechanism will provide indigenous peoples and local communities dedicated grants that are "an integral component of each pilot and linked to the forest investment strategy." Activities eligible for support from the grant mechanisms include recognizing and supporting tenure rights, forest stewardship roles, and traditional forest management systems and implementing projects integral to pilot components (CIF 2010a). These criteria may include cookstoves as part of initiatives to better manage sustainable biomass use at the local level. Current pilot countries where cookstoves are relevant include Burkina Faso, Ghana, Indonesia, Lao PDR, and Peru. Probable pilot countries include Brazil, Mexico, the Philippines, Democratic Republic of the Congo, Mozambique, and Nepal.

[20] The REDD-crediting methodologies have yet to be fully developed and approved by the CDM executive board and/or voluntary markets.

[21] The two major REDD funds fully or partially run by the World Bank are the Forest Carbon Partnership Facility and the Forest Investment Program; together they have received more than US$700 million in funding for pilot programs already under way in forested developing countries. Advanced cookstove programs can be integrated into reduced deforestation country strategies and implementation plans. In fact, most, if not all, REDD strategies developed by Sub-Saharan African countries contain action steps to make the extraction of wood-based fuel sustainable.

Like the FIP, the SREP is co-implemented by a group of multilateral development banks, including the World Bank. The SREP will provide highly concessional resources to a small group of pilot LDCs to increase the deployment of renewable energy. Insofar as sustainable biomass is considered renewable energy and biomass use is both prevalent and a priority in the pilot countries, cookstoves may play a role. Since the SREP has a primary goal of "overcoming economic and non-economic barriers in order to scale-up private-sector investments," any cookstove programs that it funds will likely focus on private-sector market development (CIF 2010b).

Because "balance among diverse contexts for scaling up renewable energy, such as urbanization, industrialization, dispersed rural populations, and stage of renewable energy development" is an important consideration for SREP country programs (CIF 2010b), cookstoves may be an appropriate complement in rural areas to the development of off-grid, mini- and micro-grid, and utility-scale, grid-connected renewable energy activities. Mali, a proposed pilot country, appears particularly poised to use SREP funding for advanced cookstoves if approved as a pilot country. The expert panel's review document for the SREP subcommittee states that "improved cookstoves have been introduced in Mali, and opportunities exist to work with the private microfinance institutions on structuring appropriate financial products and mechanisms to allow for increased uptake of these stoves" (CIF 2010b). This means that cookstoves are highly relevant to Mali's energy access agenda, and are likely to figure prominently in SREP activities in that country and perhaps other SREP pilot countries, which are likely to include Ethiopia, Honduras, Kenya, Maldives, and Nepal.

International Finance Corporation and Private-sector Development Activities

The IFC at present supports many types of efforts to promote market transformation. This includes the promotion of markets for new products in new geographic locations. It leads the implementation of Lighting Africa—a program jointly run with the World Bank, with funding support from the GEF and other sources—which is working to commercialize high-quality, off-grid lighting devices in Sub-Saharan Africa (Box 13). It also has helped to develop a large number of finance products for businesses and consumers. For consumers, it has worked to develop microfinance and leasing programs and expand banking services to the base of the income pyramid. For businesses, it has promoted energy-efficiency finance through directed lines of credit, loan guarantees, and advisory services. Clearly, all are key activities for stoves, which generally are produced and sold by the private sector in developing countries. This is especially true of the new advanced biomass stoves, most of which are sold through the private sector or promoted by NGOs and microfinance organizations.

Market Facilitation

The IFC's Sustainable Business Incubator and other advisory services divisions provide tailored solutions to help create the conditions under which markets in developing countries can thrive. Often the markets targeted are for products with social benefits, such as energy efficiency, off-grid lighting, and clean water technologies. The IFC's advisory services provide businesses and finance organizations technical assistance to help them overcome barriers to market formation. In the case of the Lighting Africa program, advisory services include market intelligence and facilitation of business linkages to spur market entrance; a quality assurance program has been implemented to ensure that only high-quality products enter the market, and consumer awareness-raising activities have been held to grow market demand for products.

Finance

Financing is a critical component of programs to introduce products in new markets and to consumers with low buying power and limited credit access. On the consumer-finance side, sales may depend entirely on partnership with microfinance institutions willing and able to collect the balance owed for a new device over time. Innovative forms of financing through cell-phone payments and phone-based accounts may help expand markets to new base-of-the-pyramid consumers, as Carbon Manna is attempting with cookstoves and solar devices in Kenya (www.carbonmanna.org).

On the supply side, manufacturers, suppliers, and retailers—particularly small-scale, local businesses—will require financing to invest in their businesses. Through its Sustainable Energy Finance and Access to Finance programs, the IFC has provided targeted credit lines to financial intermediaries in client countries. For example, it has funded designated lines of credit or provided credit guarantees for energy-efficiency loans in China, Russia, and other countries. A similar effort might be undertaken to build capacity among local banks and microfinance organizations to loan to cookstove businesses. Similar programs targeting cookstove businesses and other small-scale energy enterprises have been undertaken by seed finance organizations, such as GrassRoots Business Foundation, Acumen, and E+Co, sometimes in partnership with the IFC under the Lighting Africa and other programs (IFC 2009).

Technology Development and Other Business Services

Businesses engaged in cookstove manufacturing and sales may also need other services and support to thrive. One form of support is technology research and development, including early-stage funding for promising technologies and business ideas. The Lighting Africa program promoted this by awarding grants to 16 promising local lighting technology companies in Africa under a Development Marketplace Grant Competition (IFC 2009). When well designed, such grant competitions may help bring promising, innovative technologies to market and encourage market competition and diversity among products and technologies. One aspect of this program developed standards for small lamps, which would also be needed for advanced biomass stoves.

In addition to seed capital, businesses often need support in developing their business plans, building management skills, and defraying start-up costs—the traditional niche of business incubators. A joint World Bank-IFC program, infoDev, supports nearly 300 business incubators in developing countries worldwide, and may be well positioned to help small enterprises working in the cookstove space get off the ground. Recently, infoDev profiled two thriving cookstove manufacturing businesses in India that got their start in infoDev business incubators (Lambkin 2010). Currently, infoDev is implementing a Climate Technologies program designed to identify national needs for innovation infrastructure and cross-sectoral linkages, and help put in place nationally-tailored initiatives to develop and deploy climate-friendly technologies (infoDev 2010). India and Kenya—two large potential markets for advanced cookstoves—are the first two pilot countries in the Climate Technologies program; infoDev has already identified the inclusion of cookstove technologies in their scope of activities in Kenya.

The example of Lighting Africa is quite relevant to the IFC's potential involvement as a financing source for better stoves. The profiles of the advanced biomass stoves and the new lighting systems that have recently come to the marketplace in developing countries are similar. Both offer improved efficiency in delivering energy services, have higher initial prices, and are not well known by people in rural and remote areas. Thus, it may be feasible to create a similar campaign for improved cooking in developing countries.