A WORLD BANK STUDY

Household Energy Access for Cooking and Heating

LESSONS LEARNED AND THE WAY FORWARD

THE WORLD BANK

Koffi Ekouevi and Voravate Tuntivate

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Foreword

Providing clean and efficient stoves and fuels to poor households in developing countries is a complex challenge, cutting across many disciplines, such as the environment, forestry, energy, health, and household economics, and linked to contextual social and cultural considerations. The complexity and cross-sectoral nature of the challenge is also reflected in the mixed results that have been obtained in the field over the years. Lately, a new wave of mobilization around the importance of developing clean cooking solutions for poor households has emerged. The drivers of this mobilization are multiple. There is a growing recognition that access to energy services is important to the achievement of the Millennium Development Goals (MDGs) and to poverty alleviation. The negative health outcomes faced mostly by women and children in settings where households rely on solid fuels are serious public health concerns. Moreover, the recent discussions in the climate change community on black carbon, even if not conclusive, have drawn attention to the issues of clean cooking and cookstoves.

This mobilization has gained momentum and new opportunities—such as the Global Alliance for Clean Cookstoves, the new global partnership chaired by the United Nations Foundation—are emerging.

Against this background, this report on *Household Energy Access for Cooking and Heating: Lessons Learned and the Way Forward* is timely, since it provides a unique overview of the World Bank experience and important lessons learned by other multilateral, bilateral, and government organizations. We expect that this report will provide insights for policy makers, stakeholders, and donors in meeting the challenge of providing clean cooking and heating solutions to poor households in developing countries.

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Koffi Ekouevi is Senior Economist in the Sustainable Energy Department. Over the last 14 years, he led energy policy dialogue and lending activities in many countries. He has worked on several energy projects covering energy sector reform, energy access, and regional power trade. His main areas of concentration include off-grid rural electrification and household energy access. In addition to his work at the energy anchor, he is currently providing cross-support to teams working in Africa, Haiti, and Bangladesh. Prior to joining the World Bank, he worked with the United Nations in Senegal and with the Institute of Resource Development in the United States.

Voravate Tuntivate has more than 20 years of experience as a rural and urban energy specialist. His work has taken him to every continent, where he has designed, implemented, and analyzed multiple projects focused on household energy policy and on rural/peri-urban/urban energy access and electrification. In addition, Mr. Tuntivate has served as lecturer at the United Nations Statistical Institute for Asia and Pacific Region and has authored many reports for the World Bank (ESMAP, ASTAE, Middle East, the East Asia and Pacific and Africa Regions) as well as country governments.

Acronyms and Abbreviations

AGECC	Advisory Group on Energy and Climate Change
ALRI	acute lower respiratory infection
ARI	acute respiratory infection
ARTI-TZ	Appropriate Rural Technology Institute
ASTAE	Asia Sustainable and Alternative Energy Program
BEIA	Biomass Energy Initiative for Africa
BEST	Biomass Energy Strategy
BMZ	Bundesministerium für Wirtschaftliche Zusammenarbeit (German Federal Ministry for Economic Development Cooperation)
CDM	Clean Development Mechanism
CETA	Appropriate Technology Experimental Center
CFU	Carbon Finance Unit (World Bank)
CIA	Central Intelligence Agency
CILSS	Permanent Inter-State Committee for Drought Control in the Sahel (Comité Inter-Etat pour la Lutte contre la Sécheresse au Sahel)
CO_2	carbon dioxide
COPD	chronic obstructive pulmonary disease
DALY	disability-adjusted life year
EAETDN	East African Energy Technology Development Network
ECLAC	Economic Commission for Latin America and the Caribbean
ENCOVI	Encuesta Nacional de Condiciones de Vida (National Survey of Conditions of Life)
EnDev	Energising Development
EPA	Environmental Protection Agency
ESMAP	Energy Sector Management Assistance Program
EU ETS	European Union Emission Trading Scheme
FAO	Food and Agriculture Organization
FIS	Fondo de Inversión Social (Social Investment Fund)
GDP	gross domestic product
GEF	Global Environment Fund
GPOBA	Global Partnership on Output-Based Aid
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German International Cooperation)
GVEP	Global Village Energy Partnership
IAP	indoor air pollution
ICADA	Scientific Research Related to the Altiplano
ICR	Implementation Completion Report
IEA	International Energy Agency
ISR	Implementation Supervision Report

JET	Joint Environmental Techniques
LPG	liquefied petroleum gas
LULUCF	land use, land use change, and forestry
MDG	Millennium Development Goal
NGO	nongovernmental organization
NISP	National Improved Stoves Program
NPIC	National Program for Improved Chulhas
PCIA	Partnership for Clean Indoor Air
PM	particulate matter
PM_{10}	particulate matter up to 10 micrometers in size caused by smoke
ProBEC	Programme for Basic Energy and Conservation in Southern Africa
R&D	research and development
RPTES	Regional Program for the Traditional Energy Sector
SME	small and medium enterprises
TaTEDO	Tanzania Traditional Energy Development and Environment Organization
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WHO	World Health Organization
WODSTA	Women Development for Science and Technology Association

Executive Summary

Half of humanity—about 3 billion people—are still relying on solid fuels for cooking and heating. Of that, about 2.5 billion people depend on traditional biomass fuels (wood, charcoal, agricultural waste, and animal dung), while about 400 million people use coal as their primary cooking and heating fuel (UNDP and WHO 2009). The majority of the population relying on solid fuels lives in Sub-Saharan Africa and in South Asia. In some countries in Central America and in East Asia and the Pacific, the use of solid fuels is also significant. The inefficient and unsustainable production and use of these fuels result in a significant public health hazard, as well as negative environmental impacts that keep people in poverty.

Strategies to improve energy access to the poor have focused mainly on electricity access. They have often neglected non electricity household energy access. It is, however, estimated that about 2.8 billion people will still depend on fuelwood for cooking and heating in 2030 in a business-as-usual modus operandi (IEA 2010). The need for urgent interventions at the household level to provide alternative energy services to help improve livelihoods is becoming more and more accepted.

The failure of past large-scale fuelwood plantations and improved stoves programs has generally created pessimism in the development community about the relevance and effectiveness of interventions on household energy access. Altogether, this has affected the level of policy attention considerably and consequently the allocated resources for interventions. This situation is gradually changing. There is a growing global mobilization around household energy access issues. An important milestone is the recent launching of a public-private Global Alliance on Clean Cookstoves led by the United Nations Foundation to help 100 million households adopt clean and efficient stoves and fuels by 2020 (United Nations Foundation 2010). A primary driver of this mobilization is the realization that considerable health benefits in line with the Millennium Development Goals can be gained by improving indoor air pollution (IAP) with the use of efficient cookstoves and clean fuels (AGECC 2010). Discussion of household energy access in the climate change community is also helping keep up attention on the issues.

This report's main objective is to conduct a review of the World Bank's financed operations and selected interventions by other institutions on household energy access in an attempt to examine success and failure factors to inform the new generation of upcoming interventions. First, the report provides a brief literature review to lay out the multidimensional challenge of an overwhelming reliance on solid fuels for cooking and heating. Second, it highlights how the Bank and selected governments and organizations have been dealing with this challenge. Third, it presents lessons learned to inform upcoming interventions. And finally, it indicates an outlook on the way forward.

A Multidimensional Challenge

It is well documented that exposure to IAP from the inefficient combustion of solid fuels with low-quality stoves in poorly ventilated kitchens is a significant public health hazard. The World Health Organization (WHO) estimates that 1.9 million people die prematurely every year from exposure to smoke from traditional cookstoves and open fires; that is nearly 1 death every 16 seconds. Women and children in developing countries are particularly affected by the negative health outcomes of IAP from the use of solid fuels. Women and children in these countries are exposed daily to pollution in the form of small particulates that exceed World Health Organization and U.S. EPA recommended limits by 10 to 50 times (von Schirnding and others 2002; WHO 2006).

Although there are many studies on solid fuels, IAP and their health outcomes, research gaps remain that need to be filled to inform the design and monitoring of interventions better. At the same time that strong evidence exists that links IAP to childhood pneumonia, chronic obstructive pulmonary disease, and lung cancer (from coal) in adults, the evidence is weak on how inhaling wood smoke is associated with tuberculosis, low birth weight, and cataracts. What we do not know is the exposure-response relationship between IAP and different negative health outcomes. In other words, we do not know what different dose levels of IAP cause different negative health outcomes. Evidence on the exposure-response relationship is important in order to ensure to what level exposure should be reduced to start gaining positive health outcomes. Three main areas of further research are generally acknowledged: (a) the need for better exposure assessment to make more direct measurement of exposure-response relationships; (b) the need to handle confounding better by using more adequate statistical methodology to control the effects of confounders, such as poverty, malnutrition, and housing environment; and (c) the importance of intervention studies to complete findings of observational studies (von Schirnding and others 2002; Ezzati and Kammen 2002; and Jaakkola and Jaakkola 2006).

It is now widely accepted that the clearing of land for arable and pastoral agriculture is the main cause of deforestation rather than the use of wood for energy, as was believed in the past. Surrounding growing urban areas in some Sub-Saharan African countries and Haiti are some exceptions. In these settings, inefficient use of fuelwood is putting tremendous pressure on forest resources (World Bank 2009; ESMAP 2007b).

The reliance on fuelwood for cooking and heating is increasingly being associated with climate change. There are claims that reducing black carbon emitted from the burning of open biomass with the use of improved stoves may provide quick gains to help slow down global warming (Ramanathan and Carmichael 2008; Gustafsson 2009). Recent research indicates that while black carbon emissions from diesel is clearly shown to have a warming effect on the climate, black carbon emissions from burning biomass in inefficient cookstoves, because of their organic nature and small-size particles, may be interacting with other aerosols in the atmosphere to produce a net cooling effect on the climate (Bauer and others 2010). It appears that current science points to uncertainties around the potential climate change impact of black carbon emissions from biomass combustion.

Meeting the Challenge

During the last 25 years, household energy access issues have retained the attention of many specialists within the Bank from different sectors, such as energy, forestry, environment, health, agriculture and rural development, gender, and climate change. The

Energy Sector Management Assistance Program (ESMAP), jointly set up by the Work Bank and the United Nations Development Programme (UNDP) in 1983, has played and is still playing a leading role in funding work undertaken by specialists from these different sectors. In the specific case of Sub-Saharan Africa, the Regional Program for the Traditional Energy Sector (RPTES) supported analytical work and upstream studies between 1993 and 2003. Since 2009, work on household energy in the Africa region is supported by the Biomass Energy Initiative for Africa. Work on household energy is also done within the East Asia and Pacific energy team and also by the Asia Sustainable and Alternative Energy Program (ASTAE). Moreover, the Bank Climate Change Team is gradually including household energy access in its activities.

A total of 31 projects covering the period 1989–2010 were reviewed. Nineteen of these were selected as having the objective of improving household cooking and heating energy access through fuelwood management or improved stoves. The total cost of these projects was US$1.2 billion, to which the World Bank contributed US$698 million and of which US$161 million was devoted specifically to household fuels. These projects focused on community-based forest management to improve sustainable supply of fuelwood, substitution of polluting fuels with cleaner fuels, and institutional capacity development in the household energy subsector. With the exception of the Mongolia Urban Stove Improvement Project financed by the Global Environment Fund (GEF), the remaining projects are covering Sub-Saharan African countries.

During the period of the review, the Bank funded four biogas projects for cooking and lighting at the household level in China and Nepal. The total cost of these projects was US$1 billion to which the Bank has contributed US$365 million with 70 percent allocated to household energy access components. Similarly, the Bank has financed eight natural gas projects for cooking and heating, mostly in Europe and Central Asian countries, and one project in Colombia. The total cost for these projects is US$203 million to which the Bank has contributed US$126 million.

A review of the Implementation Completion Reports (ICRs) of five closed projects indicated that they had performed satisfactorily. Their sustainability was also rated likely and even highly likely in the case of the Senegal Sustainable and Participatory Energy Management Project.

A review of the last and current ratings of the Implementation Supervision Reports' progress suggests that while some of the projects seem to be showing a satisfactory performance, there are also projects in the portfolio that are having implementation difficulties. A further probe in assessing the reported problems on the projects rated moderately unsatisfactory or moderately satisfactory suggests that delay in physical implementation of activities is an important factor affecting their performance. This may be caused by the participatory and multidisciplinary nature of these activities, which require a broad consensus between many stakeholders—an exercise that requires a lot of time.

Lessons Learned

Reviewing the experience of household energy projects and their success and failure factors revealed the following important lessons: (a) a holistic approach to household energy issues is necessary; (b) public awareness campaigns are prerequisites for successful interventions; (b) local participation is fundamental; (d) consumer fuel subsidies

are not a good way of helping the poor; (e) both market-based and public support are relevant in the commercialization of improved stoves; (f) the needs and preferences of stoves users should be given priority; (g) durability of improved stoves is important for their successful dissemination; and (h) with microfinance the poor can gradually afford an improved stove.

1. **A holistic approach to household energy issues is necessary.**
   Successful programs are designed with a holistic approach on how household energy access can contribute to a global agenda of social transformation and poverty reduction. With this perspective, the programs are design to cover: (a) supply-side interventions ensuring that the fuelwood supply is sustainable; (b) demand-side and interfuel substitution with the introduction and dissemination of improved stoves and alternative household fuels, such as kerosene and liquefied petroleum gas (LPG); and (c) the capacity to develop and strengthen institutions to create the regulatory incentives for the sustainable production of fuelwood and for the facilitation of fuel switching.
2. **Public awareness campaigns are prerequisites for successful interventions.**
   Successful programs have paid particular attention to Public Awareness, Education, and information campaigns. Households need to be sensitized to the risks they incur by cooking with inefficient stoves. Programs that have assumed that households would adopt spontaneously improved stoves or participate in forest management initiatives have failed. Households need to perceive and to be convinced about the direct and indirect benefits associated with these interventions.
3. **Local participation is fundamental.**
   Experience indicates that the active participation of communities, governments, nongovernmental organizations (NGOs), and the private sector is fundamental for household energy access projects to be successful and sustainable. For example, local communities need to be involved at an early stage to ensure that they own supply-side forest management initiatives. They should understand why they should be the ones protecting the forests in their communities. A clear rule of engagement should be discussed for communities to know their rights and responsibilities, the prerogatives of the national forest service, the role of NGOs and local associations.
4. **Consumer fuel subsidies are not a good way of helping the poor.**
   Experience has shown that across the board consumer fuel subsidies are not a good way of helping the poor. Affluent households tend to benefit the most from prevailing fuel subsidies, given that in most cases, energy consumption increases in parallel with income. For governments, these subsidies result in heavy fiscal deficits diverting direct public expenditures away from productive and social sectors. Alternative options are usually designed in the form of social protection programs. The challenge remains in successfully implementing these options to effectively reach the poor.
5. **Both market-based and public support are relevant in the commercialization of improved stoves.**
   A market-based approach in the commercialization of improved stoves is often viewed as the best way to ensure sustainability of programs. This is based on the evidence that subsidized programs do not continue when donor or public

funding dries out. Evidence indicates, however, that a certain level of public funding is necessary at the initial program stages for improved stoves programs to take off. This is particularly true in settings where the business environment is not well developed. Funding is usually needed to support research and development (R&D), marketing, quality control, training related to stove design and maintenance, and monitoring and evaluation. Work on developing stoves standards and certification protocols rely on the availability of public funding. Without this initial support, small enterprises find it difficult to participate in improved stoves programs, and scaling up is unrealistic. A challenge is to determine what level of public funding is adequate and the timing to transition to a fully market-based business model.

6. **The needs and preferences of improved stove users should be given priority.** Successful programs pay attention to the needs and preferences of the users of improved stoves. Targeting households susceptible to buying and using these improved stoves and working with them to supply a suitable stove that responds to their needs is critical. At first, this target group is usually not the poorest of the poor. By first focusing on households that can afford to adopt an improved stove, the program can subsequently capitalize on the benefits of the demonstration effects produced. Successful, improved stoves programs are also designed bearing in mind the preferences of the users. Experience has shown that when these factors are ignored, stove dissemination rates are low, and programs are not sustainable.
7. **Durability of improved stoves is important for their successful dissemination.** For households that can afford an improved stove, the decision to adopt one or not includes their perception of durability of the stoves. The durability depends on the quality of the materials used in the production of the stove, the resistance of the stove in the climatic context where it is used, how it used, and the maintenance that is needed. It is important to account for durability issues in the design and construction of improved stoves, in addition to technical considerations, such as heat transfer efficiency and combustion efficiency.
8. **With microfinance, the poor can gradually afford an improved stove.** Availability of improved stoves and cleaner fuels is one thing, whereas their affordability is another one. Programs that have included microfinance options to help households afford the stoves tend to be more successful. The poor need to have a time horizon to gradually pay for the improved stoves. For example, in Bangladesh, Grameen Shakti has been working with international donors to provide cookstoves as part of its microfinance activities. This dimension is very important. Having an improved stove is not perceived as a first priority by the poor, but by integrating the adoption of an improved stove in a broader program, creating opportunities to generate income is a different proposition.

The Way Forward

The recent momentum aimed at providing clean cookstoves and fuels to the poor is a unique opportunity that should be firmly seized for action. The World Bank is well positioned with knowledge, expertise, and the potential for funding leverage to play

an important role in helping governments design effective and sustainable programs to provide poor households with clean energy solutions. However, this calls for strategic choices on what the Bank itself can do, and what it can do through partnerships.

What Can the World Bank Do?

The Bank can support the household energy access agenda by doing the following:

1. **Help broaden the scope of energy sector reform to include household energy access issues.**
   The Bank is uniquely placed to help broaden the scope of energy sector reform to include household energy access issues. Through its energy dialogue with countries, the priorities are focused on power sector reform, regional power trade, and electricity access expansion. Household energy access issues should be raised to a level where they are viewed as commensurate with the importance they represent in the energy balance of countries and the potential impact they can have on poverty reduction. With a global trend of rapid urbanization in developing countries in the coming years, issues dealing with pricing of household fuels will have increasing fiscal and macroeconomic significance. Raising awareness at the highest levels of policy formulation and decision making is important to generating political commitment for action.
2. **Produce strategic upstream analytical work to inform dialogue and to support technical assistance and lending operations.**
   Pertinent, timely, and convincing upstream analytical work on household energy access is necessary to strengthen the quality of the dialogue with the countries. Past authoritative analytical work done by the Bank and the scope of its lending operations are solid foundations to build on. In many countries, the upstream studies done by the Bank in the 1980s and 1990s are still the only detailed available ones to date. There is clearly a need to update these studies.
3. **Strategically mainstream household energy access interventions in lending operations.**
   Mainstreaming will require strategic internal institutional and funding arrangements capable of mobilizing and using the available high–quality, in-house multidisciplinary expertise. As it stands, the absence of mainstreaming of household energy access interventions in lending operations may be a result of the following factors: (a) these projects require detailed upstream studies that are time consuming, which can delay project preparation; (b) the interplay of many disciplines in dealing with household energy access issues makes it difficult for teams to deal with them in the context of limited project preparation budget; (c) the number of staff equipped to prepare household energy access projects is low, and this expertise is scattered throughout the institution; (d) transaction costs in preparing a household energy access project are high compared to the volume of lending they can leverage; and (e) the demand for interventions on household energy access from countries is low, probably also to the result of an absence of awareness of the issues at stake on the part of the majority of the affected populations and of many governments.

What Can Be Done through Partnerships?

To address the multidimensional challenge of improving household energy access to the poor, both internal and external partnerships are needed.

1. **Internal partnerships**
   At the moment, work on household energy access is being done by teams in the energy, health, forestry, gender, rural development, and climate change sectors. Some of these teams are with anchor departments and others are within operational units across Regions. Collaboration between these teams can be improved. Formal partnerships between these teams will help leverage the Bank's expertise and funding. Opportunities for collaboration with IFC teams should also be explored to help countries address this important challenge.
2. **External partnerships**
   There are many organizations well grounded with tremendous experience in household energy access interventions that the Bank could partner with in innovative ways. The review of household energy access projects reveals that grassroots efforts are needed to raise the awareness of populations to adopt alternative ways of harvesting their forests and using improved stoves and fuels. These behavioral changes require a lot of time and operational resources that are close to targeted communities. Civil society organizations, including NGOs and community-based associations, and the private sector are better equipped to deliver on this work.

   Another way the Bank can leverage partnerships is to help facilitate the use of funding mechanisms on climate change with windows that will allow funding to be directed at technical assistance or operational work on household energy access–related issues. A number of climate change mechanisms are available, but they are either not well known by beneficiary countries or are difficult to access. In working with other multilateral and bilateral organizations and governments, the Bank can play a pivotal role in making this funding accessible.

   Going forward, it appears that partnerships have an important role in scaling up household energy access interventions. However, selectivity should be exercised in the choice of partners, and tools should be developed to measure performance and impact.

CHAPTER 1

Introduction

It is recognized that access to modern energy services—including electricity and clean fuels—is important for achieving the Millennium Development Goals (MDG) (UNDP 2005). Strategies to improve energy access to the poor have focused mainly on electricity access. They have often neglected non electricity household energy access. It is estimated, however, that about 2.8 billion people will still depend on fuelwood for cooking and heating in 2030 in a business-as-usual modus operandi (IEA 2010). The inefficient and unsustainable production and use of these fuels result in a significant public health hazard accompanied by negative environmental impacts that keep people in poverty.

The failure of past large-scale fuelwood plantations and improved stoves programs has generally created pessimism in the development community about the relevance and effectiveness of interventions on household energy access. Altogether, this has affected the level of policy attention considerably and consequently the allocated resources for interventions. This situation is gradually changing. Global mobilization around household energy access issues is growing. An important milestone is the recent launching of a public-private Global Alliance on Clean Cookstoves led by the United Nations Foundation to help 100 million households adopt clean and efficient stoves and fuels by 2020 (United Nations Foundation 2010). An important driver of this mobilization is the realization that considerable health benefits in line with the Millennium Development Goals can be gained by improving IAP with the use of efficient cookstoves and clean fuels (AGECC 2010). The fact that the climate change community is also discussing household energy access is helping sustain attention on the issues.

The main objective of this report is to conduct a review of the World Bank's financed operations and selected interventions by other institutions on household energy access in an attempt to examine success and failure factors to inform the new generation of upcoming interventions. The report first provides a brief literature review to lay out the multidimensional challenge of the reliance on solid fuels for cooking and heating. Second, an overview highlights how the Bank and selected governments and organizations have been dealing with this challenge. In the next section of the report, lessons learned are drawn to inform upcoming interventions. A final section presents ideas on the way forward.

CHAPTER 2

A Multidimensional Challenge

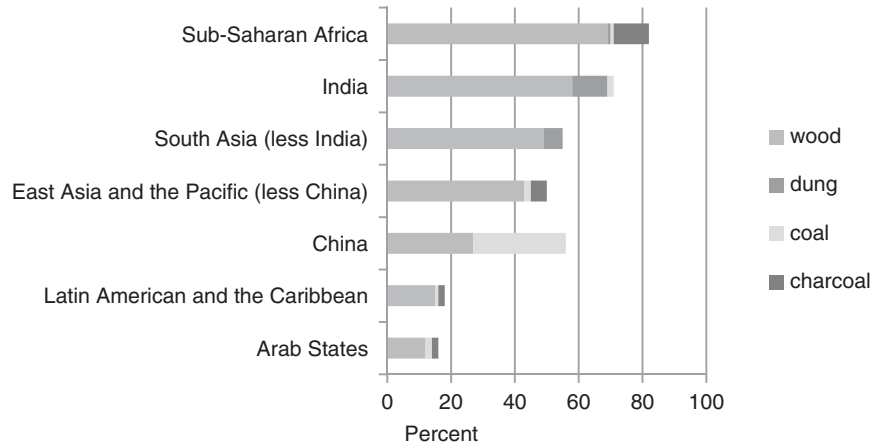
This section describes (a) the overwhelming reliance on solid fuels in developing countries by showing levels and trends across regions and selected countries; (b) the linkages between the use of solid fuels and energy poverty, including the complexity of the ongoing household energy transition; (c) the relationships among household energy use, IAP, and health impacts; and (d) the resulting local and global environmental impacts.

An Overwhelming Reliance on Solid Fuels in Developing Countries

Half of humanity—about 3 billion people—is still relying on solid fuels for cooking and heating. Of that, about 2.5 billion people depend on traditional biomass fuels (wood, charcoal, agricultural waste, and animal dung), while about 400 million people use coal as their primary cooking and heating fuel (UNDP and WHO 2009). As indicated in figure 2.1, the majority of the population relying on solid fuels for cooking and heating live in Sub-Saharan Africa and in South Asia.

The reliance on solid fuels remains the same for countries in Sub-Saharan Africa whether they have large oil and gas reserves or are without hydrocarbon endowments (table 2.1). For example, Benin and Chad are both in the 90th percentile for solid fuel dependence, even though Chad is an oil-exporting country and Benin is an oil-importing country. After Sub-Saharan Africa, India is the most reliant on solid fuels with about

Figure 2.1: Percentage of population relying on solid fuels for cooking, by fuel type and region, 2007



Source: UNDP and WHO 2009.

Table 2.1: Percentage of national population by type of fuel used for cooking in selected countries

Country	Charcoal	Wood	Dung	Coal	Total
Sub-Saharan Africa					
Oil-exporting countries					
Angola	18.7	28.6	0.4		**47.7**
Chad	15.4	70.8	0.1	4.9	**91.2**
Côte d'Ivoire	19.6	66.3			**85.9**
Nigeria	2.2	72.3	0.5	0.1	**75.1**
Sudan	1.3	56.2	0.5	14.3	**72.3**
Oil-importing countries					
Benin	21.2	72.2			**93.4**
Botswana		43.4	0.1	0.1	**43.6**
Burkina Faso	4.3	88.5			**92.8**
Lesotho	0.1	56.6	5.7		**62.4**
Mali	14.5	82.6	2		**99.1**
South Asia					
Afghanistan	0.5	57.5	27		**85.0**
Bangladesh		82.6	8.3		**90.9**
Bhutan		40.7			**40.7**
India	0.4	57.9	10.6	1.9	**70.8**
Nepal	0.1	75.2	8		**83.3**
Pakistan	0.4	60.2	6.9		**67.5**
Sri Lanka		79.5			**79.5**
East Asia					
Cambodia	7.9	84.4	0.1		**92.4**
China		26.7		28.9	**55.6**
Indonesia	0.4	53.4			**53.8**
Lao PDR	1.5	74.8		21.2	**97.5**
Mongolia	0.2	34.0	23.3	19.4	**76.9**
Myanmar	22.4	70.2			**92.6**
Philippines	6.8	41.8			**48.6**
Vietnam	3.5	56.8		5.2	**65.5**
Latin America					
Bolivia		28.4			**28.4**
El Salvador		21.8		0.1	**21.9**
Guatemala	0.4	61.3			**61.7**
Haiti	41.6	51.8		0.3	**93.7**
Honduras		52.2		0.1	**52.3**
Nicaragua		56.5		0.6	**57.1**
Paraguay		33.8		13.8	**47.6**
Peru		30.0	4.0	3.0	**37.0**

Source: Extracted and adapted from UNDP and WHO 2009.

71 percent reliant on solid fuels, and within that, 11 percent using dung. Within the rest of the South Asian region, reliance remains high in Afghanistan, Bangladesh, Nepal, Pakistan, and Sri Lanka (table 2.1).

In middle-income countries, there is also reliance on solid fuels. For example, in China 56 percent of the population are users of solid fuel. Furthermore, 29 percent of the Chinese rely on coal as a household fuel—more than any other country. In other East Asian countries, such as Cambodia, Lao PDR, Mongolia, Vietnam, and especially Indonesia and the Philippines, the use of solid fuels remain high.

In the Latin American and Caribbean countries, there is also reliance on solid fuels, but to a lesser extent than the other regions. Countries such as Brazil, Guatemala, Haiti, Honduras, Nicaragua, and Paraguay have a critical mass of its population using solid fuels. Economic Commission for Latin America and the Caribbean (ECLAC 2010) reported that total firewood consumption decreased in Latin America and the Caribbean until the mid-1990s, but has started to increase again because of the rise of poverty in the region during the last decade. This situation may be further exacerbated, given the rise in international oil prices and oil derivatives experienced between 2004 and 2008.

Although the use of solid fuels is more prevalent in rural areas, there is still a significant reliance within the urban areas as well. In Sub-Saharan Africa, about 83 percent of the rural population is estimated to rely on solid fuels for cooking as compared to 60 percent of households in urban areas (IEA 2010). It is projected that households in developing countries will continue to rely on solid fuels for many more years to come, with about 2.8 billion people in 2030 (IEA 2010) as shown by table 2.2.

The Use of Solid Fuels and Energy Poverty

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

As shown in figure 2.2, access to modern energy services fulfills the basic human needs of cooking, heating, and lighting; improves productivity; and addresses the needs of everyday life in a modern society.

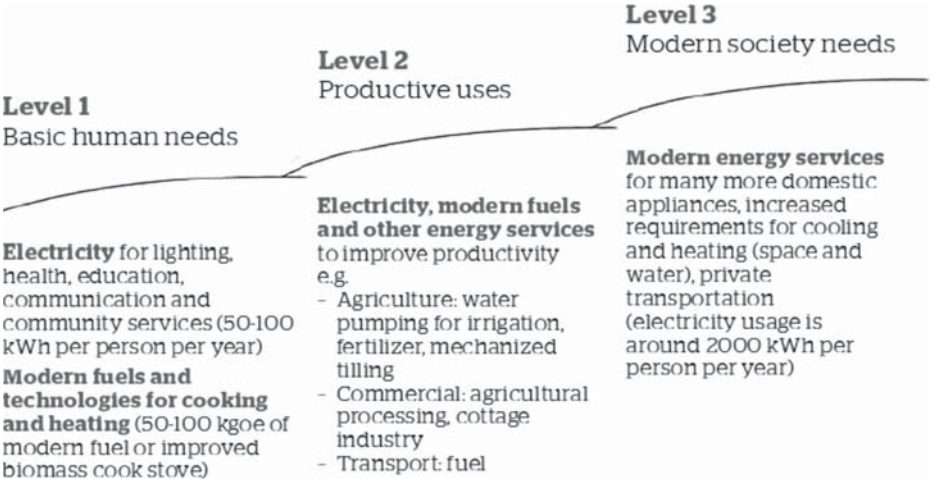
In most societies where solid fuels, and particularly fuelwood, are used for cooking and heating, women are generally the ones who devote most of their time to collection and transport. In times of fuelwood scarcity, the distance they have to go to find wood increases and requires more time. Box 2.1 describes how the role of women in the collection of fuelwood results from the prevailing and generally accepted sexual division of labor within poor households in developing countries. The literature has described how fuelwood collection deprives women and girls of the opportunity for education, for engaging in income generating activities, and for having leisure time (Clancy, Skutch,

Table 2.2: People using traditional biomass for cooking

Region/Country	2009	2015	2030
	(millions)		
Africa	657	745	922
Sub-Saharan Africa	653	741	918
Developing Asia	1,937	1,944	1,769
China	423	393	280
India	855	863	780
Other developing Asian countries	659	688	709
Latin America	85	85	79
Total	2,679	2,774	2,770

Source: IEA 2010.

Figure 2.2: Incremental levels of access to energy services



Source: AGECC 2010.

Box 2.1: The sexual division of labor and the reliance of the poor on fuelwood

There is a relationship between the sexual division of labor and the reliance of the poor on traditional energy sources. The division of labor affects women and men, and boys and girls differently. Women generally work in both productive activities and in tasks associated with child-rearing, food processing and cooking, caring for the sick, and caring for the house. Girls are more likely than boys to provide support in these tasks. The poorer the household, the greater the time and the physical and health burdens associated with these tasks. The absence of basic labor-saving devices and "clean" technologies, such as fuel-efficient stoves, not only burdens poor women in these ways, but also prevents them from doing other productive activities (Standing 2002).

and Batchelor 2004; Blackden and Wodon 2006). Access to modern energy services increases the likelihood for women and girls to break out of this poverty trap.

In some countries, fuelwood collection is not necessarily just a task for women. Cooke, Köhlin, and Hyde (2008) highlighted studies from Ethiopia, India, Indonesia, Madagascar, Nepal, and Vietnam that found that both men and women were involved in fuelwood collection. Amacher, Hyde, and Joshee (1993) indicated that when fuelwood scarcity increased, men were more involved in fuelwood collection from agricultural lands. Studies showing that men were also involved in fuelwood collection indicated the existence of more diverse intrahousehold labor allocation than the generally described pattern showing women as the only ones associated with fuelwood collection. This suggests that household energy access interventions should pay attention to contextual social and prevailing intrahousehold labor allocation and not be derived from stereotypical considerations.

There is evidence indicating that households in developing countries are following more complex energy transition trajectories than those prescribed by the energy ladder model. This model describes a three-stage fuel-switching process. The first stage is characterized by universal reliance on traditional biomass energy—mainly crop waste, dung, and wood—by households when income levels are low. The second stage is marked by a switch to intermediary fuels, such as charcoal and coal, as households' income levels improve. At this stage, urbanization has begun, along with some signs of deforestation. In the third stage, households switch to modern and clean fuels, such as liquefied petroleum gas (LPG), kerosene (in a high pressure stove), natural gas, and electricity as income levels become sufficiently high (Leach 1992; IEA 2002).

The energy ladder model assumed that as income levels increase, people will switch from the use of solid fuels to cleaner fuels. Instead of an orderly fuel-switching process based on income levels, evidence points to fuel stacking or the simultaneous use of different fuel regardless of income levels (Masera, Saatkamp, and Kammen 2000; ESMAP 2003b; Bacon, Bhattacharya, and Kojima 2010). Households continue to use different fuels as their incomes rise, and they do not immediately abandon the use of fuelwood. This suggests that high income levels alone may not be a sufficient determinant of fuel switching. Other factors, such as reliability of supply, safety, and taste preferences of food cooked using fuelwood, may be factors under consideration by households. There is also evidence indicating that fuel switching is not the only option for cleaner affordable cooking and heating in settings where viable alternative fuels are not yet available. For example, work in Mongolia has shown that fuel efficiency and combustion efficiency are equally important factors to consider. Emphasis should therefore be placed on matching appropriate appliances with fuels to ensure cleanliness (World Bank 2009).

Some developing countries have sufficient financing resources to lift their populations out of the energy poverty trap. The International Energy Agency (IEA 2008) focused on oil- and gas-exporting Sub-Saharan African countries and assessed whether their resources could alleviate energy poverty.[1] Despite the enormous revenues expected to be collected by these countries from hydrocarbon exports, a significant portion of their population is expected to remain without access to electricity and without access to clean cooking fuels in 2030. The IEA estimated that the capital cost of providing minimal energy services, such as electricity and LPG stoves and cylinders, to households during the 2006–30 period would represent only 0.4 percent of governments' take from oil and gas exports.

Relationships among Household Energy Use, Indoor Air Pollution, and Health Impacts

Burning solid fuels in traditional stoves emits smoke that contains large quantities of particulate matter (PM) and gaseous pollutants. Switching to clean fuels has been identified as the most effective way of reducing IAP, while having an improved stove and improving ventilation conditions can reduce IAP considerably as well. Inefficient combustion of traditional biomass results in high levels of IAP from a mixture of PM, carbon monoxide, hydrocarbons, formaldehyde, and benzene, which has been shown to significantly exceed safe levels (Smith and others 2000; Smith and others 2009, and Venkataraman and others 2010). Research has shown that having a clean stove, such as an LPG or kerosene stove, as the primary stove significantly reduces IAP concentrations. For example, Zhang (2010) showed that if an average household switches from using both a traditional primary stove and a traditional secondary stove to using only one clean stove, the PM concentration will decline by more than 70 percent. However, having a clean stove as the secondary stove does not necessarily reduce IAP levels. If households use clean fuels only occasionally, such as for making tea, and still use traditional biomass for primary cooking, the household IAP level does not change much.

A number of studies have examined whether improved stoves reduce IAP and have found that various types of improved cooking stoves have resulted in reductions of toxic pollutants (for example, Ezzati and Kammen 2002; Díaz and others 2008). The actual effect of an improved stove will depend on how the stove is designed and constructed and whether it is used properly. Ventilation conditions also play a significant role in IAP levels. Ventilation conditions can relate to a number of factors, such as kitchen location, housing structure, and cooking practices.

Improved stoves are designed and constructed bearing in mind two main technical considerations. The stoves need to aim simultaneously at improving heat transfer to the pot and at improving combustion efficiency. Heat transfer efficiency decreases fuel use, while combustion efficiency decreases harmful emissions. These relationships are described in box 2.2.

Exposure to IAP from the inefficient combustion of solid fuels with low-quality stoves in poorly ventilated kitchens is a significant public health hazard. A growing number of research studies has shown a strong correlation between IAP and negative health outcomes. A number of studies have found associations between IAP and acute lower respiratory infections (ALRIs) (Smith and others 2000, Ezzati and Kammen, 2001a, 2001b, Dherani and others 2008), chronic obstructive pulmonary diseases (Bruce and others 2000; WHO 2002), and lung cancer (Mumford 1987; Smith and others 1993). Ezzati and Kammen (2001a) used longitudinal data from Kenya to test the exposure-response relation. They found that acute respiratory infections (ARIs) and ALRIs are increasing concave functions of average daily exposure to PM_{10} with the rate of increase declining for exposures above 1,000–2,000 $\mu g/m^3$ (figure 2.3).

Emerging evidence is showing that IAP increases the risk of other child and adult health problems, including low birth weight, perinatal mortality, asthma, middle ear infection, tuberculosis, nasopharyngeal cancer, cataracts, blindness, and cardiovascular disease (WHO 2002). Table 2.3 summarizes the status of evidence on the health effects of IAP.

Several studies have quantitatively assessed the relationship between exposure to smoke from solid fuel combustion and ALRIs in young children in developing countries.

Box 2.2: Heat transfer efficiency and combustion efficiency

How heat transfer efficiency decreases fuel use

In continuous-feed stoves, heat transfer efficiency into the pot is determined by the following:

- **Temperature** difference between the flue gases and the outer surface of the pot.
  - The flue gases should be kept as hot as possible.
- **Proximity** of the flue gases to the pot.
  - The gases should be forced to pass close to the bottom and sides of the pot. Heat transfer is slowed by the boundary layer of still air around the pot.
- **Velocity** of the flue gases.
  - Hot flue gases more effectively heat the pot when velocity is increased. Faster flue gases get closer to the pot.

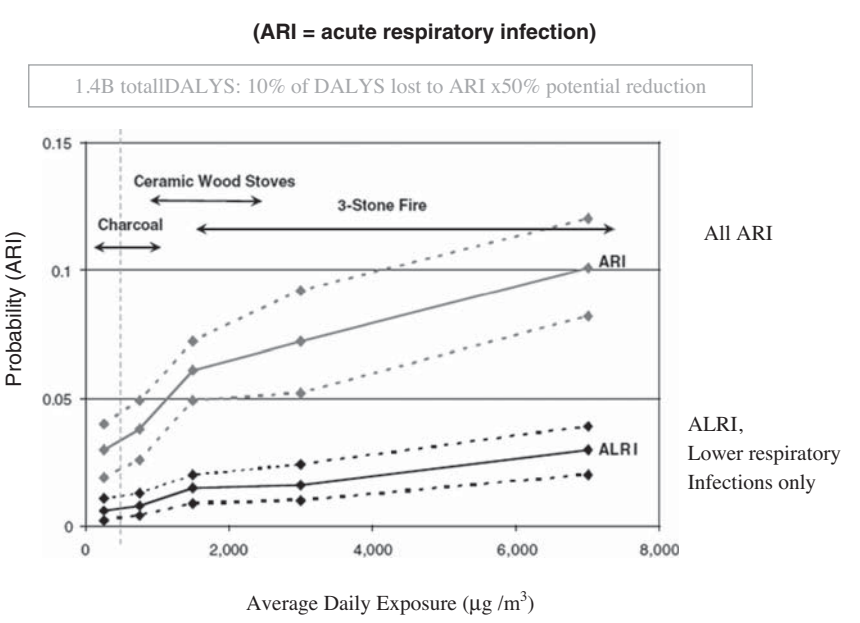
How combustion efficiency decreases harmful emissions

To improve combustion efficiency:

- Keep the combustion area as hot as possible to burn up pollution.
- Direct incoming air into the fire and coals. High-velocity, low-volume jets of air clean combustion. Too much air can cool the combustion zone.
- Burn small amounts of fuel. Heating wood makes gas. All the gas should become flame. Too much fuel makes too much gas for the flame to burn and emissions rise.
- Shape the combustion chamber to encourage mixing of gases, air, and flame. This is the most important factor in clean combustion.

Source: Still 2007.

Figure 2.3: Illness reduction observed in Kenya



Source: Ezzati and Kammen 2001a.

Table 2.3: Summary of the status of evidence on the health effects of IAP

Health Outcome	Nature and Extent of Evidence
ALRIs (children under 5)[a] COPD (adults)[b] Lung cancer	10–20+ studies from developing countries; fairly consistent results across studies, but confounding is not dealt with in many studies; supported by studies of ambient air pollution and environmental tobacco smoke (ETS) and, to some extent, by animal studies.
Cancer of nasopharynx and larynx Cataracts Tuberculosis	2–3 studies from developing countries; consistent results across studies; supported by evidence from smoking and animal studies.
Low birth weight Perinatal mortality	2–3 studies from developing countries; supported by evidence from ambient air pollution and ETS.
Acute otitis media Cardiovascular disease	No studies from developing counties, but an association may be expected from studies of ambient air pollution and studies of wood smoke in developed countries.
Asthma	Several studies from developing countries, but results are inconsistent; some support from studies of ambient air pollution, but results are also inconsistent.

Sources: Von Schirnding and others (2002), WHO (2002), Desai, and others (2004), Fullerton, Bruce, and Gordon (2008), Smith and others (2009).
[a]ALRIs refer to acute lower respiratory infections.
[b]COPD refers to chronic obstructive pulmonary disease.

For example, Smith and others (2000) reviewed 13 studies that reported wide-ranging odds ratios ranging from 2 to 10. More recently, Dherani and others (2008) conducted a meta-analysis of pneumonia risk from IAP in children under five years of age. Out of 5,317 reviewed studies, 24 were selected for the meta-analysis. Despite heterogeneity and evidence of publication bias, Dherani and others (2008) were able to provide sufficient consistency to conclude that the risk of pneumonia in young children is increased by exposure to unprocessed solid fuels by a factor of 1.8. However, since few studies directly measure IAP, this meta-analysis was unable to examine further how IAP intensity affects health. In addition to using indirect exposure proxies instead of measuring IAP directly, many studies fail to deal adequately with confounding issues. Households who have taken measures to improve their indoor air quality may do so following improvements in their socioeconomic characteristics (such as income, education, nutrition, and medical care), which strongly influence many health outcomes (Bruce and others 1998). Thus, inadequate control over these confounding factors is likely to result in an overestimate of the health impacts of IAP. More recent studies have given more attention to confounding issues. For example, some have adjusted for factors such as socioeconomic status, parental education, breastfeeding, nutritional status, environmental tobacco smoke, crowding, and vaccination status. However, the adequacy of control of and/or adjustment for confounding factors has varied considerably (Dherani and others 2008).

A more recent study on India (Zhang 2010) that used direct IAP measures, objective doctor-measured spirometric indicators as health outcomes, and sophisticated econometric models controlling confounding factors provided additional and more fundamental evidence on the health impacts of IAP. By analyzing the impacts on spirometric indicators, the study found that IAP has major impacts on restrictive lung disease rather than obstructive lung disease. Thus it provided an explanation for why the literature contains more evidence of IAP's impact on certain respiratory diseases, such as ALRIs,

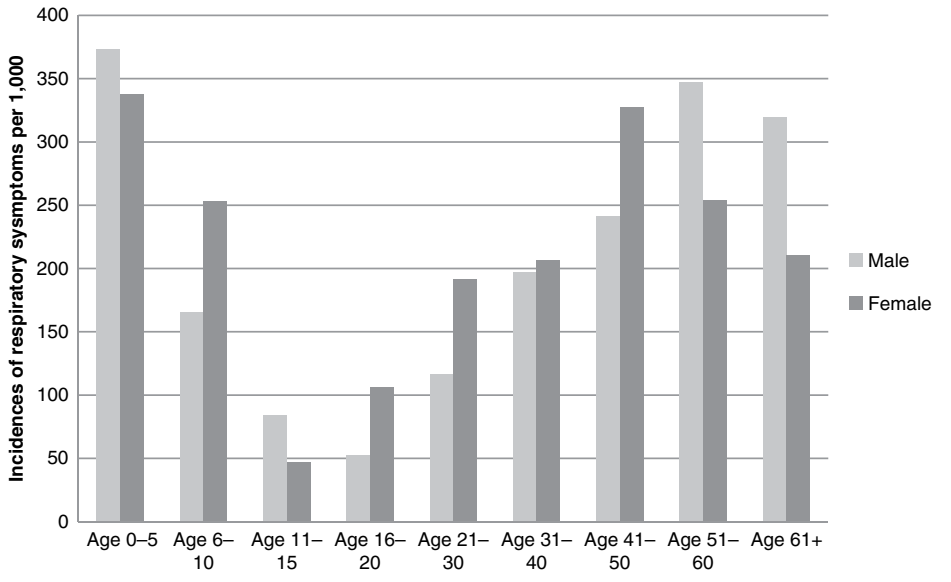
for children, but less and inconsistent evidence of IAP's impacts on other diseases such as asthma (a typical obstructive lung disease).

These studies lend robustness to the conclusion that the harmful health effects from household fuel use truly comprise a global problem (UNDP and WHO 2009). The World Health Organization (WHO) estimates that 1.9 million people die prematurely every year from exposure to smoke from traditional cookstoves and open fires—that is, nearly 1 death every 16 seconds (WHO 2010).

Women and children in developing countries are particularly affected by the negative health outcomes of IAP from the use of solid fuels. Since women are usually responsible for cooking while taking care of children, women and children are most exposed to IAP from the use of solid fuel and its subsequent health impacts. For example, as shown in figure 2.4, using the survey data from India, children under age 5 have the highest incidence of respiratory symptoms among all age groups, and women in the age group of 16–50 who are likely to spend lot of time cooking for their families have higher incidences of respiratory symptoms than men in the same age group, even though men smoke more.

Young children living in households exposed to biomass indoor pollution have a two to three times greater risk of developing an ALRI than others. They are more susceptible than adults to absorb pollutants, since their lungs are not fully developed until they reach their late teens (Budds, Biran, and Rouse 2001). A study in rural Kenya found that the amount of pollution a child is exposed to correlates to the risk of developing pneumonia (Ezzati and Kammen 2001a). Data from Ecuador show deterioration in lung

Figure 2.4: Incidences of respiratory symptoms for males and females by age group



Source: Zhang 2010.

function when children are exposed to high levels of IAP from biomass fuels (Rinne and others 2006). It was found in Guatemala that the babies of mothers using open wood fires were on average 63 grams lighter compared with babies born to mothers using cleaner fuels (Boy and others 2002). Children under five suffer severely from the IAP. More than 40 percent of the environmental disease is registered among this age group, although they constitute only 10 percent of the world population (WHO 2002).

Why do people use household energy technologies that can make them sick or even contribute to their death, and what are the factors affecting household fuel choices? A few studies, such as Heltberg (2004, 2005), Ouedraogo (2006), and Jack (2006) have examined factors determining household fuel choices. Heltberg found that in addition to income, factors such as opportunity costs of time used to collect firewood, education level, and access to electricity also play an essential role. However, there is little systematic evidence indicating which factors determine household behavior with respect to fuel use and motivate households to switch cooking technologies. More recently, Zhang (2010) explicitly modeled household behavior regarding the energy technology choices based on their attributes, including cooking costs (including stove cost and fuel cost), convenience, and cleanliness. The study found that the marginal utility of income decreases as income increases and that this effect carries over into the cooking technology choice. Thus, households are less sensitive to cooking cost as income increases. The study simulated that rural households barely change their energy technology choices if the LPG stove cost is reduced by 50 percent. But if income is doubled, 14–24 percent of rural households switch their primary stove from a traditional stove to a clean stove depending on their residence. This result is consistent with the conclusions in Heltberg (2004, 2005), Zhang, Barnes, Sen (2007), and Zhang and Vanneman (2008) that fuel switching on a large scale will not occur in rural areas unless rural economies become substantially more developed.

Households are more likely to choose energy technologies with shorter cooking times in areas with higher wage rates for unskilled women. With respect to cleanliness, the study showed that residents of households that know IAP is harmful to health are more likely to choose energy technologies with lower pollution levels. Therefore, improving the overall rural economies, particularly for women's employment opportunities, and promoting health education seem to be the long-term strategy to help households move up the energy ladder. Meanwhile, improving efficient use of solid fuels through improved stoves and conducting advocacy campaigns on health education and how to improve indoor ventilations could be the short- to medium term strategy to improve the current situation.

Inefficient Use of Solid Fuels Is Associated with Environmental Degradation and Climate Change

Local environmental impacts are associated with the inefficient use of fuelwood, especially surrounding growing urban areas. It is now widely accepted that the clearing of land for arable and pastoral agriculture is the main cause of deforestation rather than the use of wood for energy, as was believed in the past. As noted by Dewees (1989), the fuelwood crisis has not made a significant difference between physical and economic fuelwood scarcities. With the rapid urbanization in many countries in Sub-Saharan Africa and South Asia, inefficient production of charcoal for growing urban populations might

be threatening forest cover in the neighboring catchment areas (Arnold and others 2003). In these countries, in addition to households, small and medium-sized enterprises, such as bakeries, laundries, and restaurants, rely heavily on charcoal. The energy efficiency of charcoal production ranges from 25 percent in Africa, which uses mainly artisanal methods, to 48 percent in Brazil, which uses industrial kilns with extensive energy and material recovery. A recent study conducted in Tanzania by the World Bank (2009) reveals that between 2001 and 2007, the proportion of households in Dar es Salaam using charcoal climbed from 47 percent to 71 percent, and about half of Tanzania's annual consumption of charcoal takes place in Dar es Salaam, amounting to approximately 500,000 tons per year.

The reliance on fuelwood for cooking and heating is increasingly being associated with global warming. A growing body of literature from the climate change community indicates that black carbon originating from incomplete combustion of solid fuels and diesel exhaust might be the second most important factor affecting the rise in global temperatures after carbon dioxide (CO_2) (Ramanathan and Carmichael 2008; Gustafsson 2009). Black carbon is formed from the incomplete combustion of fossil fuels, biomass fuels, and biomass burning. Black carbon warms the planet by absorbing heat from the atmosphere and by reducing albedo, the ability to reflect sunlight, when deposited on snow and ice. Black carbon stays in the atmosphere for only several days to weeks, whereas CO_2 has an atmospheric lifetime of more than 100 years. Because black carbon remains in the atmosphere only for a few weeks, reducing black carbon emissions may be the fastest means of slowing climate change in the near term. It is estimated that approximately 40 percent of black carbon comes from fossil fuels, 40 percent from open biomass burning (such as natural fires and slash and burn), and 20 percent from burning biomass in stoves in the household and service sectors and from burning it in industrial processes, such as crop drying, food manufacture, and brick and tile production. There are claims that reducing black carbon emitted from the burning of open biomass with the use of improved stoves may provide quick gains to help slow down global warming. A closer look at the effects of black carbon suggests the opposite. According to Bauer and others 2010, smaller particles stay longer and travel longer distances and behave differently than larger particles. In fact, this study suggests that while black carbon emissions from diesel is clearly shown to have a warming effect on the climate, black carbon emissions from cookstoves, because of their organic nature and small-size particles, may be interacting with other aerosols in the atmosphere to produce a net cooling effect on the climate. It appears that current science points to uncertainties around the potential climate change impact of black carbon emissions from biomass combustion.

Note

1. The selected oil- and gas-exporting Sub-Saharan African countries are Angola, Cameroon, Chad, the Democratic Republic of Congo, Côte d'Ivoire, Equatorial Guinea, Gabon, Mozambique, Nigeria, and Sudan.

CHAPTER 3

Meeting the Challenge

The objective of this section is to assess how the challenge of improving household energy access to the poor for cooking and heating is being met. First, an overview on the main technical assistance and advisory programs that were implemented or being implemented by the Bank is provided. Second, a review of Bank lending operations over the last 20 years with an attempt to point out their main characteristics, their success and failure factors is conducted. And third, selected programs undertaken by governments or other organizations are highlighted with an acknowledgement of their main strengths and weaknesses.

An Overview of Main World Bank Programs with Focus on Household Energy

During the last 25 years, household energy access issues have retained the attention of many specialists within the Bank from different sectors, such as energy, forestry, environment, health, agriculture and rural development, gender, and climate change. The Energy Sector Management Assistance Program (ESMAP) jointly set up by the World Bank and the United Nations Development Programme (UNDP) in 1983, has played and is still playing a leading role in funding work undertaken by specialists from these different sectors. In the specific case of Sub-Saharan Africa, the RPTES supported analytical work and upstream studies between 1993 and 2003. Since 2009, work on household energy in the Africa region has been supported by the Biomass Energy Initiative for Africa. ASTAE, created in 1992, has been supporting activities on household energy access. Work done by the Carbon Finance Unit also includes activities related to household energy access.

Energy Sector Management Assistance Program

The Energy Sector Management Assistance Program's (ESMAP) focus on household energy access issues began in 1985 as many completed energy assessment reports highlighted the major challenge securing an adequate long-term supply of household fuels at affordable prices (ESMAP 1985). Alarming reports were surfacing on the scarcity of fuelwood mostly in Sub-Saharan Africa, South Asia, and part of Latin America, as detailed in box 3.1.

Box 3.1: A description of the fuelwood scarcity

Some 2 billion people who depend on wood and other traditional fuels for their basic energy needs are facing a deepening crisis of energy scarcity as local resources are depleted and the more distant forests are cut down. The implications of this crisis reach far beyond the supply of energy itself. As trees are lost and people are forced to burn fuels that are taken from the fields, the land that provides their livelihood and feeds the nation may become increasingly vulnerable to erosion and soil degradation. In some areas of the developing world, the process has reached its terminal stages where the land produces nothing, and starvation or migration are the only alternatives (Leach and Gowen 1987).

ESMAP had a Household Energy Division to work on household energy access issues (ESMAP 1987). Household energy access subtopics included (a) household energy strategy; (b) traditional fuel (fuelwood planting, biomass residues); (c) traditional fuel utilization (improved stoves, charcoal kilns, and biomass utilization in industries); (d) substitution (household use of modern fuels); and (e) renewables.

The focus on household energy access remained strong between 1988 and 1994. The 1988 household energy unit portfolio included 29 activities, with a total cost of about US$7.4 million (ESMAP 1988) Soon thereafter, rural household energy access was included, and the thematic priority area of "Household and Rural Energy" remained robust. As stated in the 1993 Annual Report, "ESMAP household and rural energy activities, one of the Program's long-term strengths, have continued vigorously." Many studies have since been carried out to develop household energy strategies in several countries, including Bolivia, Botswana, Haiti, India, Jamaica, Mexico, Mali, Chad, Rwanda, and Vietnam. These studies provided a clear picture of supply and demand on traditional fuels that were overlooked by conventional energy planning, often for the first time in many countries.[1] In some cases, these assessments were followed by prefeasibility studies of investment projects related to biomass and charcoal productive uses. These technical and analytical pieces assisted countries in scoping their household energy use for planning, policy, and investment purposes. Records indicate that by the end of 1995, ESMAP had designed household energy components for projects in 10 countries, namely, Bolivia, Burundi, Ethiopia, Guinea, Haiti, Madagascar, Mali, Mauritania, Niger, and Rwanda (World Bank 1996).

However, a shift came in the mid-1990s, when household energy access activities declined during the 1996–97 period as growing attention focused on rural electricity access. Some believe that the realization that the fuelwood crisis was exaggerated because of faulty data may have played a role in this declining trend. The 1997 ESMAP Annual Report acknowledged that biomass projects had a relatively lower profile in 1997 than previously and reported that ESMAP initiated only one purely urban household energy activity—the India Urban Energy Study—to assess households' use of traditional fuels and to propose appropriate energy policies and potential investments. Furthermore, ESMAP activities within the rural and household energy theme focused principally on developing least-cost rural electrification, promoting the use of modern biofuels, and enlarging the role of cost-effective, small-scale renewable energy sources.

The 2002 annual report pointed out that ESMAP supported analytical work on household energy in five countries—China, Guatemala, India, Mongolia, and Nicaragua—covering a range of issues, such as IAP's health impacts, barriers to commercializing of improved cookstoves, and promotion of the use of alternative cooking fuels, such as LPG, kerosene, and natural gas.

In 2003, the growing Gender-Energy portfolio under ESMAP's "Increased Access to Modern Energy Services" thematic led to two studies to (a) assess the impact of energy on women's lives in rural India and (b) identify ways to integrate gender in energy provision in Bangladesh. Furthermore, in 2004, the "Energy and Poverty" thematic, which replaced the "Increased Access to Modern Energy Services," included access to modern cooking fuels for the poor and rural households and efficient use of biomass in its agenda.

During 2005–08, ESMAP household energy access work ramped up through the introduction of the regional block grants and the energy small and medium enterprise (SME) program. In accordance with ESMAP's 2005–07 business plan, the program retained

management of cutting-edge and knowledge dissemination activities, but devolved pre-investment activity implementation to the World Bank regional energy units by providing them with annual block grants to support activities falling within ESMAP's five redefined business lines—energy security, renewable energy, energy poverty, market efficiency, and governance. In addition, ESMAP initiated the energy SME program funded by the United Kingdom, which launched cross-cutting thematic activities, including improved cookstoves in Haiti, small-scale, off-grid systems in Cambodia and Cameroun, and solar home systems in Bolivia (ESMAP 2007a). The program has also strengthened its support to the Global Village Energy Partnership (GVEP) by setting up a grant program, the GAPFund, which focuses partly on the role of SMEs in improving energy access. These initiatives resulted in a stronger household energy access portfolio. In fiscal 2008, 28 percent of the total annual block grants (US$7.1 million) were allocated to activities under the Energy Poverty thematic area, which covers household energy access issues (ESMAP 2009b). Notable ESMAP publications on household energy access included (a) *Household Energy, Indoor Air Pollution, and Health: A Multisectoral Intervention Program in Rural China;* (b) *Haiti: Strategy to Alleviate the Pressure of Fuel Demand on National Wood Fuel Resources;* and (c) *Cleaner Hearths, Better Homes: Improved Stoves for India and for the Developing World.*

In 2008, ESMAP transitioned into a five-year business plan model and adopted its 2008–13 Strategic Business Plan focusing on its global thematic challenges (climate change, poverty reduction, and energy security) through its core functions of knowledge clearinghouse, operational leveraging, and think tank. A pillar of ESMAP's program was dedicated to poverty and energy access through dedicated programs on rural electrification, SMEs, access to the urban poor, and gender and energy (ESMAP 2009a).

Regional Program for the Traditional Energy Sector

Another important program within the Bank that focused on household energy issues was the Regional Program for the Traditional Energy Sector (RPTES). The RPTES was based in the Africa Technical Energy Group. It was funded with a trust fund provided by the Directorate General for International Cooperation of the Netherlands Government. The RPTES started in 1993 with a review of policies, strategies, and programs in the traditional energy sector. The core objectives of the review were (a) undertaking a retrospective evaluation of traditional energy work done in Africa; (b) identifying the principal critical intersectoral linkages that influence the operation of the traditional energy sector; (c) identifying projects and programs; and (d) disseminating the operational results (RPTES 1996). The review of policies, strategies, and programs was completed in 1995. A short-term extension was provided to the RPTES between 1995 and 1996 to keep the momentum generated in countries.

A full program was funded between 1997 and 2003 by the Directorate General for International Cooperation of the Netherlands Government (US$7.2 million). The objectives this program were mainly to (a) rationalize the structure and functioning of the traditional and biomass energy sector; (b) support capacity and institutional development in the sector; (c) support the review, formulation, and implementation of enabling policy and regulatory framework for the sector; (d) identify and assist in the preparation and implementation supervision of sectoral investment projects; (e) identify and promote the implementation of sustainable fuelwood supply management systems; and (f) identify and promote sustainable and economically viable interfuel substitution options. The RPTES supported a number of strategy papers and upstream studies intended

to help mainstream into lending operations household energy issues—and particularly those related to the efficient production and use of biomass energy. The flagship investment operation generated through the RPTES was the 1997 Senegal Sustainable and Participatory Energy Management Program. Work initiated by the RPTES helped the preparation of other lending operations with components on household energy in Benin, Burkina Faso, Mali, and Ethiopia. In June 2010, the Senegal Second Sustainable and Participatory Energy Management Project (PROGEDE II) was approved with the objective of contributing to increasing the availability of diversified household fuels in a sustainable and gender-equitable way and to contribute to increasing the income of participating communities while preserving the forest ecosystems.

Biomass Energy Initiative for Africa: The Africa Energy Team is currently implementing the Biomass Energy Initiative for Africa (BEIA) since March 2009. The BEIA is funded through trust fund resources (US$3.5 million) as part of the broader AFREA program supported by the Netherlands Government through ESMAP. The primary objective of the BEIA is to test promising building blocks dealing with biomass energy that have the potential to be incorporated into the future Bank's lending portfolio. The BEIA is focusing on the following four themes: (a) enabling market conditions for high-quality and high-performance cooking stoves; (b) modernization of the charcoal industry by improving the industry's environmental sustainability and energy efficiency in charcoal production and use; (c) demonstrating the feasibility of social biofuels; and (d) increasing power capacity with bioelectricity—use biomass as fuel for power generation for off-grid or add-on capacity (BEIA 2009). About 11 pilot projects have been selected around these themes to be executed by recipients in selected African countries. Through the BEIA, the Africa Energy Team produced an issues and approaches paper on household biomass energy for Africa in February 2011. This paper advocates that any policy reform in the biomass energy sector should entail a combination of clear rules, transparent enforcement, strong incentives, awareness creation, and capacity development. It indicates that the World Bank—together with other development partners, CSOs, and the private sector—can choose from a large portfolio of options in providing assistance to countries. Some of the main options are (a) promotion of secure and long-term tree and land tenure rights for communities as essential prerequisites for implementing and sustaining community-based forest management; (b) modernization of fuelwood markets for both fuelwood and charcoal as an opportunity for stakeholders to engage formally in the sector, (c) application of improved kiln technologies to enhance the efficiency of charcoal production, (d) reforms of taxation and revenue systems providing fiscal incentives for the sustainable production of fuelwood, and (e) promotion of improved cookstove technology.

ASTAE is a global program and partnership with a mandate to scale up the use of sustainable energy in Asia and Pacific to reduce energy poverty and protect the environment. Table 3.1 illustrates its recent activities on household energy access.

The East Asia and Pacific Region of the World Bank is in the process of finalizing its Flagship Report on Energy Access—"One Goal, Two Paths." The report explores strategies along two paths to achieve universal access to electricity and clean and efficient cooking solutions in the region by the year 2030. The report addresses access to modern cooking fuels (mainly LPG, and biogas in rural areas), as well as the provision of improved cookstoves that reduce indoor pollution and provide greater combustion efficiency. The range of issues that is covered includes institutional frameworks, financial requirements, and policy responses. A proposal to launch a clean and efficient cookstove

Table 3.1: Indicative list of ESMAP's past activities on household energy access for cooking and heating, 2002–09

Country	Brief Activity Description	Results
India	A study that includes a review of best-performing improved biomass stove programs in six states of India Completed in 2002	A report—*India: Household Energy, Indoor Air Pollution and Health*—that includes lessons learned for successful implementation and replication of improved cookstove projects.
Guatemala	An analysis of household energy consumption patterns and interfuel substitution constraints using living standard and measurement surveys. Completed in 2003.	A report—*Household Fuel Use and Fuel Switching in Guatemala*—that recommends that interfuel substitution be complemented by policies aiming to promote improved cookstoves.
Guatemala	A study to better understand the implications of indoor air pollution and the mitigation options. Completed in 2005.	A report—*Environmental Health and Traditional Fuel use in Guatemala*—that provides policy recommendations to facilitate the adoption of cleaner cooking fuel and improved cookstoves.
Nicaragua	Assistance to promote the commercialization of improved cookstoves. Completed in 2005.	Market assessment of improved cookstoves demand and development of improved cookstoves models.
Global	A study on energy policies and multitopic household surveys. Completed in 2007.	A paper that provides guidelines on how Living Standards Measurement Studies (LSMS) can help policymakers design household energy transition policies and monitor progress toward adoption of cleaner cooking fuel.
Haiti	Technical assistance to promote the involvement of small & medium enterprises in producing and commercializing improved cookstoves Completed in 2009.	Dissemination of 11,000 energy efficient cookstoves. 144 artisans trained. Established a Quality and Energy Efficiency Label.
Cambodia	Technical assistance to support the involvement of SMEs in providing energy services. Completed in 2009.	About 8,000 improved cookstoves and 600 light emitting diode (LED) lanterns were distributed to households.
Bangladesh	A study to draw lessons from past and existing cookstove dissemination programs in Bangladesh. Completed in 2009.	Recommendations for large-scale cookstove commercialization and policy support.

Source: Authors, compiled from ESMAP information.

program covering the region is under preparation. Table 3.2 illustrates recent activities of the East Asia and Pacific Region on household energy access with the support of ASTAE.

The World Bank Carbon Finance Unit's (CFU's) Initiatives

The World Bank Carbon Finance Unit's (CFU's) initiatives are part of the larger global effort to combat climate change. The CFU uses financial resources contributed by governments

Table 3.2: Indicative list of ASTAE activities on household energy access for cooking and heating, 2007–10

Country	Brief Activity Description	Results
China	Just-in-time advisory support to share knowledge and international experience with transitioning to meter-based heating supply systems through reviews and analysis of the activities performed by the city of Tianjin in China. Completed in 2007.	Contributed to improved solutions to address problems encountered in heat metering programs. If successful, scale up potential in other cities in northern China.
Cambodia	Help to create a model production facility using improved technologies and management practices that could be replicated by SMEs, including women, to produce the Neang Kongrey Stove (cookstove) for broad-scale dissemination. Completed in 2008.	Production capacity of model production facility, with 30 potters about 2,000 stoves a month, a dramatic increase from the earlier artisanal outputs. The planned scaling-up phase converting traditional stove makers into improved cookstove producers, including women.
Mongolia	Comprehensive study on Energy Efficient and Cleaner Heating in Peri Urban Areas to mobilize a wide range of resources to develop and support abatement measures for air pollution in Ulaanbaatar. Completed in 2009.	An outline of a program to replace stoves and introduce new fuels, including setting technical standards and testing compliance of emissions, assistance to Mongolian stove producers and linking them up to international counterparts, convincing households to switch to better fuel-stove combinations.
Timor-Leste	A household energy study, an assessment of rural and renewable energy options, with complete techno-economical analysis of the different options, including improved stoves. Completed in 2010.	A report to help the government with its rural energy policy choices, with focus to assist in developing clear and coherent policies and guide planning of the subsequent phases of ongoing programs, initiation of new programs, and prioritization of projects competing for limited funds.
Cambodia	Technical assistance to develop a service delivery model of a biodigester and to implement it in three test provinces by establishing and training private biodigester contracting companies. Completed in 2010.	The privatization of biodigester services in eight provinces. Twenty-one biodigester construction companies created, well above initial targets. A sixfold increase in the number of bio-digesters installed and further targeting the installation of 21,800 biodigesters in 12 provinces by 2012.

Source: Authors, compiled from ASTAE information.

and companies—the overall volume is currently at about US$2.5 billion—to purchase project-based greenhouse gas emission reductions in developing countries and countries with economies in transition. The emission reductions are purchased through one of the CFU's carbon funds on behalf of the contributor, and within the framework of the Kyoto Protocol's Clean Development Mechanism (CDM) or Joint Implementation. Some of the CFU's carbon funds, such as the Community Development Carbon Fund, specifically provide carbon finance to projects in the poorer areas of the developing world. The Bio Carbon Fund focuses on land use, land use change, and forestry (LULUCF) projects

and seeks to extend its reach to new landscape approaches that includes LULUCF and energy components. The Carbon Partnership Facility aims for programmatic approaches to carbon finance and for up-scaling from the project-by-project approach. Overall the CFU's portfolio contains a number of projects with a focus on household energy, including installation of solar home systems in Bangladesh and domestic biogas installations in China and Nepal. The Bangladesh solar home systems program could result in an estimated 2.6 million tons of CO2 equivalent reduction of emissions over a 7-year period. In all these activities, besides purchasing carbon, the CFU systematically develops CDM projects and programs and helps its clients to access the carbon markets. Given the development of the current carbon markets, the CDM will focus more and more on projects in low-income countries, increasing the interest for the household energy sector. Appendix A provides lessons learned from using carbon markets for household energy access programs and information on the elaboration on carbon finance and its potential catalytic role for cookstove programs.

A Review of World Bank-Financed Lending Operations on Household Energy Access for Cooking and Heating

The following section provides a review of World Bank-financed projects, which are directly aimed at improving household energy access for cooking and heating energy access.

Data and Methodology

It proved difficult to track and find nonelectricity household energy access projects. The only forms of nonelectricity energy that is often taken into consideration in the coding of projects are coal, gas, and oil products, while household energy access interventions are often lumped as "new renewable energy" or "other energy" projects.

The list of projects included here has gone through several rounds of revision. An initial list was prepared as part of a broader study entitled *Modernizing Energy Services for the Poor: A World Bank Investment Review* (Barnes, Singh, and Shi 2010). Generating the list required a keyword search through the text of several hundred energy projects financed by the Bank between fiscal years 2000 and 2008 and reading through documents individually to determine whether the projects had a household energy access intervention for cooking and heating or not. The examination of each project component focused on whether or not and how each project component addressed topics of demand and supply of household cooking and heating energy access. This analysis was extended to cover a 20-year period from fiscal years 1990 to 2010.

The methods used to review these projects included examination of each component of the project and its project budget allocation, as described in the Project Appraisal Document or Staff Appraisal Report. For projects that are still active, the ratings of the last Implementation Supervision Reports were examined. For the projects that have already been closed, the ICRs or Project Performance Audit Reports were examined.

A List of Selected Projects and Their Costs

A total of about 70 projects during the past 20 years have been reviewed, of which 19 projects were selected as having the objective of improving household cooking and heating energy access through fuelwood management or improved stoves. The total cost of these projects was US$1.2 billion, to which the World Bank contributed

US$698 million and of which US$161 million was devoted specifically to household fuels (see table 3.3). These projects have focused on community-based forest management for sustainable supply of fuelwood, substitution of polluting fuels with cleaner fuels, and institutional capacity development. With the exception of the Mongolia Urban Stove Improvement Project financed by the GEF, the remaining projects were on Sub-Saharan African countries.

Table 3.3: World Bank-funded projects with access to fuelwood and/or stove component (US$ million)

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

Source: Project Appraisal Documents and Project Database.

During the period of the review, the Bank funded four biogas projects for cooking and lighting at the household level in China and Nepal (table 3.4). The total cost of these projects was US$1 billion, to which the Bank contributed US$365 million with 70 percent allocated to household energy access components. Similarly, the Bank has financed 8 household energy access projects on natural gas for cooking and heating, mostly in Europe and Central Asian countries, and one project in Colombia (table 3.5). The total

Table 3.4: World Bank-funded projects with household access to biogas component

	Project	Year	Total project cost	IBRD, IDA, GEF, GPOBA	HH energy access component	% of total project costs	Project closing date
1	China: Second Red Soil Area Development Project	1994	336.02	139.67	3.1	1	9/30/01
2	NEPAL: Fourth Biogas Support program (GPOBA)	2006	76.41	5.15	76.41	100	4/30/12
3	China: Changjiang and Pearl River Watershed Rehabilitation	2006	200.00	100.00	17.73	9	6/30/12
4	China: Eco Farming (with Biogas CDM program)	2008	439.75	120.00	157.00	36	6/30/14
	Total		**1,052.18**	**364.82**	**254.24**	**24**	
	Average loan/credit		263.05	91.21	63.56		

Source: Project Appraisal Documents and Project Database.

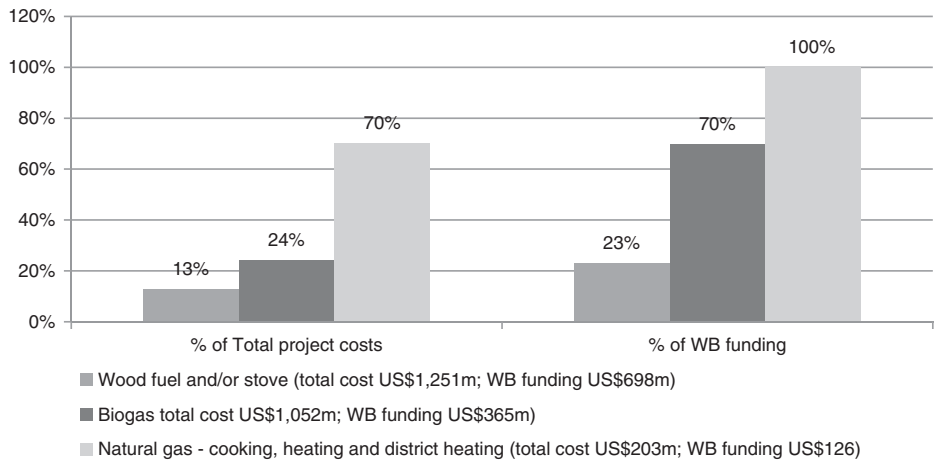
Table 3.5: World Bank-funded projects with household access to natural gas for cooking and heating and district heating component

	Project	Year	Total project cost	IBRD, IDA, GEF, GPOBA	HH energy access component	% of total project costs	Project closing date
1	Bosnia and Herzegovina: Emergency District Heating Reconstruction Project	1996	44.50	20.00	44.50	100	3/31/99
2	Moldova: Energy Project	1996	12.63	9.08	12.63	100	12/31/01
3	Bosnia and Herzegovina: Emergency Natural Gas System Reconstruction Pro	1997	40.53	10.00	40.53	100	7/31/99
4	Armenia: Urban Heating Project	2005	21.95	15.00	13.90	63	12/31/09
5	Armenia: Access to Gas & Heat Supply for Poor Urban Households (GPOBA)	2006	3.09	3.09	3.09	100	12/31/09
6	Belarus: Chernobyl Recovery	2006	60.90	50.00	8.50	100	12/31/11
7	Colombia: Natural Gas Distribution for Low Income Families in the Caribbean Coast Project (GPOBA)	2006	5.10	5.10	5.10	100	3/31/08
8	Tajikistan: Energy Emergency	2008	13.90	13.90	13.90	100	31/12/12
	Total		**202.60**	**126.17**	**194.55**	**96**	
	Average loan/credit		25.33	15.77	24.32		

Source: Project Appraisal Documents and Project Database.

project cost is US$203 million, to which the Bank has contributed US$126 million. The total cost of specific components on household access to natural gas is US$142 million. Figure 3.1 provides a summary of the respective share of funding allocated to fuelwood and stove, biogas, and natural gas programs. It appears that relatively few resources were allocated to fuelwood and stove programs.

Figure 3.1: Household access component as a percentage of total project cost and of total World Bank funding



Source: Authors.

Main Components and Performance of Household Energy Access Projects on Fuelwood and Improved Stoves

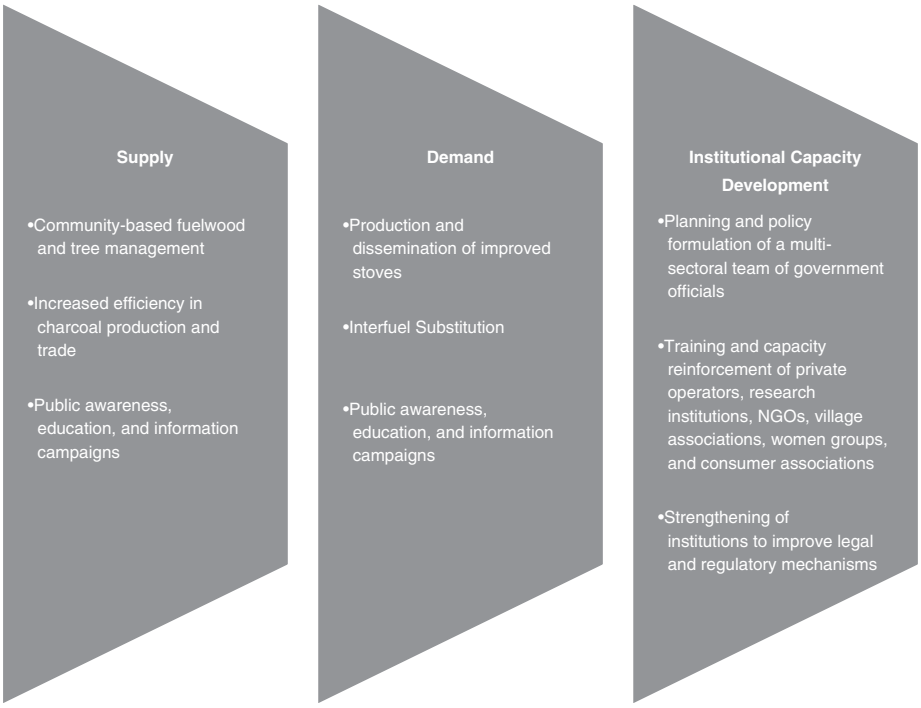
World Bank–financed projects on household energy access in several countries have followed similar design and intervention approaches. An emphasis was placed on dealing with supply-side and demand-side issues while initiatives were undertaken to reinforce institutions. Figure 3.2 is a broad summary of key components of these projects. It should be noted that not all the projects have dealt with all three of these components simultaneously. Some projects have had either only a supply-side focus, while others have focused solely on demand-side issues. In most of the cases however, institutional capacity development was given a considerable place.

Supply-Side Components

Community-Based Fuelwood and Tree Management

To establish community-based fuelwood management plans, projects rely on information from fuelwood supply assessment studies. These studies generally help identify areas of intervention. For example, the community-based fuelwood supply management plan and implementation plan at the village level for the Niger Energy Project gives villagers guidelines on how to exercise their right to manage forests in their communities.

Figure 3.2: Key components of household energy access projects



Source: Authors.

The plan recommended how to divide the forest area into parcels for woodcutting rotation. Village committees are set to play an interface role between national forest service officials, woodcutters with an established permit, random woodcutters without permits, and wood buyers. According the Mali Household Energy Project, village forest management plans were effectively implemented in 200 villages, bringing about 320,000 hectares of forest land under local community management. The ICR for The Senegal Sustainable and Participatory Energy Management Program of 1997 has also confirmed successful results in the establishment of effective community base fuelwood management plans. The ICR concluded that the Sustainable Woodfuels Supply Management Component was able to (a) establish sustainable community-based forest management systems over an area of 378,161 hectares with a capacity to supply more than 370,596 tons per year of sustainable fuelwood equivalent to some 67,400 tons of charcoal per year; and (b) adopt effective strategies to strengthen the buffer zone around the Niokolo-Koba National Park.

Development of Sustainable Charcoal Production

A message that emerges from all of the projects reviewed is that the demand of charcoal has increased steadily, especially in the urban area. Another message is that wood for charcoal production is usually mined from unmanaged forest areas with inefficient

carbonization techniques. The Staff Appraisal Report for Mali Household Energy Project indicates that approximately 8 tons of wood are needed to produce only 1 ton of charcoal with caloric value only twice that of wood. As a result, all projects consider charcoal production one of the most important parts of the fuelwood supply system. In general, projects focus on improving carbonization techniques. The Senegal Sustainable and Participatory Energy Management Project directly supported the rural community to establish rural-based, micro enterprise units to produce efficiently and sell charcoal. The main motive was to ensure that local communities manage their own wood resources to increase sustainability.

Public Awareness, Education, and Information Campaigns

Information and educational campaigns were also directed to training villagers, fuelwood traders, and charcoal producers. Many projects have successfully conducted awareness-raising activities at the level of the national forest services, community organizations, and private sector operators involved in the fuelwood trade business.

Demand-Side Components

Promotion and Dissemination of Improved Stoves

Outcomes of the improved stove dissemination component are mixed with satisfactory and some unsatisfactory results. According to the project ICR, improved stoves manufactured by a local stove maker in Mali were relatively successful in attaining a relatively high market penetration in the target areas. In total, about 100,000 improved stoves were sold under the Mali Household Energy Project, which are about 40,000 stoves more than the original target of the project. Similarly, the Senegal program has supported the dissemination of about 225,000 improved stoves. These successful achievements were attributed to (a) an effective marketing strategy with tailored information and educational campaigns; (b) profit-making strategies developed to support stove producers; and (c) actual recognition by consumers that improved stoves help them effectively reduce fuel consumption and ultimately save money.

On the contrary, the ICR of the Chad Household Energy Project noted that the project was able to disseminate only 14,900 improved stoves in the market, which is only about half of target, as stated in the Staff Appraisal Report. The number of improved heating stoves distributed under the Mongolia Urban Stove Improvement project also falls short of expectations. However, the project has been successful in educating consumers and raising awareness regarding air pollution in the city and the use of traditional versus improved heating stove.

Regarding project implementation, projects work with governments to use leverage to reach a national audience. In addition, projects also work directly with local government to gain direct access to stove users, particularly women in the case of cooking stoves and heads of households in the case of heating stoves in Mongolia.

Interfuel Substitution Initiatives

The Mali, Niger, and Senegal projects promoted commercialization of both kerosene and LPG stoves by private entrepreneurs. It is important to note that activities of

these projects were designed to build on the ongoing, interfuel substitution programs being carried out by the government under the support of the Permanent Inter-State Committee for Drought Control in the Sahel (CILSS). The promotion of low-cost kerosene and LPG stoves was an objective of the Chad Project, but it was subsequently dropped during project implementation. The ICR stated that households showed no interest in kerosene stoves, mainly because the cost of cooking with kerosene is much higher than with charcoal. It also noted that, although LPG was highly subsidized, it was generally unavailable.

In general, the introduction of kerosene stoves was not very successful in these countries. The ICR of the Mali project summarized the reasons as follows: (a) price increase of petroleum products make kerosene very expensive for poor households; (b) high exchange rates affect the cost of kerosene stoves and burners, making it difficult for households to adopt them; and (c) quality and technical problems associated with the imported kerosene stoves presented risks of explosion and fire.

There was an attempt in Niger to support private operators to manufacture kerosene stoves. The idea was to import kerosene burners and stoves from Indonesia and modify it for use in Niger by a local company. The modified stove was called "Tchip stove." According to the project PPAR, the domestically built stoves became available only at the end of the project and could no longer benefit from support for dissemination to households. Additionally, the devaluation of the CFA franc in 1994 made it difficult for the domestically produced kerosene stoves to be successful.

The promotion of LPG use in the projects reviewed centered on providing subsidies to support the dissemination of 3 kilogram and 6 kilogram of LPG cylinders with support for pots and pans, and burners that screw directly onto the top. The main reason for focusing on small LPG cylinders and stoves is that they cost less than the 12.5 kilogram cylinders, and they tend to be the ones used by lower- to middle-class households. LPG promotion was more successful in Senegal than in the other countries. The LPG promotion program led to a remarkable boom in LPG consumption, which grew from less than 3,000 tons in 1974 to 15,000 tons in 1987 and nearly 100,000 tons today. Nearly 85 percent of households in Senegal's capital city, Dakar, and 66 percent of those in the other main urban areas now own LPG stoves. Although the program has not succeeded in fully replacing other fuels, it has at least encouraged some diversification of cooking fuels. The main reasons for the success appear to result from two important factors. First, the LPG promotion program in Senegal was launched in the early 1970s and was further reinforced by the support of the CILSS. Second, the continued support for LPG price subsidy, which began in 1987, has made the price of LPG more affordable to the majority of households in the capital city. However, the subsidies have come with a tremendous cost and fiscal pressure. The government tried several times in the early 2000s to gradually remove the subsidies, but did not succeed until 2008. As expected, the removal of subsidies has resulted in the reduction of LPG consumption. Based on a study conducted by TOTALGAZ, per capita consumption of LPG is expected to drop from the peak annual per capita consumption of 11.7 kilogram per person in 2005 to 8.6 kilogram per persons in 2008. Recent evidence suggests that the demand for charcoal in Dakar and other urban areas has increased.

Public Awareness, Education, and Information Campaigns

Most projects recognize that awareness raising, public information, and educational campaigns are essential for promoting and developing a market for improved stoves. The targeted audiences on awareness and motivation include not only consumers, but also stove producers and stove retailers. The aim is to convince stove producers to learn new technologies and only produce improved stoves for the market. For example, as part of the demand side component, the Niger Household Energy Project provided direct support for a publicity campaign to promote improved fuelwood stoves. The project relied on radio, television, billboards, and demonstrations. The publicity campaign to promote improved fuelwood stoves was done alongside the promotion of LPG and kerosene stoves. The project provided interest-free loans to private entrepreneurs to open energy shops to sell and provide after-sales support for improved fuelwood stoves, as well as kerosene and LPG stoves, promoted by the project. To overcome the problem of price volatility and reliability of the kerosene supply, the project arranged to have energy shops carry kerosene at concessionary prices and to sell it at the price set by the Ministry of Commerce. Although the messages and publicity campaign reached the targeted audiences, they failed to convince households to switch from the traditional three stones to improved fuelwood stoves or switch to kerosene or LPG. This falling so short of expectations may have resulted from a combination of reasons, including economic hardship in the 1990s and low prices for firewood.

The improved stoves project in Mongolia also had specific activities aimed at increasing awareness and social marketing. The project divided this activity into three stages. During the first year of project implementation, the awareness campaign concentrated on introducing improved heating stoves to the public, primarily *ger* area residents in Ulaanbaatar city.[2] The project informed the public about the overall aspects and benefits of improved stoves. In the second year, the campaign transitioned its focus to building demand for and promoting improved heating stoves. From the third year to the end of the project implementation period, the project's awareness campaign included more customized dissemination, demonstration of improved stoves, and training on fuel-saving techniques. Various modes of information dissemination have been utilized, including radio, television, newspaper, and billboards, with the information dissemination campaign directed at stove users in the *ger* areas. To help consumers overcome the upfront cost, the project received help from output-based aid, which enabled the dissemination of about 3,000 improved stoves in a short time before the project ended.

Institutional Development and Capacity Building

Projects carry out the recognition that structural, institutional, and organizational changes are needed to successfully promote a sustainable supply of fuelwood. In general, policy, institutional, and organizational changes include activities to promote the transfer of responsibility for forest management from state or central government to local communities and changes in fuelwood taxation policy. With respect to taxation, all four projects with completed ICRs have successfully worked with their respective central governments to enact taxation reform on fuelwood production and supply to ensure harvesting from forests under community management. All projects had successfully

carried out a comprehensive training and client consultation program on forest management tailored to village communities and the creation of rural fuelwood markets.

Performance evaluation of closed projects

Table 3.6 shows the ICRs of closed projects. Overall, the projects have performed satisfactorily. Their sustainability was also rated likely and even highly likely in the case of the Senegal Sustainable and Participatory Energy Management Project. In table 3.6, the performance of key components of these projects is discussed in order to provide some insights on some of their success factors and areas that were difficult to implement.

Table 3.6: Principal performance ratings from selected projects' implementation completion reports

	Niger Energy Project	Mali Household Energy Project	Senegal Sustainable Participatory Energy Management Project	Chad Household Energy Project	Mongolia Urban Stove Improvement Project
Outcome	S	S	HS	S	S
Sustainability	L	L	HL	L	S
Institutional development impact	S	SU	SU	H	S
Bank performance	S	S	HS	S	n.a.
Borrower performance	S	S	S	S	n.a.
Quality at entry	n.a.	S	HS	S	S
Project at risk at any time	n.a.	No	Yes	No	n.a.

Source: ICRs.
Note: HS = highly satisfactory, S = satisfactory, U = unsatisfactory, HL = highly likely, L = likely, UN = unlikely, HUN = highly unlikely, HU = highly unsatisfactory, H = high, SU = substantial, M = modest, N = negligible, n.a. = not available.

Performance of projects under implementation

Table 3.7 shows the ratings of the two last Implementation Supervision Reports of the project under implementation. It is too early to make a call on the success or failure of these projects. A review of the last and current ratings of the implementation progress suggest that, while some of the projects seem to be showing a satisfactory performance, there are also projects in the portfolio that are having implementation difficulties. A further probe in assessing the reported problems on the projects rated moderately unsatisfactory or moderately satisfactory suggests that a delay in the physical implementation of activities is an important factor that affects the performance of the projects. This may be because of the participatory and multidisciplinary nature of these activities, which require a broad consensus between many stakeholders—an exercise that requires a lot of time.

An Overview of Selected Interventions from Governments and Other Organizations

This overview focuses on five programs that feature the diversity in approach and scope of household energy interventions. These programs are based in China, Guatemala, Tanzania, and Thailand, in addition to the GIZ Programme for Poverty-oriented Basic Energy Services covering countries in Africa, Asia, and Latin America. These programs were selected to demonstrate the diversity and scope of household energy access interventions and also with the

Table 3.7: Project implementation supervision report rating

Project	Year	Objective		Implementation Progress	
		Last	Current	Last	Current
Ethiopia: Energy Access Project	2002	S	n.a.	S	n.a.
Mali: Household Energy and Universal Access	2003	S	S	S	S
Madagascar: Environment Program	2004	U	MS	U	MS
Senegal: Electricity Services for Rural Area	2004	MS	n.a.	MS	n.a.
Benin: Energy Services Delivery	2004	S	S	MS	MS
Rwanda: Urgent Electricity Rehabilitation	2004	S	S	S	S
Chad: Community-Based Ecosystem Management	2005	MS	n.a.	MS	n.a.
Armenia: Urban Heating Project	2005	S	S	S	S
Armenia: Access to Gas & Heat Supply for Poor Urban Households (GPOBA)	2006	n.a.	n.a.	n.a.	n.a.
Benin: Forests and Adjacent Lands Management (GEF)	2006	MU	MS	MU	MS
NEPAL: Fourth Biogas Support Program (GPOBA)	2006	n.a.	S	n.a.	S
China: Changjiang and Pearl River Watershed Rehab.	2006	MS	MS	MU	MS
Belarus: Chernobyl Recovery	2006	S	S	S	S
Colombia: Natural Gas Distribution for Low Income Families in the Caribbean Coast Project (GPOBA)	2006	n.a.	n.a.	n.a.	n.a.
Burkina Faso: Energy Access	2008	U	U	U	MU
China: Eco Farming (with Biogas CDM Program)	2008	S	S	MS	MS
Benin: Increase Access to modern Energy	2009	MS	S	MU	MS
Rwanda: Sustainable Energy Development (GEF)	2009	S	S	S	S
Mozambique: APL for Energy Development and Access	2010	n.a.	S	n.a.	S
Senegal: Second Sustainable and Participatory Energy Management (PRODEGE II)	2010	n.a.	n.a.	n.a.	n.a.

Source: ICRs.
Note: HS = highly satisfactory, S = satisfactory, U = unsatisfactory, HL = highly likely, L = likely, UN = unlikely, HUN = highly unlikely, HU = highly unsatisfactory, H = high, SU = substantial, M = modest, N = negligible, n.a. = not available.

expectation that some of their successful features could be replicated in other settings with the required adaptive measures. A detailed description of key features, lessons learned, and the challenges of these programs is provided, respectively, for China (in Appendix B), Guatemala (in Appendix C), Tanzania (in Appendix D), Thailand (in Appendix E), and the GIZ Programme for Poverty-oriented Basic Energy Services (in Appendix F).

China: The National Improved Stoves Program

The world's largest publicly financed improved stoves initiative is found in China. In the early 1980s, the Chinese government funded the National Improved Stoves Program (NISP) to provide rural households with more efficient biomass stoves, and later improved coal stoves, for cooking and heating (Smith and others 1993; Sinton and others 2004). The program expanded to cover 860 counties representing 40 percent of all counties in the country. The government provided subsidies to support the dissemination of the stoves with average subsidies for improved biomass and coal stoves at, respectively, 26 percent and 10 percent.

In the mid-1990s, the Ministry of Health started a program to promote improved kitchens in poorer regions. The National Development and Reform Commission initiated the Yangtze River Valley Environmental Protection Project, which included provincial and county stove programs. By 1998, 185 million of China's 236 million rural households had improved biomass or coal stoves. However, only 22 percent of households in western provinces were covered by the program, compared with nearly 100 percent in eastern provinces and 70 percent in the central region (ESMAP 2007c).

A review in 2002 found that China's improved household stove programs had succeeded in providing better biomass stoves to most households in the targeted counties. Most biomass stoves introduced were found to have flues and other technical improvements. Most coal stoves, in contrast, could not be considered improved because they lacked flues and hence caused higher-than-standard PM levels of IAP.

Switching to coal from biomass in cooking may have undermined the benefits of improved biomass stoves, because coal stoves used in rural areas are usually inefficient and more polluting, despite the higher thermal efficiency that coal stoves can reach. A government program to reduce fluorine and arsenic poisoning from coal use, including an improved stoves program, has been carried out in those areas where disease from these toxins is endemic and serious. The program is expecting that 75–95 percent of households in high-disease areas will have improved stoves by 2010, compared with 20 percent in 2007 (ESMAP 2007c).

Most of the earlier household energy projects in China were directed primarily at energy efficiency and reduced use of biomass fuels rather than reducing IAP exposure. The World Bank initiated a project in China to test affordable household energy interventions designed to substantially reduce IAP. The interventions include improved stoves with better ventilation, health education, and behavioral changes. The anticipated outcomes are substantially improved fuel efficiency and lower IAP levels, as well as more advanced knowledge about location-specific factors in designing and implementing IAP interventions.

The project was implemented in four provinces that are characterized by widespread rural poverty: Gansu, Guizhou, Shaanxi, and Inner Mongolia. A total of 5,550 households were chosen from the 11 townships. Specific interventions included distribution and installation of improved stoves and ventilation systems, behavioral interventions (health education and practices to improve household energy use), small grants for capacity building, and awareness building to raise awareness about the health risks of IAP and methods to reduce them.

The project was implemented in four phases. The first phase (in Guizhou and Shaanxi) pilot-tested alternative stove design and monitored pollutants from the use of coal and biomass. The second phase (in selected counties, townships, and villages in all four provinces) collected baseline data from surveys on energy use, IAP, and health. The third phase focused on intervention design and implementation (both technological and behavioral). The fourth phase collected post-intervention data and evaluated the effects of intervention programs.

While fuel combustion pattern in cooking activities exhibited a large intensity fluctuation, the energy consumed in heating was more stable and less intense. The improved heating stoves with combustion chambers for ventilation were effective in reducing IAP and were not sensitive to user behaviors. Well-designed and constructed heating stove improvements can significantly contribute to IAP exposure reduction and control of

associated diseases. The other implication for scaling up intervention programs is that sustained and robust reduction in IAP exposure requires strategies to initiate and disseminate alternative fuels. For example, converting solid fuels to clean liquid and gaseous fuels offers great potential.

Even though more is required to account for a reduction of IAP, the Chinese experience with improved stoves is a remarkable example of what can be achieved with long-term planning supported by organized administrative and technical oversights involving many actors at the local and national levels. Its replicability may be difficult in other settings where institutional organization is weak.

Guatemala: A Multitude of Improved Stoves Programs

Guatemala has been a laboratory of improved cookstove programs since the 1970s supported by government agencies, international development organizations, NGOs, and private companies. The history of the programs have been divided into five periods: technology innovation, 1976–1980; technology diversification, 1980–86; a period of decline, 1986–1993; the development of commercial models, 1993–2001; and the commercial phase, 2001 to the present (Ahmed and others 2005; Alvarez, Palma, and Tay 2004).

Currently the largest commercial stove program by far is run by Helps International, a nonprofit that has been providing social services in Guatemala since 1982. Helps primarily sells the ONIL stove, an installed plancha-style indoor stove made of cement. The ONIL stoves program is attempting to overcome a number of major barriers that have hampered earlier stove programs. According to proprietary research Helps has presented, the ONIL stove reduces carbon monoxide emissions by more than 95 percent and fuel consumption by about two-thirds (Grinnell 2008). If these results are borne out over time in the field, the ONIL stoves have the potential to deliver the combination of major health and fuel-saving benefits that has been elusive in previous cookstove efforts. Helps is hoping to establish stringent quality controls and keep costs down through centralized local manufacturing. Third, Helps is creating local networks for distribution and retail, anchored by "rural micro-franchises in targeted areas" (Grinnell 2008), which it hopes will provide a steady supply of stoves at reasonable cost; provide sales, installation, and maintenance capacity; and create market demand in rural areas. Fourth, ONIL is focusing heavily on social marketing efforts and feedback from rural communities where the target consumers reside.

Key challenges faced by the Government of Guatemala in the promotion of improved stoves are (a) the coordination of different and multiple actors and stakeholders; (b) capacity building to oversee programs and control stove quality; and (c) the provision of adequate financing for businesses, consumers, and support structures.

Tanzania: NGOs, Community Organizations, and Small and Medium-Size Enterprises Involved in Improved Stoves Programs

A number of NGOs, community organizations, and small companies have carved out a niche in the household energy space, thereby becoming de facto leaders promoting clean household energy in Tanzania. Some of the most prominent include the Appropriate Rural Technology Institute (ARTI-TZ), East African Energy Technology Development Network (EAETDN) Tanzania, Tanzania Traditional Energy Development and Environment Organization (TaTEDO), and Women Development for Science and Technology Association (WODSTA). ARTI-TZ is a nonprofit organization founded in

India that develops and markets efficient household energy technologies. ARTI-TZ, in partnership with Joint Environmental Techniques Ltd. (JET), markets charcoal briquette makers, biogas systems, improved cookstoves, efficient cookers, and charcoal kilns (ARTI-TZ website). More than 700 Sarai cookers were sold in Tanzania in 2009 (ARTI-TZ 2010). The East African Energy Technology Development Network is a network of 27 local community organizations in Tanzania promoting the use of clean energy technologies (GVEP 2009). The Village Education Resource Center, an NGO, has worked at the grassroots level to build consumer demand and change cooking behaviors. Grameen Shakti has also been working with international donors on providing stoves with microfinance, a promising model.

TaTEDO is one of the leading civic organizations conducting research and implementing projects in community-level energy in Tanzania. TaTEDO designs "indoor smoke removal interventions" including "improved wood stoves with chimney, improved kitchen designs, as well as sensitizing households on the need for increased kitchen ventilation" (PCIA 2010). TaTEDO also promotes solar PV technologies for lighting in off-grid areas as clean energy options. TaTEDO has also conducted extensive public awareness work and consultations with the public and local government leaders, and trains entrepreneurs in the clean household energy space (PCIA 2010).

WODSTA works to develop capacity in villages to implement clean and efficient household energy solutions. WODSTA trains women "on how to build wonder baskets (insulated cooking baskets), energy efficient stoves, double burning stoves, and biogas tanks" and produces sawdust briquettes for cooking and heating (WODSTA website). WODSTA also provides information and training to communities to have access to alternative fuels such as used kerosene and bio fuels (PCIA 2010)

New donor-funded initiatives have promoted entrepreneurship in the community energy space. UNEP's Alternative Rural Energy Entrepreneurship Development program supported entrepreneurs in this space through the early 2000s. More recently, the Developing Energy Enterprise Project is a program funded by the European Union that involves four of GVEP International's partners: EAETDN; the Aga Khan Foundation's Coastal Rural Support Project, Kenya; IT Power East Africa; and Practical Action East Africa. The program aims to support 1,800 small-scale energy entrepreneurs, whose commercial plans include "improved cookstoves, briquette production, sustainable charcoal production, small hydro power generation schemes, and wind power generation" (GVEP 2009).

Probably the largest sustained donor-funded improved cookstove initiative is ProBEC. ProBEC is a program funded and implemented by GTZ, the German development agency. ProBEC partnered with three government agencies, including the Ministry of Energy and Minerals, the Zanzibar Department of Energy, and the Commission for Science and Technology in Tanzania, as well as with 13 companies and civic organizations. Information on the scope and results of these programs does not yet appear to have been widely disseminated.

The Tanzania improved stoves programs are challenged to organize themselves to come up with microcredit facilities to help consumers afford the stoves. Innovative financing mechanisms are also required to support the development of stove manufacturing, distribution, retail capabilities; and quality control. Moreover, more effective public awareness campaigns are needed to help people perceive the adverse health outcomes associated with the inefficient use of fuelwood.

Thailand: Promotion of LPG Supply and Use

With the discovery of natural gas in the gulf of Thailand in 1981 and the completion of the first gas separation plant in the country a few years later, the government took the opportunity to promote the use of LPG by households. As part of the effort to create a sustainable supply of LPG and market beyond Greater Bangkok Metropolitan Area, the government directly provided subsidies to the state-owned oil company to implement an LPG market development program. This program includes the construction of six large LPG storage and terminal facilities nationwide. One facility is located in Bangkok, serving the Greater Bangkok Metropolitan Area. The remaining five facilities are located throughout the country. In 1986, the government began providing subsidies to LPG producers and suppliers to maintain and operate storage facilities in the regions, once it realized that demand for LPG in the initial stage of LPG promotion was too low for private sector investment in storage and refilling facilities. The subsidy intervention was financed by the oil fund levy and was phased out in 1996.

The Oil Stabilization Fund has played an important role in keeping the price of LPG under control, as well as to allow the LPG market to grow. Through the Fund, cross-subsidy schemes have provided successful results, but have also created several negative consequences. Empirical evidence has shown that subsidies have helped consumers and suppliers develop the LPG market throughout the country. However, it has been very expensive. The Fund has been on the verge of bankruptcy several times, but has rebounded either when the international prices of petroleum have declined or the government has acted to increase fuel levies or reduce the subsidy, or both.

Interestingly, the LPG promotion program in Thailand did not aim specifically at helping poor households switch to LPG, but rather to help all households switch from firewood and charcoal to LPG. As a result, the program did not provide any subsidy to help low-income households overcome the commonly known upfront cost problem. The program did not provide any subsidy to households to purchase LPG stoves or assist in paying deposits for LPG cylinders. The subsidy concentrated on lowering the price of LPG, especially in the areas beyond Bangkok.

The GIZ Programme for Poverty-Oriented Basic Energy Services

The program formally started in December 2003 as a household energy program. It provides knowledge management, backstopping to projects in Africa, Asia, and Latin America and develops concepts for sustainable local market approaches.

The program has contributed to improving access to cleaner and energy-efficient cookstoves for households, small businesses, and social institutions. In Bangladesh, Benin, Bolivia, Burkina Faso, Ethiopia, Honduras, Kenya, Peru, Senegal, and Uganda more than 2.5 millions improved cookstoves adapted to local needs have been sold to households, small businesses, and social institutions within 5 years until the end of 2010.

Notes

1. In most of these countries, these reports produced by ESMAP are still the only detailed assessments on supply and demand of fuelwood that exist to date.
2. A *ger* is the traditional Mongolian tent used by herders; *ger* areas in Ulaanbaatar are sections of the city where people settled in their *gers,* and gradually constructed wooden or brick houses. The *ger* areas in Ulaanbaatar is generally regarded as informal settlements of the city.

CHAPTER 4

Lessons Learned

Reviewing the experience of household energy projects and their success factors revealed the following important lessons: (a) a holistic approach to household energy issues is necessary; (b) public awareness campaigns are prerequisites for successful interventions; (c) local participation is fundamental; (d) consumer fuel subsidies are not a good way of helping the poor; (e) both market-based and public support are relevant in the commercialization of improved stoves; (f) needs and preferences of stoves users should be given priority; (g) durability of improved stoves is important for their successful dissemination; and (h) with microfinance the poor can gradually afford an improved stove.

A Holistic Approach to Household Energy Issues Is Necessary

Successful programs are designed with a view of how household energy access can contribute to a global agenda of social transformation and poverty reduction. With this perspective, the programs are designed to cover (a) supply-side interventions ensuring that fuelwood supply is sustainable; (b) demand-side and interfuel substitution with the introduction and dissemination of improved stoves and alternative household fuels, such as kerosene and LPG; and (c) institutional capacity development to strengthen institutions and to create the regulatory incentives for sustainable production of fuelwood and for the facilitation of fuel switching. The Bank-financed project in Burkina Faso, Mali, Niger, and Senegal are good examples of projects that apply this comprehensive approach. For example, improved charcoal production goes hand in hand with improved management of fuelwood production. Similarly, the introduction of LPG stoves should be supported by an improvement in supply reliability and safety of use.

Public Awareness Campaigns Are Prerequisites for Successful Interventions

Successful programs have paid particular attention to public awareness, education, and information campaigns. Households need to be sensitized to the risks they incur by cooking with inefficient stoves and inferior fuels. Programs that have assumed that households would spontaneously adopt improved stoves or participate in forest management initiatives that were intended to improve sustainability of fuelwood supply have failed. Households need to perceive and to be convinced about the direct and indirect benefits associated with these interventions.

Local Participation Is Fundamental

Experience indicates that without active participation of communities, governments, NGOs, and the private sector, household energy projects are not successful and sustainable. For example, local communities need to be involved at an early stage to ensure that they own supply-side forest management initiatives. They should understand why they

should be the ones protecting forests in their communities. A clear rule of engagement should be discussed for communities to know their rights and responsibilities, the prerogatives of the national forest service, the role of NGOs and local associations. In this process, the role of NGOs is particularly important in creating and strengthening capacity of local communities. The Senegal Sustainable and Participatory Energy Management Project is a good example where these principles have been implemented satisfactorily. For improved stoves programs, providing training to local residents on stove maintenance not only promotes local ownership, but also reduces maintenance costs and provides employment opportunities.

Consumer Fuel or Stove Subsidies Are Not a Good Way of Helping the Poor

Experience has shown that across-the-board consumer fuel subsidies are not a good way of helping the poor. Affluent households tend to benefit the most from prevailing fuel subsidies, given that in most cases, energy consumption increases in parallel with income. Subsidies on stoves also often do more harm than good. Experiences from some improved stoves programs, such as the National Program for Improved Chulhas (NPIC) in India showed that the high subsidies on improved stoves resulted in poor maintenance by households. And households simply switched to traditional stoves when improved stoves were broken. For governments, these subsidies result in heavy fiscal deficits diverting direct public expenditures away from more productive and social sectors. Alternative options are usually designed in the form of social protection programs. The challenge in successfully implementing these options remains to effectively reach the poor.

Both Market-Based and Public Support Are Relevant in the Commercialization of Improved Stoves

A market based approach in the commercialization of improved stoves is often viewed as the best way to ensure sustainability of programs. This is based on the accumulated evidence that subsidized programs do not continue when the donor or public funding dries up. Evidence also indicates that a certain level of public funding is necessary at the initial program stages for their takeoff. This is particularly true in settings where the business environment is not well developed. Funding is usually needed to support research and development, marketing, quality control, and training related to stove design and maintenance, and monitoring and evaluation. Work on developing stove standards and certification protocols relies on the availability of public funding. Without this initial support, small enterprises find it difficult to participate in improved stoves programs, and scaling up is unrealistic. A challenge is to determine what level of public funding is adequate and the timing to transition to a fully market-based commercialization business model.

Needs and Preferences of Improved Stoves Users Should Be Given Priority

Successful programs pay attention to the needs and preferences of the users of improved stoves. Targeting households susceptible to buying and using these improved stoves, and working with them to supply a suitable stove responding to their needs is critical. At first, this target group is usually not the poorest of the poor. By first focusing on households that can afford to adopt an improved stove, the program can subsequently capitalize on the benefits of the demonstration effects produced. Successful improved

stoves programs are also designed bearing in mind the preferences of the users, such as the shape and size of the stoves. Experiences have shown that when these factors are ignored, stove dissemination rates are low and programs are not sustainable. In most cases, these are the needs and preferences of the women who are actually using these stoves on a daily basis. Other important factors to account for are family size, the type of food cooked, and the cooking techniques used. Women are generally willing to adopt an improved stove if they can afford it, if it does not alter the taste, and if does not change the quantity of food they are used to cooking with their traditional stoves. The China and the Kenya stove programs have paid detailed attention to the needs and preferences of the stove users. The involvement of local artisans in the manufacturing of improved stoves in Kenya made accounting for the needs and preferences an integral part of the program.

Durability of Improved Stoves Is Key for Their Successful Dissemination

For households that can afford an improved stove, the decision to adopt includes their perception of durability of the stoves. The durability depends on the quality of the materials used in the production of the stove, the resistance of the stove in the climatic context where it is used and how it used, the possibility or not of technical assistance in case of repairs, and the convenience of getting spare parts if they are needed. It is important to account for durability issues in the design and construction of improved stoves, in addition to technical considerations, such as heat transfer efficiency and combustion efficiency. One important lesson learned from the NPIC in India is that the poor quality of improved stoves that are broken in a few months can destroy households' trust and lead to a low adoption rate. Fuel efficiency and combustion efficiency are important, but durability is also important for households interested in improved stoves. Experience in China, Kenya, and Tanzania indicate that local production of improved stoves offers the advantage of adaptive improvements in quality and durability.

With Microfinance, the Poor Can Gradually Afford an Improved Stove

Availability of improved stoves and cleaner fuels is one thing, whereas their affordability is another. Programs that have included microfinance options that will allow households to afford the stoves tend to be more successful. The poor need to have a time horizon to gradually pay for the improved stoves. For example, in Bangladesh, Grameen Shakti has been working with international donors to provide cookstoves as part of its microfinance activities. This dimension is very important. Having an improved stove is not perceived as a first priority by the poor, but integrating the adoption of an improved stove in a broader program that creates opportunities to generate income is a different proposition.

CHAPTER 5

The Way Forward

The recent momentum aimed at providing clean cookstoves and fuels to the poor is a unique opportunity that should be firmly seized for action. The World Bank is well positioned with knowledge, expertise, and funding leverage potentials to play an important role in helping governments design effective and sustainable programs to provide poor households with clean energy solutions. However, this calls for strategic choices on what the Bank can do itself, and what it can do through partnerships.

What Can the World Bank Do?

The Bank can support the household energy access agenda by doing the following:

- **Help broaden the scope of energy sector reform to include household energy access issues.**
  The Bank is uniquely placed to help broaden the scope of energy sector reform to include household energy access issues. Through its energy dialogue with countries, the priorities are focused on power sector reform, regional power trade, and electricity access expansion. Household energy access issues should be raised to a level where they are viewed as commensurate with the importance they represent in the energy balance of countries and the potential impact they can have on poverty reduction. With a global trend of a rapid urbanization in developing countries in the coming years, issues dealing with the pricing of household fuels will have increasing fiscal and macroeconomic significance. Raising awareness at the highest levels of policy formulation and decision making is important for generating political commitment for action.
- **Produce strategic upstream analytical work to inform dialogue and to support technical assistance and lending operations.**
  Pertinent, timely, and convincing upstream analytical work on household energy access is necessary to strengthen the quality of the dialogue with the countries. Past authoritative analytical work done by the Bank and the scope of its lending operations are solid foundations on which to build. In many countries, the upstream studies done by the Bank in the 1980s and 1990s are still the only detailed available ones to date. There is clearly a need to update these studies.
- **Strategically mainstream household energy access interventions in lending operations.**
  Mainstreaming will require strategic internal institutional and funding arrangements capable of mobilizing and using the available high–quality, in-house multidisciplinary expertise. As it stands, the absence of mainstreaming household energy access interventions in lending operations may be a result of the following factors: (a) these projects require detailed upstream studies that are time–consuming, which can delay project preparation; (b) the interplay of many disciplines in dealing with household energy access issues makes it difficult for

teams to deal with them in the context of a limited project preparation budget; (c) the number of staff equipped to prepare household energy access projects is low, and this expertise is scattered throughout the institution; (d) transaction costs in preparing a household energy access project is high compared to the volume of lending it can leverage; and (e) the demand for interventions on household energy access from countries is low, probably caused by an absence of awareness of the issues at stake by the majority of the affected populations and by many governments.

What Can Be Done through Partnerships?

To address the multidimensional challenge of improving household energy access to the poor, both internal and external partnerships are needed.

- **Internal partnerships**
  As it stands, work on household energy access is being done by teams in the energy, health, forestry, gender, rural development, and climate change sectors. Some of these teams are with anchor departments, and others are within operational units across regions. Collaboration between these teams is often lacking. Formal partnerships between these teams will help leverage the Bank's expertise and funding. Opportunities of collaboration with IFC teams should also be explored to help countries address this important challenge.
- **External partnerships**
  There are many organizations that are well grounded with tremendous experience in household energy access interventions that the Bank could partnership with in innovative ways. The review of household energy access projects reveals that grassroots efforts are needed to raise awareness of populations to adopt alternative ways of harvesting their forests and using improved stoves and fuels. These behavioral changes require a lot of time and operational resources that are close to targeted communities. Civil society organizations, including NGOs and community-based associations, and the private sector are better equipped to deliver this work.

  Another way the Bank can leverage partnerships is to help facilitate the use of funding mechanisms on climate change with windows that will allow funding to be directed at technical assistance or operational work on household energy access related issues. There are a number of climate change mechanisms available, but they are either not well known by beneficiary countries or are difficult to access. In working with other multilateral, bilateral organizations and governments, the Bank can play a pivotal role in making this funding accessible.

  Going forward, it appears that partnerships have an important role in scaling up household energy access interventions. However, selectivity should be exercised in the choice of partners, and tools should be developed to measure performance and impact.

APPENDIX A

Lessons Learned from Using Carbon Markets for Household Energy Access Programs

The World Bank Carbon Finance Unit (CFU) uses financial resources contributed by governments and companies (called "participants") to purchase project-based greenhouse gas emission reductions in developing countries and countries with economies in transition. The emission reductions are purchased on behalf of the participants through a variety of carbon funds and facilities, predominantly within the framework of the Kyoto Protocol's Clean Development Mechanism (CDM) or Joint Implementation. The funds have demonstrated the role market instruments can play in supporting cost-effective emission reductions and channeling mitigation finance to developing countries. The capital in these funds and facilities has increased over time from US$160 million in 2000 to about US$2.5 billion now; part of this is purchasing credits from projects with a focus on household energy, including installation of solar home systems in Bangladesh and domestic biogas in China and Nepal. These projects provide valuable experience in the use of carbon markets from household energy programs.

Carbon Markets as a Revenue Source

Carbon finance can complement more traditional forms of development assistance for household energy programs. Cookstoves can generate emission reductions of 1–3 tons CO_2 equivalent per year at a price of around US$10 per ton. The proceeds from carbon can therefore in principle defray much if not all of the equipment purchase price and/or the costs of a cookstove program related to capacity building, training, awareness raising, and potential supply-side activities.

The emission reductions that are purchased in the carbon market are only created once the program is in place and households are using the technology. This leaves sponsors with the challenge of identifying upfront financing for the household energy program. One approach, used in the Nepal Biogas Program, is to use carbon revenues to replenish funds initiated by donors, improving the financial sustainability of the program and enabling it to extend its reach. Another approach, used by the World Bank's Carbon Finance Unit in other projects, is to identify lenders willing to lend against future flows of carbon revenues in combination as part of the broader financing scheme. However, further work is needed to develop innovative ways of front-loading carbon revenues, including by mixing with other sources of development assistance. This can include upfront loans made using the future expected carbon revenues as collateral, reimbursable grants, or guarantees backed by future carbon revenues.

Once a household energy program is operational and generating emission reductions, involving carbon finance creates new financing opportunities. In particular, as each generation of cookstoves generates carbon revenues that can be used to incentivize the next generation, a sustainable revolving funding mechanism that is independent from further donor funding can potentially be established.

Involving carbon finance also means systematic monitoring and verification of the achieved outcomes for emissions reductions. This can be combined with monitoring sustainable development benefits, since it is already the practice in the Community Development Carbon Fund of the World Bank's CFU. This strong performance orientation can increase the attractiveness of carbon-based programs for the required donor funding in the ramp-up phase.

Methodological Issues

In most of the existing carbon finance schemes, including the CDM, the technical aspects of the project and the quantification of the emission reductions are based on standard approaches and methodologies.

At the moment, in the CDM several methodologies are available that could apply to technologies that supply household-level cooking and heating solutions. These methodologies cover the following:

- Activities to displace the use of nonrenewable biomass by introducing renewable energy technologies. Examples of these technologies include, but are not limited to, biogas stoves, solar cookers, and passive solar homes.
- Activities to improve the thermal efficiency appliances using nonrenewable biomass. Examples of these technologies and measures include the introduction of high–efficiency, biomass-fired cookstoves, or ovens or dryers, and/or the improvement of energy efficiency of existing biomass-fired cookstoves, or ovens or dryers.
- Activities to generate renewable thermal energy using renewable biomass or biogas for use that is replacing fossil fuel consumption in residential, commercial, and institutional applications (for example, for supply to households, small farms or for use in built environment of institutions such as schools). Examples of these technologies include but are not limited to biogas cookstoves, biomass briquette cookstoves, small-scale baking and drying systems, water heating, or space heating systems.
- Activities that support the recovery and destruction of methane from manure and wastes from agricultural activities that normally would be decaying anaerobically, hence emitting methane to the atmosphere (for example, where the farmer would have used an open lagoon for storing manure).

Besides the CDM, there is also the voluntary market that offers its own approaches that are sometimes simpler than the ones used in the CDM, or that allow more flexibility. However, the overall volume of the voluntary market is very limited in size and can currently provide a testing ground for pilots rather than a basis for large-scale programs.

The application of CDM and other methodologies creates new challenges. For example, CDM projects that aim to replace nonrenewable biomass are expected by the methodology to estimate the average annual consumption of woody biomass per appliance and, for this consumed biomass, determine the share of renewable and nonrenewable

woody biomass. These shares should be determined using nationally approved methods (such as surveys or government data, if available). However, in many developing countries, adequate data on this are not available or are open to different interpretations. Furthermore, the share of nonrenewable biomass is supposed to be substantiated by using indicators, such as "trend showing increase in time spent or distance travelled by users (or fuel-wood suppliers) for gathering fuel wood." This type of data is usually not available and will need to be collected specifically for the purpose of obtaining carbon finance.

Developing a project as a carbon project also introduces new demands for monitoring. For example, CDM projects that aim to replace nonrenewable biomass need to monitor their performance through an annual check of all appliances or a representative sample thereof to ensure that they are still operating or are replaced by an equivalent-in-service appliance. Furthermore, monitoring shall include data on the amount of woody biomass saved under the project activity that is used by nonproject households and users (who had previously used renewable energy sources), and it should confirm the displacement or substitution of the nonrenewable woody biomass at each location. Projects often have difficulties meeting such requirements, since they are new for the implementing entities that often lack sufficient capacity and resources.

Future Outlook for Carbon Finance for Domestic Energy Programs

With the first commitment period of the Kyoto Protocol coming to an end in 2012, the focus of the carbon markets is switching to developing countries. This is largely driven by new rules for the European Union Emission Trading Scheme (EU ETS), which is one of the most important markets for CDM credits. In the third phase of the EU ETS, which runs from 2013 to 2020, credits from projects that are registered post-2012 are eligible only if the projects take place in a developing country. Together with the LULUCF sectors, household energy is one of the main GHG mitigation opportunities in these countries.

APPENDIX B

China: Household Energy Programs

China (population: 1.33 billion) is the most populous nation in the world with about 56 percent (or 745 million) rural population (World Bank 2010b). Since the late 1970s, China's economy has changed from a centrally planned system that was largely closed to international trade to a more market-oriented economy that has a rapidly growing private sector and is a major player in the global economy. Measured in 2009 on a purchasing power parity basis, China was the second largest economy (GDP: US$4.985 trillion in 2009 U.S. dollars) in the world after the United States, although the country is still lower-middle-income in per capita terms (GDP per capita: US$3,650 in 2009 U.S. dollars). Despite the impressive economic growth during the past two decades, more than 100 million rural Chinese still live in acute poverty, and the disparity between urban and rural areas is significant (ESMAP 2007c).

National Household Energy Use

Virtually all of China's rural households, representing about 770 million of the country's population (UNdata 2008), rely on biomass and coal to meet their daily cooking and heating needs. During the six-year period from 1998 to 2004, rural energy consumption increased sharply, 90 percent of which came from the increase in solid fuel (straw, fuelwood, and coal). Absolute and per capita increases by 2004 were 31 percent and 28 percent, respectively. In 2004, biomass accounted for 55 percent of the rural energy supply, while coal contributed 34 percent. National spending on household energy has increased dramatically since the 1990s. The supply-and-demand pressures resulted in a significant rise in the cost of fuel for heating and cooking. The rural poor, who strongly rely on biomass and low-grade coal, faced immense difficulty absorbing soaring costs for household energy (ESMAP 2007c).

Rural household energy consumption in China varies with different regions. The Northeast relies heavily on biomass as 83 percent of its energy sources. Provinces with extensive coal deposits consume mainly coal, whereas households close to urban areas depend more on electricity. The low price of coal and restrictions on wood-gathering encourage households to switch from biomass to coal. Although 98 percent of the rural households have access to electricity, electricity contributes only 6 percent, primarily in the form of lighting, of the total energy consumption, and all the households use a combination of biomass, coal, and electricity (ESMAP 2007c).

Rural China is in the early stage of energy transition. The pace of the transition process, that is, substituting modern fuels for biomass and coal, is affected in order of importance by location, geographic condition, income, occupation, education, household

size, expenditure, and sex (Jiang and O'Neill 2004). Concurrent with this transition, China is experiencing rapid growth in energy consumption. Although per capita net income in the past two decades increased fourfold and hence greater reliance on commercial energy is expected, the extensive use of biomass continues. With no clear policy interventions in sight, IAP caused by continued burning of solid fuels for cooking and heating remains a serious health problem in China.

Health Impacts of Household Fuel Use

The UNDP and WHO (2009) estimate that every year 9,100 Chinese children under the age of 5 die of pneumonia from exposure to smoke from solid fuels. The numbers of adults beyond age 30 who die of chronic obstructive pulmonary disorders and lung cancer resulting from solid fuel use are 505,900 and 33,900, respectively. Likewise, for every 1,000 children under 5, pneumonia caused by solid fuel use causes 4 disability-adjusted life years (DALYs); all respiratory diseases from solid fuels cause 3 DALYs for every 1,000 Chinese of all ages (UNDP and WHO 2009).

Rural households using solid fuels (firewood, crop residues, and coal) are chronically exposed to levels of pollution far higher than those determined by the Chinese government to be harmful to human health (Sinton and others 2004). IAP was the fourth leading health risk factor contributing to mortality in China, causing more than 500,000 deaths (WHO 2002). Indoor smoke from solid fuels was the fifth most important risk factor in terms of DALYs, accounting for 2.5 percent of the total lost healthy life years (ESMAP 2007c). In addition, emission of SO_2 from the extensive use of coal imposes adverse health impacts on the rural population. In those regions where coal is contaminated by fluorine or arsenic, the health risk from coal use is especially high.

Household Energy Programs

Many interventions on household energy access have been implemented in China. Some of them were successful and others had mix results.

The National Improved Stoves Program

A publicly financed program of the Ministry of Agriculture initiated in the early 1980s, the Chinese NISP, aimed to provide rural households with more efficient biomass stoves first and then with improved coal stoves for cooking and heating (Smith and others 1993; Sinton and others 2004). The primary purpose of this program was the development of fuelwood forests as part of the national reforestation program and rural energy development beginning with the Sixth Five-Year Plan.

The NISP extended to 860 counties, or 40 percent of all counties in China. The average subsidies for improved biomass and coal stoves were 26 percent and 10 percent, respectively. As claimed by the Ministry of Agriculture, by 1998, 185 million of China's 236 million rural households had improved biomass or coal stoves. However, only 22 percent of households in western provinces were covered by the program, compared with nearly 100 percent in eastern provinces and 70 percent in the central region (ESMAP 2007c).

In the mid-1990s, the Ministry of Health started a program to promote improved kitchens in poorer regions. The National Development and Reform Commission initiated the Yangtze River Valley Environmental Protection Project that included provincial and county stove programs. A review in 2002 found that China's improved household stove

programs had succeeded in providing better biomass stoves to most households in the targeted counties. Most biomass stoves introduced were found to have flues and other technical improvements. Most coal stoves, in contrast, could not be considered improved because they lacked flues and hence caused higher-than-standard PM levels of indoor air.

Coal Poisoning Reduction Program

Switching to coal from biomass in cooking may have undermined the benefits of improved biomass stoves, because coal stoves used in rural areas are usually inefficient and more polluting, despite the higher thermal efficiency that coal stoves can reach. A government program to reduce fluorine and arsenic poisoning from coal use, including an improved stoves program, has been carried out in those areas where disease from these toxins is endemic and serious. The program is expecting that 75–95 percent of households in high-disease areas will have improved stoves by 2010, compared to 20 percent in 2007 (ESMAP 2007c).

Biogas Program

Biogas was first introduced in China in 1930s and was widely disseminated in the 1970s. Despite strong motivation to reduce fuelwood use, earlier biogas programs since the 1970s yielded mixed results because of the lack of consideration of local conditions and inadequate staff in operation and maintenance. Recent programs have been more successful, except that monitoring the effects has not been thorough or specific.

Supported by the Ministry of Agriculture, biogas technology has matured in China. Good standard designs have been disseminated, while research and development have been pushed forward. Improved technology results in advanced effectiveness, reduced costs, and extended operating period. By 2005, more than 750 large and medium-sized biogas projects had been completed in China (Zhao 2005).

World Bank Project in Household Energy Intervention

Most of the earlier household energy projects in China were directed primarily at energy efficiency and reduced use of biomass fuels rather than reducing IAP exposure. The World Bank initiated a project in China to test affordable household energy interventions designed to substantially reduce IAP. The interventions include improving stoves with better ventilation, and introducing health education and behavioral changes. The anticipated outcomes are substantially improved fuel efficiency and lower IAP levels, as well as more advanced knowledge about location-specific factors in designing and implementing IAP interventions.

The project was implemented in four provinces that are characterized by widespread rural poverty: Gansu, Guizhou, Shaanxi, and Inner Mongolia. A total of 5,550 households were chosen from the 11 townships. Specific interventions included distribution and installation of improved stoves and ventilation systems, behavioral interventions (health education and practices to improve household energy use), small grants for capacity building, awareness building to raise awareness about the health risks of IAP, and methods to reduce them.

The project was implemented in four phases. The first phase (in Guizhou and Shaanxi) pilot-tested alternative stove designs and monitored pollutants from using coal and biomass. The second phase (in selected counties, townships, and villages in all four provinces) collected baseline data from surveys on energy use, IAP, and health. The third

phase focused on intervention design and implementation (both technological and behavioral). The fourth phase collected post-intervention data and evaluated the effects of intervention programs.

The improved heating stoves with a combustion chamber of ventilation were effective in reducing IAP and were not sensitive to user behaviors. Well-designed and -constructed heating stove improvements can significantly contribute to IAP exposure reduction and control of associated diseases. The other implication for scaling up intervention programs is that sustained and robust reduction in IAP exposure requires strategies to initiate and disseminate alternative fuels. For example, converting solid fuels to clean liquid and gaseous fuels offers great potential.

Lessons Learned

- IAP caused by incomplete burning of biomass and coal remains a critical factor threatening the health of rural residents, even after the extensive distribution of improved stoves.
- Policy interventions need to facilitate R&D by the private sector in new technologies promoting cleaner, more efficient ways of using biomass fuels.
- Improved coal stoves with flues are critical in reducing IAP poisoning and indoor PM.
- Improved stoves must be subject to rigorous scientifically based design criteria.
- In the phase of intervention design and implementation, the practices of low-income rural families need to be customized based on living environment and conditions. Low-cost, low-maintenance technologies are essential for affordability and sustainability.
- To succeed in reducing IAP from cooking, cookstove interventions require greater modification of user behaviors.
- Interventions tailored to households' needs must take into consideration economic constraints faced by low-income rural households.
- Provincial- and community-level energy infrastructure is important for IAP intervention programs.
- Health education and behavioral intervention may have long-term benefits by facilitating the uptake of other interventions.
- IAP reduction must be mainstreamed into the policy-making process, and interventions should be packaged to reduce multiple risk factors.
- Subsidies supporting the introduction of new energy technologies are needed to stimulate progression and help offset initial production and distribution costs before economies of scale become operational.
- The public sector needs to support the development of human capital related to household energy use.
- Standards of fuel efficiency and emissions must be carefully designed.

Challenges

- Limited knowledge about the design and dissemination of appropriate interventions for IAP caused by household solid fuel use.
- Lack of systematic studies on household energy interventions that hamper the ability to draw lessons from international experience. For example, the motivation

for the adoption of such interventions, sustainability and long-term effects, and broader environmental and socioeconomic implications have not been sufficiently researched and understood.

- Complex interactions among technological, behavioral, economic, and infrastructure factors that determine the success of the interventions.
- Lack of funding, technology, and information exchange, and microcredit to foster local design, implementation, and commercialization.
- The small effect on people's behaviors, in spite of their knowledge and concern about the long-term health impacts of heating and cooking. Behavioral intervention design needs to be improved.
- The requirement for household fuel–associated IAP studies and interventions to include interdisciplinary expertise and multisectoral cooperation. A comprehensive approach to household energy use and IAP exposure is needed.
- The unresponsiveness of market mechanisms the IAP problem. Further research is needed to facilitate private sector responses.

APPENDIX C

Guatemala: Improved Stoves Programs

Guatemala is the most populous of the Central American countries (population: 14 million) with a GDP per capita roughly half that of the average for Latin America and the Caribbean, approximately US$2,661 per capita (in 2009 U.S. dollars, World Bank 2010b). Significant cultural, linguistic, and geoclimatic diversity exists throughout the country, which has distinct coastal, highland, and tropical forest regions. The country remains heavily agricultural, with the agricultural sector accounting for nearly 12 percent of GDP and one third of the labor force. Key agricultural exports include coffee, sugar, and bananas (World Bank 2010b). Guatemala is characterized by social stratification along urban-rural, rich-poor, and European-mestizo-indigenous ethnic lines. The high poverty rate and low levels of human development among indigenous groups are borne out across a range of health, economic, and energy indicators.

National Household Energy Use

Electricity access and modern energy consumption in Guatemala are quite low, even by regional standards. In 2008, annual electricity consumption per capita was a low 558 kWh, trailing most Central American neighbors, including Honduras (692 kWh) and El Salvador (939 kWh) (World Bank 2010b). A particularly large divide exists in energy access between urban and rural areas. According to WHO country household survey data (last updated in 2003), 84.8 percent of rural dwellers use solid biomass fuel, primarily wood, as their primary household fuel, with only 14.4 percent using LPG and virtually none using electricity for cooking (UNDP and WHO 2009). In urban areas, by contrast, 69.1 percent of households use clean fuels (mainly LPG), while only 30.1 percent rely primarily on wood (UNDP and WHO 2009). These numbers are corroborated by very similar urban and rural wood and clean fuel use data gathered in the 1999 DHS and 2000 LSMS household surveys (Ahmed and others 2005). Charcoal, coal, and other fuels are used relatively little, although corn cobs and other biomass are often cocombusted with wood. Energy expenditures comprise about 5–7 percent of household budgets nationwide, although the figure rises significantly in very poor areas (ESMAP 2003b).

Guatemala vividly represents the primacy of the fuel stack model—the concurrent use of multiple fuels in the same household—over that of the fuel ladder. According to ESMAP (2003b), multiple fuel usage is widespread—in urban areas 48 percent and in rural areas 27 percent cook with more than one fuel in a given month. Urban cooking fuel combinations typically involve LPG, wood, and charcoal (in that order). Even the top urban quintile has widespread wood usage, at 23 percent. Rural fuel combina-

tions usually include firewood, sometimes LPG, and occasionally a small amount of kerosene.

Heltberg (2005) found that the most common household fuel use patterns were, in order of descending frequency, "wood only, wood and LPG, LPG only, charcoal and LPG, kerosene and wood, and charcoal, wood, and LPG" (based on a 2000 ENCOVI household survey).

There are significant cultural and economic barriers to fuel switching. LPG costs, which tend to follow global oil prices, have roughly doubled from the late 1990s to 2009 from roughly US$3 per household per month to US$6 (World Bank 2010a). In Guatemala, LPG retail prices were already high in 2002, or about 65 quetzales (US$8) per household per month (ESMAP 2003b). The steep rise in global oil prices since the early 2000s suggests that fuel prices have likely risen more, further challenging the economic feasibility of fuel switching. The desire to cook traditional wood-baked tortillas appears important for wood usage, explaining continued use of wood as fuel in urban areas, even after adoption of LPG and when wood is quite expensive (ESMAP 2003b).

Health Impacts of Household Fuel Use

The health impacts of fuel use patterns are significant. The UNDP and WHO (2009) estimate that every year 1,200 Guatemalan children under 5 die of pneumonia and 300 adults die prematurely of chronic obstructive pulmonary disorders resulting from solid fuel use. Likewise, for every 1,000 children under 5, pneumonia from using solid fuel causes 21 DALYs, and all respiratory diseases from solid fuels cause 4 DALYs for every 1,000 Guatemalans of all ages (UNDP and WHO 2009).

The pattern of cookstove use in Guatemala is also a major determinant of exposure to IAP. Many wood-burning cookstoves do not have chimneys, and are indoors or in open areas where exposure to smoke is significant.

Among firewood-using households, one-third in rural areas and one-fourth in urban areas cook outside the main home, mostly in a separate building. This share is much larger as compared to households not using firewood. Cooking outside the main home limits the overall household smoke exposure, although the cook and any infants with her remain exposed. A substantial proportion (24.4 percent) of the country's population, however, resides in households that cook with firewood inside their house in a room that is not a partitioned kitchen. Exposure levels are likely to exceed safe levels for this group, of which only 18 percent live in a house with a chimney (ESMAP 2003b).

Consequently, there is broad potential to disseminate improved cookstoves and alternative fuels that reduce exposure to smoke. A study focusing on user perception of improved stoves working with young Mayan women in the Guatemalan highlands found conclusively that "[w]omen's perception of their health [and that of their children] was improved" (Díaz and others 2008). In particular, "smoke reduction was valued . . . mainly with alleviation of non-respiratory symptoms like eye discomfort and headache" (Díaz and others 2008). However, Ahmed and others (2005) found that among the perceived benefits of improved stoves, improved health ranks well below reduced expenditures on fuelwood and comals (special clay pans for cooking tortillas) and a cleaner house. Thus, at present there is evidence that the health benefits of improved cookstoves are recognized, but underappreciated.

Household Energy Programs

Guatemala does not have a history of government energy subsidies to encourage the switch from solid biomass to clean-burning fossil fuels, such as LPG and kerosene (Heltberg 2005). Because LPG prices remain far beyond the means of most rural dwellers, a fuel subsidy program would be regressive and would not be likely to reduce fuelwood use significantly (Heltberg 2005). Charcoal use is relatively limited, and thus does not figure significantly into government policy. Consequently, most government, civil society, and international interventions have focused on improved cookstoves.

Improved Cookstoves

Guatemala makes for an interesting case study because it has been a laboratory of improved cookstoves since the 1970s. Government agencies, international development organizations, NGOs, and private companies have all made forays into the improved cookstove space. A number of informed observers have divided the history of cookstove programs in Guatemala into five periods: technology innovation, 1976–1980; technology diversification, 1980–86; a period of decline, 1986–1993; the development of commercial models, 1993–2001; and the commercial phase, 2001 to the present (Ahmed and others 2005; Alvarez, Palma, and Tay 2004). It is also noteworthy that Guatemala's improved stoves are fairly unique in the developing world in that they are almost all large, permanent structures that are very expensive, costing US$50–150 compared to US$5–10 in Africa and Asia (Ahmed and others 2005). Small, portable, and less expensive improved stoves have been introduced very little, although this may be changing (cf. Biolite stove, Biolite 2010).

Early Efforts of the 1970s

In the early 1970s, the ICADA Choqui Experimental Station in the Guatemalan highlands began developing improved stoves constructed with local materials and labor as part of a number of interventions to alleviate rural poverty. Following a large earthquake in 1976, the Choqui Station began disseminating the Lorena stove, similar to a plancha stove (with a mostly enclosed firebox, two or three burners, and a chimney) made of clay and sand. Each stove was constructed on-site to local specifications. There were no standard designs or materials used, and quality varied widely (Ahmed and others 2005). Although at first the users of the installed stoves purchased the materials for the stoves' construction, over time as international donors provided more support, many stoves began to be supplied for free. The high level of subsidies in the late 1970s threatened stove quality and user feedback to cookstove providers, because cookstove users often no longer contributed materially to the stoves they received, and thus did not express market preferences (Alvarez, Palma, and Tay 2004).

National Coordination in the Early 1980s

The period from 1980 to 1986 was typified by a diversification of stove technologies, although with continued reliance on free, "gifted" stoves that undercut market development. Following a large national conference on cookstoves in February 1980, new cookstove technologies began to appear, and the government began to get involved more actively in the field. In 1982 the Ministry of Energy and Mines engaged an entity called the National Group for Improved Stoves to coordinate more than two dozen

institutions active in cookstoves (Ahmed and others 2005). This effort commenced a period of strong government-NGO collaboration: up to 27 formally registered groups "exchanged ideas, logistics, information, and technical resources" while working independently (Alvarez, Palma, and Tay 2004). However, after a change in administration at the national government level, the National Group began to dissolve (Alvarez, Palma, and Tay 2004).

Late 1980s: Failure of the Highly Subsidized Stove Model

From 1986 to 1993, a number of entities distributed improved cookstoves without any significant coordination among them. The Ministry of Energy and Environment continued its support for a technical stove prototype developed by the Appropriate Technology Experimental Center (CETA), which enjoyed popularity, but did not achieve preeminence (Alvarez, Palma, and Tay 2004). The performance of many Lorena stoves declined at higher rates as they aged, and users began to sour on their value (Ahmed and others 2005). A national cookstove survey in 1985 determined that more than 90 percent of improved stoves were some version of the Lorena stove. The survey found that cookstove construction was often poor partly because of high subsidies, and that the ability to pay for stoves was low, which hurt efforts at commercialization (Alvarez, Palma, and Tay 2004). It was found that, in the absence of a coordinated national effort to commercialize stoves, achieving consistent quality was not realistic (Ahmed and others 2005).

Development of Commercialization, 1993–2001

During this period, plancha stoves (also known as plancha-armada made of bricks, with enclosed fireboxes and high-quality metal griddles with multiple burners) became the predominant model, as stoves with metal parts were introduced in trials and gradually improved in quality. The Fondo de Inversión Social (FIS), a decentralized government program, installed more than 90,000 plancha stoves in the late 1990s and early 2000s, which were met with user acclaim (Ahmed and others 2005). This period culminated in August 2001 when local NGO Fundación Solar organized the Mesoamerican Exchange of Efficient Cooking Techniques and Improved Stoves, convened in Antigua, Guatemala. At this exposition, improved plancha stoves were showcased, as were prefabricated designs that facilitated transport of stove materials and installation (Alvarez, Palma, and Tay 2004).

Era of Commercialization, 2001 to the Present

With the end of the civil war and the introduction of newer, high-quality stoves, the government has promoted a number of new cookstove initiatives with significant international development assistance. Several Guatemalan national social funds have recently contributed significantly to the commercialization of improved cookstoves. These funds include the Social Investment Fund (FIS), National Fund for Peace (FONAPAZ), and the Indigenous Development Fund of Guatemala (FODIGUA) (Ahmed and others 2005). As responsibility for government programs was transferred from the Ministry of Energy and Mines to the social funds, oversight improved, and political will grew (Ahmed and others 2005). Additionally, thanks in part to efforts of the Global Village Energy Program (GVEP) and Fundación Solar, the Guatemalan government has made progress creating an enabling environment for sustainable energy through national policy development (GVEP International 2007).

It should be noted, however, that many independent charities and NGOs continue to operate in Guatemala, many of them disseminating and assembling plancha stoves in impoverished areas at little or no cost to the recipients. These programs—including Engineers without Borders, Intervida, Masons on a Mission, the San Lucas Mission, Trees for Life International, and Trees, Water & People(see websites in bibliography)—employ a mix of volunteer and professional labor. The donation of a stove generally costs about US$150 (including components, labor, and transport costs), a rough estimate of all-in unit costs. Some nonprofit cookstove programs charge a small fee of US$7 or US$14 to the recipients (Trees for Life International), while other provide the stoves for free (San Lucas Mission). Most improved stoves programs have subsidies of 80 percent or higher of the stove cost, although a few have smaller subsidies as low as 55 percent, such as in the Tezulutlan project in Baja Verapaz (Ahmed and others 2005). The stoves are usually provided to highly impoverished communities, often in the Mayan highlands, and appear to use fairly high-quality materials and labor, building plancha stoves that appear to be major improvements over early locally built stoves of the 1970s and 1980s. Nevertheless, these programs tend not to have much quality control or maintenance capacity, and it is unclear how these independent programs will affect national efforts at stove commercialization. Earlier efforts at highly subsidized cookstove dissemination created large market distortions (Ahmed and others 2005).

Currently the largest commercial stove program by far is run by Helps International, a nonprofit that has been providing social services in Guatemala since 1982. Helps primarily sells the ONIL stove, an installed plancha-style indoor stove made of cement. ONIL is run as a commercial venture. The ONIL stove usually retails for 650 quetzales, or about US$80. Helps International has established manufacturing plants in Guatemala (at two different sites, Rio Bravo and Chiquimula) and in Mexico, and is currently taking its cookstove programs to full-scale production. From 2001 to 2004 Helps slowly began rolling out sales of the ONIL. Having sold more than 10,000 stoves in each of the years 2005–08, Helps has been projecting 45,000 stove sales in 2009 and 90,000 in 2010 (PCIA 2009).

The ONIL stoves program is attempting to overcome a number of major barriers that have hampered earlier stove programs. First, they claim that the stove has dramatic benefits from reduced IAP and dramatic reduction of fuelwood use. According to proprietary research Helps has presented, the ONIL stove reduces carbon monoxide emissions by more than 95 percent and fuel consumption by about two-thirds (Grinnell 2008). If these results are borne out over time in the field, the ONIL stoves have the potential to deliver the combination of major health and fuel-saving benefits that has been elusive in previous cookstove efforts. (These results are by no means guaranteed. For example, according to recent field research, the much-vaunted plancha cookstoves have not been shown to have a demonstrable fuel-saving effect over open fires (Granderson and others 2009).)

Second, Helps is hoping to establish stringent quality controls and keep costs down through centralized local manufacturing. Third, Helps is creating local networks for distribution and retail, anchored by "rural microfranchises in targeted areas" (Grinnell 2008), which it hopes will provide a steady supply of stoves at reasonable cost; provide sales, installation; and maintenance capacity; and create market demand in rural areas. Fourth, ONIL is focusing heavily on social marketing efforts and feedback from rural communities where the target consumers reside. Strong two-way communications

between manufacturers and consumers has been a major barrier to cookstove sustainability in the past, since cookstoves have often not met the needs and preferences of users. ONIL conducts public demonstrations of the technology, advertises the fuel savings and price on billboards, and widely disseminates information on how to install the stoves (Grinnell 2008).

Finally, ONIL has committed to a fully commercial business model for the stoves. Unlike many charities that install stoves in rural homes for free, Helps seeks to make its stove program sustainable and subsidy-free. To do this, Helps studies the purchasing behaviors of rural communities to meet consumer demand, and invests in marketing and advertising to build demand. It has also created a microcredit subsidiary, CrediUNIL. Microcredit allows deferred payments that spread the up-front purchase costs over time, since high purchase costs and lack of available credit are persistent suppressors of market demand (Grinnell 2008).

Lessons Learned

- LPG is not an affordable fuel for the rural poor. Improved cookstoves are a more realistic approach for communities with low buying power.
- LPG subsidies are not a viable option to promote fuel switching. LPG users are (a) concentrated in urban areas and (b) predominantly in the higher quintiles of society.
- High subsidies distort markets, preventing consumer feedback from reaching manufacturers and retailers, and thwarting efforts at sustainable commercialization.
- A focus on community participation and local capacity building, particularly among women, improves cookstove program outcomes and creates buy-in of beneficiaries. Most cookstove programs to date have lacked "systematic community feedback, monitoring and evaluation" (Ahmed and others 2005).
- Smaller subsidies can be devised to keep stoves affordable while promoting commercialization. However, larger subsidies may be necessary in the poorest areas, particularly because of social preferences for permanent, expensive stoves.
- NGOs and communities play important roles in promoting stoves at the local level, including building capacity, facilitating distribution and installation, and contributing to subsidies at the household level.
- Cookstove programs in almost all cases promote only one kind of stove, leading to a de facto monopoly at the local level. This approach prevents learning and improvement through competition and denies consumers choice.
- A lack of technical assistance has prevented the customization of stoves to local needs and the adoption of more efficient and functional stoves.
- "Use of trials, quality certification, consultations with stove users, and the training of stove builders" can help ensure stove quality and durability (Ahmed and others 2005).
- A national program may be able to balance subsidies with market mechanisms. One proposal is to provide a fixed, per-household cookstove subsidy or voucher that can be applied to the consumer's cookstove of choice, thereby spurring a market for a diversity of cookstoves with different retail prices and features.
- The market for high-quality, small improved cookstoves with low retail prices has not yet been well explored.

Challenges

- Extreme poverty and the remoteness of many areas of Guatemala hinder the development of markets and keep the buying power for stoves or alternative household fuels very low. The predominance of large, expensive plancha and Lorena stoves throughout the country has heightened the challenge of providing desirable stoves to the poor in a sustainable and affordable manner.
- LPG costs are beyond the means of most households in Guatemala. Some reductions in cost may be achievable through supply chain improvements and consumer education, although these efforts will likely be limited to urban areas.
- To encourage consumers to appreciate the full value of improved cookstoves and clean fuels—particularly from a health perspective—public information campaigns will be necessary. Such campaigns may also be necessary to market cookstoves; to raise awareness of their performance, reliability, durability, and potential for fuel savings; and to promote cultural acceptance.
- Lack of a national cookstoves program.
- The government must improve its capacity to coordinate actors and stakeholders. Unlike China and India, Guatemala has never initiated a lasting, centralized national cookstoves program that might direct government resources and administrative capacity to disseminating cookstoves and creating an enabling environment for cookstove markets to take root (without high subsidies).

APPENDIX D

Tanzania: Household Energy Programs

Tanzania is a large East African nation of 43.7 million people. GDP per capita is approximately US$509 (World Bank 2010b). As of 2001, about 36 percent of the population lived below the poverty line, which is relatively low for East African and low-income countries (World Bank 2010b). The economy relies heavily on agriculture, which accounts for 45 percent of GDP (as of 2006, World Bank 2010b). Topography and climate, however, limit cultivated crops to about 4 percent of the land area (World Bank 2010b. Since reforms in the early 2000s, GDP has increased steadily at about 5 percent per year. Governance and human development indicators, such as life expectancy, literacy, early childhood mortality, and school enrollment have improved markedly in recent years (World Bank 2010b). The population in 2007 was 33 percent urban, up from 21 percent in 2001 (World Bank 2009).

National Household Energy Use

Only 11 percent of Tanzania's population has access to electricity (UNDP and WHO 2009). Electricity access is virtually absent in rural areas, with connectivity at only 2 percent of households (UNDP and WHO 2009Because of low population densities, low purchasing power of electricity consumers, limited grid extension, and low generation capacity, off-grid electrification strategies are necessary to bring electricity access to rural populations.

Only 3 percent of Tanzania's population has access to clean household fuels, primarily kerosene (2.3 percent) with very low penetration of LPG and electricity (UNDP and WHO 2009). As late as 2008, more than 95 percent of households relied primarily on fuelwood (77.6 percent) or charcoal (19 percent) for cooking (UNDP and WHO 2009). Among that vast majority relying on solid fuels, only 1 percent of households was using improved cookstoves (UNDP and WHO 2009).

Biomass fuels are predominant in Tanzania, accounting for about 90 percent of the total primary energy supply (Eisentraut 2010; TaTEDO 2010). The primary biomass fuels are fuelwood, charcoal, and bio-residues. About 40.4 million cubic meters (95 percent) out of a total estimated 42 million cubic meters of wood consumption in Tanzania in 1999 were consumed as fuelwood, (TaTEDO 2010; World Bank 2009). Out of this, about 65 percent was consumed in rural areas as fuelwood, while 35 percent was consumed in the urban areas mainly as charcoal (TaTEDO 2010).

There is a sharp divide in fuel-use patterns between rural and urban areas. Charcoal use as a primary cooking fuel is low in rural areas—about 5 percent—compared to reliance at 59.6 percent and is growing rapidly in urban and periurban areas (UNDP and WHO 2009; World Bank 2010a). With urbanization increasing at 4.2 percent per

year (annualized rate from 2005 to 2010), the trend toward increased charcoal use is pronounced and growing (World Bank 2009). In Dar es Salaam, the share of households using charcoal rose from 47 to 71 percent in just six years from 2001 to 2007 (World Bank 2009).

In urban areas, charcoal consumption and expenditures are enormous. Countrywide annual consumption of charcoal in urban areas has been estimated at 1 million tons (World Bank 2009). Dar es Salaam city alone is estimated to consume about 50 percent of the total amount in the country, and it is estimated that about 200,000 bags of charcoal enter Dar es Salaam daily (World Bank 2009). Charcoal is estimated to be responsible for US$650 million in economic activity annually (World Bank 2009).

In addition to its contributions to health problems and deforestation, charcoal use is an inefficient and expensive form of household energy. When used in an inefficient stove, charcoal is more expensive than electricity. Household energy expenditure varies from 17 percent (high-income group) to 35 percent (low-income group) (ProBEC report). After charcoal use was banned briefly in 2006, urban charcoal prices doubled, but did not fall back when the ban was rescinded (World Bank 2009).

Given low levels of GDP and exports from the country, Tanzanian businesses and households are particularly vulnerable to oil price shocks, and oil and petroleum imports are a major drain on buying power. In 2006, Tanzania spent almost 24 percent of its national budget on oil and gas imports.

Health Impacts of Household Fuel Use

The health impacts of fuel use patterns are significant. The UNDP and WHO (2009) estimate that every year 15,900 Tanzanian children under 5 die of pneumonia and 3,000 adults die prematurely of chronic obstructive pulmonary disorders resulting from solid fuel use. Likewise, for every 1,000 children under 5, pneumonia resulting from solid fuel use causes 84 DALYs; all respiratory diseases from solid fuels cause 16 DALYs for every 1,000 Tanzanians of all ages (UNDP and WHO 2009).

Household Energy Program

The World Bank's Environment and Natural Resources Unit for the Africa region has recently produced two extensive studies with policy recommendations for charcoal sector management (World Bank 2009, 2010a). According to one study, the "illegal and informal nature" of the charcoal trade deprives the Government of Tanzania of approximately US$100 million in taxes annually (World Bank 2009). There are several leading causes for this. First, local governments, the parties responsible for licensing and regulating the charcoal trade, keep only a very small fraction of legally obtainable revenue, which undermines incentives for honest oversight and fuels corruption. Second, the ingrained nature of corruption, including the widespread engagement of government officials in the illicit charcoal trade, undermines efforts to reform and legalize the sector. Third, capacity constraints at the local level—where the fuelwood is harvested and charcoal is produced—are severe (World Bank 2009).

The government has attempted to address the charcoal sector problem, but with little success. A two-week charcoal ban in 2006 only served to drive up prices and cause a public outcry before the government overturned the ban (World Bank 2009). It is likely

that positive incentives for compliance with rules—such as tax breaks and privileges for certification of sustainably harvested and produced charcoal—are the best route to better management of the charcoal sector. Empowering communities to manage their own woodlots and produce their own charcoal would also likely reduce clandestine charcoal production.

Additionally, World Bank policy recommendations include the following:

- Centralize the sale of charcoal in markets to diffuse market information and facilitate regulatory oversight.
- Build capacity and incentives for improved charcoal kilns, aided by better management of forest fuelwood stocks.
- Allow district authorities to retain a larger share of charcoal licensing revenues to reduce corruption and improve industry oversight.
- Impose transport-based charcoal fees, so that opting out of regulatory oversight by sourcing far away is penalized.
- Increase the number and effectiveness of law enforcement checkpoints.
- Mitigate demand and the impact of high charcoal prices on household budgets by introducing fuel-efficient charcoal cookstoves and switching to less-expensive alternative fuels (such as ethanol gels).

To execute effective reforms, it will be necessary to fully engage all major stakeholders in charcoal supply and consumption in an open dialogue. The steps for such a process have recently been assiduously mapped out in a new World Bank study (World Bank 2010a).

Nongovernmental Organization Activities

A number of NGOs, community organizations, and small companies have forged a niche in the household energy space, thereby becoming de facto leaders promoting clean household energy in Tanzania. Some of the most prominent include ARTI-TZ, EAETDN Tanzania, TaTEDO, and WODSTA. ARTI-TZ is a nonprofit organization founded in India that develops and markets efficient household energy technologies. ARTI-TZ, in partnership with JET, markets charcoal briquette makers, biogas systems, improved cookstoves, efficient cookers, and charcoal kilns (ARTI-TZ website). More than 700 Sarai cookers have been sold in Tanzania in 2009 (ARTI-TZ 2010). The East African Energy Technology Development Network is a network of 27 local community organizations in Tanzania promoting the use of clean energy technologies (GVEP 2009).

TaTEDO is one of the leading civic organizations conducting research and implementing projects in community-level energy in Tanzania. TaTEDO designs "indoor smoke removal interventions," including "improved wood stoves with chimney, improved kitchen designs, as well as sensitizing households on the need for increased kitchen ventilation" (PCIA 2010). TaTEDO also promotes solar PV technologies for lighting in off-grid areas as clean energy options. TaTEDO has also conducted extensive public awareness work and consultations with the public and local government leaders, and trains entrepreneurs in the clean household energy space (PCIA 2010).

WODSTA works to develop capacity in villages to implement clean and efficient household energy solutions. WODSTA trains women "on how to build wonder baskets

(insulated cooking baskets), energy efficient stoves, double burning stoves, and biogas tanks" and produces sawdust briquettes for cooking and heating (WODSTA website). WODSTA also provides information and training to communities to have access to alternative fuels, such as used kerosene and biofuels (WODSTA website).

There have also been new donor-funded initiatives to promote entrepreneurship in the community energy space. UNEP's Alternative Rural Energy Entrepreneurship Development program supported entrepreneurs in this space through the early 2000s. More recently, the Developing Energy Enterprise Project is a program funded by the European Union that involves four of GVEP International's partners: EAETDN; the Aga Khan Foundation's Coastal Rural Support Project, Kenya; IT Power East Africa; and Practical Action East Africa. The program aims to support 1,800 small-scale energy entrepreneurs, whose commercial plans include "improved cookstoves, briquette production, sustainable charcoal production, small hydro power generation schemes, and wind power generation" (GVEP 2009).

Dedicated Improved Cookstove Initiatives

Probably the largest sustained donor-funded improved cookstove initiative is ProBEC. ProBEC is a program funded and implemented by GTZ. ProBEC commenced in 1998 in the countries of southern Africa to promote efficient household energy use, focusing on the permanent adoption of efficient wood cookstoves (GTZ website). In 2007 and 2008, after having invested extensively in cookstove design and development, ProBEC pilot tested a wide variety of fixed and portable stoves in households and small enterprises (ProBEC 2010). From June 2008 to December 2009 the program entered the scale-up phase, and included eight types of improved cookstoves, most domestically produced (ProBEC 2010). Importantly, ProBEC partnered with three government agencies, including the Ministry of Energy and Minerals, the Zanzibar Department of Energy, and the Commission for Science and Technology in Tanzania, as well as with 13 companies and civic organizations.

Lessons Learned

- Improved cookstoves have great potential to improve health outcomes and reduce pressure on forests, particularly related to the use of charcoal. Where fuel is purchased in urban areas, improved cookstoves should be readily marketable.
- Market development and supply reliability and quality are essential for the development of a domestic improved cookstove market.
- Charcoal is the fastest-growing component of the household energy sector. To address issues of cost, sustainability, and management, significant reforms will be necessary. Because of the entrenched interests of many of the players in the charcoal sector and the lack of transparency, an open dialogue with key stakeholders is a necessary first step.

Challenges

- Because of low incomes, dispersed populations, and weak distribution channels, many short- and medium-term household energy interventions will likely have to rely on local resources, such as biomass fuels and locally constructed

cookstoves. Fuel switching and importation of advanced stoves will likely be beyond the means of most households, particularly in rural areas.

- Despite its high cost, charcoal remains the fuel of choice in urban areas of Tanzania. Ensuring the sustainability of fuelwood stocks through regulation and policy incentives will be a monumental challenge for the Tanzanian government.
- Encouraging complete fuel switching away from biomass will be difficult, even for the wealthier middle and upper classes in urban areas. This challenge is illustrated vividly in the large cities of Tanzania, particularly in Dar es Salaam.
- Because of the still limited development of the improved cookstove market, scale-up and commercialization will require extensive consumer education; development of manufacturing, distribution, and retail capabilities; quality control; and other forms of industry support.
- Because of consumers' limited buying power, enabling subsidies and microcredit facilities will have to be developed to ensure affordability.

APPENDIX E

Thailand: Promoting the Uses of LPG for Cooking

Located in southeastern Asia, Thailand has a population of 67.8 million people with more than 66 percent (or 45 million) living in rural areas (World Bank 2010b). GDP per capita is approximately US$3,893 (2009 US dollars, World Bank 2010b). Thai exports—mostly machinery and electronic components, agricultural commodities, and jewelry—are the major driving force of the economy, accounting for 76 percent of the total GDP as of 2008 (World Bank 2010b). CO_2 emissions per capita has been much higher in Thailand than in other East Asian countries and lower middle income countries (World Bank 2010b).

National Household Energy Use

The use of LPG for cooking in Thailand began in the mid-1970s. At that time, large petroleum companies, such as Shell, Esso, and Caltexc, began selling LPG to households in Bangkok. LPG sold by these three petroleum companies was largely by-products from their oil refinery plants in the country, and a small amount was from imports. Only a small group of financially better-off households in Bangkok was able to afford LPG.

In the early 1980s, LPG was gradually being used by upper-middle– and middle-income households in Bangkok. With the discovery of natural gas in the Gulf of Thailand in 1981 and the completion of the first gas separation plant in the country, the government seized the opportunity to promote LPG use in the household sector. Like other countries in the early part of 1980, the government was very concerned about the unsustainable production and use of fuelwood for cooking associated with deforestation in the country. The government started to promote initiatives aiming at increasing LPG use by all households in Bangkok and throughout the country.

Over the years, these initiatives have produced positive results. Currently, about 79 percent of urban households and 72 percent of rural household in the country are using LPG for cooking.[1] Total LPG consumption for the household cooking in 2009 was estimated at about 2.23 million tons, which accounted for about half of total LPG consumed in the country. Although the amount of LPG used for cooking has increased on average by about 10 percent per year during the past 25 years, the share of LPG used for cooking has been declining from the peak of 78 percent in 1989 to just about half in 2009. This is the result of two compounding factors, which include increasing uses of LPG for automobile and as the feedstock for the petrochemical industry during the past 10 years.[2]

The Government Approach

Setup of an Oil Stabilization Fund

In response to the second international oil crisis during 1979–1981, the government set up an Oil Stabilization Fund. The Fund was set up from levies collected from petroleum-

based fuels used in the country.[3] The main objectives were first that the Fund was designed to stabilize the retail price of petroleum-based fuels in the country. This was to alleviate the economic and financial impacts when the price of petroleum-based fuels increased significantly; the Fund was to be used to bring down prices to alleviate the impacts. On the contrary, when the prices are low, fuel levies would be accumulated for future uses when needed.

Second, the fuel levies collected from each fuel are accumulated to cross-subsidize diesel fuel, which is used in the transport sector, and LPG, which is used in the household sector for cooking. The Fund was designed to establish cross-price subsidies between gasoline users and diesel fuel and LPG. In practice, fuel levies for gasoline are higher than fuel levies for high-speed diesel fuel and LPG. In effect, when LPG price increases beyond a certain level, a cross-subsidy from gasoline is to be used to bring down the price of LPG. The current law and decree designate the Energy Policy and Planning Office, Ministry of Energy, as the agency responsible for managing the Oil Stabilization Fund for the country.

Providing Cross-Price Subsidies

In an effort to promote the use of LPG among households that live in the provincial cities and rural areas, the government in 1986 enacted a uniform wholesale pricing policy for LPG. The government decree states that wholesale prices at five large regional storage facilities (with capacity of at least 2,000 cubic meters) serving consumers outside the Greater Bangkok Metropolitan Area are to be the same as the wholesale price in the Bangkok Metropolitan Area. Using fuel levies from the Fund, the government provided subsidies for the transportation costs of LPG from the three main LPG storage facilities to regional storage facilities, which also serve as the distribution center for the region.

Subsidies for transportation are provided on a per-kilogram basis. Subsidy rates to transport LPG vary, depending on mode of transportation (sea, train, or truck), and the three designated origins to five storage facilities as the destination. On the contrary, there is no transportation subsidy between the main storage facilities and storage facilities that serve consumers living in the Greater Bangkok Metropolitan Area. Since the LPG levy is collected from all LPG produced or imported and sold in the country, in effect the subsidy scheme for transportation cost is a partial cross-price subsidy between Greater Bangkok Metropolitan area consumers and consumers outside Bangkok Metropolitan Area.

Currently, LPG consumption in Bangkok Metropolitan Area accounts for about 40 percent of total LPG consumed in the country, and occasionally fuel levies for LPG are lower than transportation subsidies (collected and subsidized on a baht-per-kilogram basis), and the transportation equalization subsidy in effect receives a cross-subsidy from LPG users in Greater Bangkok Metropolitan Area and from gasoline users, all of which are accumulated from the Oil Stabilization Fund to reduce the retail price. The transportation equalization subsidy is estimated to reduce the retail price of LPG by about 5 percent, directly benefitting users living the provincial cities, towns, and rural areas.

The second part of direct price subsidy was designed to benefit all consumers. If the international price of LPG increases beyond the established threshold, the Fund will be used to directly subsidize and bring down the price of LPG. In effect, this part of the subsidy is cross-subsidized by gasoline users and surplus accumulated in the Fund.

Developing a Sustainable and Reliable Supply of LPG

As part of the effort to create a sustainable supply of LPG and market beyond the Greater Bangkok Metropolitan Area, the government directly engaged with the state-owned oil company to implement an LPG market development program, which included construction of six large LPG storage and terminal facilities nationwide. One is located in Bangkok, serving Greater Bangkok Metropolitan Area, and the remaining five facilities are located throughout the country in Nakornsawan Province (serving the upper central and low northern regions), Lampang Province (serving the northern region), Khonkean Province (serving the northeastern region), Suratthani and Songkhla Provinces (serving the southern region). Construction of all LPG storage was completed in 1985.

In realizing that demand for LPG in the initial stage of LPG promotion, especially at the provincial level, was too low for LPG producers and suppliers to invest in storage and refilling facilities, the government in 1986 began providing a subsidy to LPG producers and suppliers to maintain and operate storage facilities in the region. The subsidy intervention, which is paid for by the oil fund levy was aimed at helping correct insufficient market power, since the initial stage of demand for LPG, especially in the province, periurban, small towns, and rural areas was too low for LPG producers and suppliers to invest in the LPG market. The subsidy, which was designed to help LPG producers and suppliers maintain a steady supply of LPG in the region outside Bangkok, ended in 1996.

To promote the new entry of LPG distributors in the country, especially outside the Bangkok Metropolitan Area, the government instructed the state-owned oil company, which owns a storage facility, to allow other LPG suppliers, distributors, and traders to use the company-owned storage facility free of charge. As a result, the number of LPG suppliers and distributors in the country increased from three to six. Currently, Thailand has a total of seven LPG suppliers and distributors, which are actively selling LPG for cooking throughout the country.

Safety Regulation and Promoting Good Business Practices

In 2002, the government identified several safety problems, regulatory loopholes, and undesirable and illegal business practices of LPG traders and filling plants. They included the safety issues related to millions of LPG cylinders that have not had appropriate maintenance and the illegal production of LPG cylinders by cylinder manufacturers. These cylinders are in circulation, but it is not possible to identify any parties to be responsible for maintaining them.

In 2002, about 361 LPG filling plants of various sizes existed throughout the country. However, the vast majority of these LPG filling plants were owned by independent LPG traders—not by the seven LPG suppliers and distributors. In practice, these independent LPG filling plants buy LPG from any LPG producer or supplier and sell LPG (filling LPG and cylinder) to anyone, regardless of whether a brand name is printed on the cylinder. Such practices are usually referred to as "cross filling" and illegal filling (into noncertified or LPG cylinders). As a result of cross filling and illegal filling by independent filling plants, no party was especially willing to take responsibility for providing maintenance and repair, or for removing damaged and old cylinders.

To solve this safety issue, the government has tightened up and issued several new regulations to change the business practices of LPG suppliers and distributors, filling plants, and retailers, as well as LPG cylinder manufacturers. For example, every filling plant is required to be affiliated with a specific LPG supplier or distributor, and cross filling is prohibited. LPG cylinder manufacturers are not allowed to produce any LPG cylinders without an order from the LPG suppliers or distributors. The government also took immediate action to repair, remove, and replace unsafe LPG cylinders.

In 2002, the government initiated a program to exchange LPG cylinders deemed unsafe with new ones. The cylinder exchange program is financed jointly (50–50) by the government using the Oil Stabilization Fund and by LPG suppliers and producers.

Conclusion

Promotion of LPG market for cooking in Thailand has been successful. LPG is used for cooking, not only by urban households, but also by rural households. About three quarters of households in the country are currently using LPG for cooking. Promotion of the LPG market for cooking began with the availability of a domestic supply of LPG. Although the uses of LPG for cooking began in the late 1970s and are concentrated only among financially well off households in Bangkok, the government did not begin actively promoting the uses of LPG until it was certain that a domestic supply would be available.[4]

The Oil Stabilization Fund has played an important role in keeping the price of LPG under control, as well as to allow the LPG market to grow. Through the Fund, cross-subsidy schemes have provided successful results, but they have also created several negative consequences. Empirical evidence has shown that subsidies have helped consumers and suppliers develop the LPG market throughout the country. However, it has been very expensive. The Fund has been on the verge of bankruptcy several times, but has rebounded either when the international prices of petroleum have declined or the government has acted to increase fuel levies or reduce the subsidy, or both.

The government was able to develop a LPG market throughout the country, because it gave equal support on both the supply and demand side. The government not only provided a cross-price subsidy on the demand side; it engaged directly with the state-owned oil company to build and maintain large storage facilities throughout the country on the supply side as well.

Recognizing that in the initial stage of LPG promotion, demand for LPG, especially at the provincial level, was too low for LPG producers and suppliers to invest in storage and refilling facilities, the government provided subsidy directly to LPG producers and suppliers to help them maintain LPG storage and bottling facilities in the provinces.

Interestingly, the LPG promotion program in Thailand did not aim specifically at helping poor households switch to LPG, but rather at helping all households switch from firewood and charcoal to LPG. As a result, the program did not provide any subsidy to help low-income households overcome the commonly known upfront cost problem. The program did not provide any subsidy to households to purchase LPG stoves or assist in paying deposit for LPG cylinders. The subsidy concentrated on lowering the price of LPG, especially in the areas beyond Bangkok.

Notes

1. Bacon, Bhattacharya, and Kojima 2010. The figures include households that incur LPG expenditures (that is, households that use LPG as a primary cooking fuel, as well as households that use LPG as a backup cooking fuel).
2. Total LPG used for automotive has increased from only 91,000 tons per year in 1999 to about 666,000 tons in 2009, whereas LPG used as the feedstock has increased from only 85,000 tons per year in 1992 to about 1,288,000 tons in 2009.
3. The fuel levy rate for LPG is collected on a per-kilogram basis; the levy for other fuels, such as gasoline, diesel fuel, and bunker oil is collected on a per-liter basis.
4. Before 1985, the supply of LPG came from only three oil refinery plants in the country and from imports. Oil for these three oil refinery plans was also imported.

APPENDIX F

The GIZ Programme for Poverty-Oriented Basic Energy Services

The GIZ Programme for Poverty-oriented Basic Energy Services: The program formally started in December 2003. It provides backstopping to pro-poor basic energy services projects in selected countries in Africa, Asia and Latin America. The GIZ is also running the Energy Access Programme "Energising Development" (EnDev). EnDev provides access to cooking energy (besides access to electricity) and therefore is implementing projects, which receive backstopping from the program for poverty-oriented basic energy services. The following is a brief summary of the programme for poverty-oriented basic energy services' objective and approach, main results, and lessons learned.

Objective and Approach

GIZ (2011a) provides a description of the objectives and approach. Basically, the program develops and disseminates strategies and concepts for pro-poor basic energy services in relation to:

- Consumers: the aim is to use energy more efficiently through improved technology (efficient stoves, energy-saving lamps).
- Supply-side management: to promote the supply of affordable, environmentally friendly and sustainable energy from renewable resource.
- Policy advice: to integrate poverty-oriented basic energy services into energy policy of its partner countries.
- Lobbying: to represent household energy access issues at international conferences and on international bodies.

Main Results

The program has contributed to improving access to cleaner and energy-efficient cookstoves for households, small businesses, and social institutions. In Bangladesh, Benin, Bolivia, Burkina Faso, Ethiopia, Honduras, Kenya, Peru, Senegal, and Uganda more than 2.5 millions improved cookstoves adapted to local needs have been sold to households, small businesses, and social institutions until the end of 2010.

Lessons Learned

GIZ has provided an extensive description of lessons learned from its experience in the assistance to development, production and dissemination of locally produced improved stoves (GIZ, 2011b). These lessons are articulated around the following four main themes: (a) planning and policy level; (b) product development; (c) dissemination approach; and (d) marketing and financing. A brief summary is provided as the following:

Planning and Policy Level

- Adequate planning is subject to an in-depth feasibility that looks into various interrelated aspects including poverty alleviation, gender, cost-benefits analyses, technical efficiency, environment impact and policy that affect the implementation process.
- For decision makers to be convinced of the relevance and benefits of clean and efficient energy provision, positive cost-benefit results need to be demonstrated.

Product Development

- The acceptability of a product by users depends not only on its potential in meeting high quality standards (availability, affordability, reliability, measurable advantages in terms of money and time saving, reduction of indoor air pollution and ease of practical use) but also on its attractiveness (modern and desirable by users).
- Professional organizations where producers and stove builders discuss the importance of quality labeling, warranty, user satisfaction and user awareness issues are necessary.
- International stove standards are in the process of being developed. They will need to be adapted to the specific situation in each country and regularly be brought up to date.

Dissemination Approach

- A fully commercial approach is the most important step in achieving long term sustainability.
- A strong focus on advisory and technical support for the partners may be more important than giving only financial assistance. Sound training of local technical and marketing expertise is the best guarantee of having a successful project in the long run.
- Appropriate incentives and adequate monitoring are key factors for success when disseminating a technology.

Marketing and Financing

- Micro-credit opportunities and longer payment periods offer more advantages for users to value the stoves than to build them for free.
- Independent stove producers known to produce high quality products should be able to competitively market their stoves.

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Household Energy Access for Cooking and Heating: Lessons Learned and the Way Forward is part of the World Bank Studies series. These papers are published to communicate the results of the Bank's ongoing research and to stimulate public discussion.

This study conducts a review of World Bank-financed operations, and selected interventions by other institutions, on household energy access in an attempt to examine success and failure factors and to inform the new generation of upcoming interventions. First, the report provides a brief literature review to lay out the multidimensional challenge of an overwhelming reliance on solid fuels for cooking and heating. Second, it highlights how the World Bank and selected governments and organizations have dealt with this challenge. Third, it presents lessons learned to inform upcoming interventions. And finally, it provides an outlook for the future. The following eight major lessons emerged from this review: (1) a holistic approach to household energy issues is necessary; (2) public awareness campaigns are prerequisites for successful interventions; (3) local participation is fundamental; (4) consumer fuel subsidies are not a good way of helping the poor; (5) both market-based and public support are relevant in the commercialization of improved stoves; (6) the needs and preferences of stove users should be given priority; (7) durability of improved stoves is important for their successful dissemination; and (8) with microfinance the poor can gradually afford an improved stove. The report invites stakeholders to use the recent momentum aimed at providing clean cookstoves and fuels to the poor as an opportunity for action.

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