



# Wood-Based Biomass Energy Development for Sub-Saharan Africa

ISSUES AND APPROACHES



Africa Renewable Energy  
Access Program (AFREA)

Copyright © 2011  
The International Bank for Reconstruction  
and Development/THE WORLD BANK GROUP  
1818 H Street, N.W.  
Washington, D.C. 20433, U.S.A.  
africaenergyunit@worldbank.org

All rights reserved  
Manufactured in the United States of America  
First printing September 2011

This is a publication by the Africa Renewable Energy Access Program (AFREA), a Trust Fund Grant Program funded by the Kingdom of the Netherlands. The materials in this publication are copyrighted, and requests for permission to reproduce portions of it should be sent to the AFREA Manager at the address shown in the copyright notice above. No fees will be requested.

Some sources cited in this paper may be informal documents that are not readily available. The findings, interpretations, and conclusions expressed in this report are entirely those of the author(s) and should not be attributed in any manner to the World Bank, or its affiliated organizations, or to members of its board of executive directors for the countries they represent, to donors, or AFREA. The World Bank and AFREA do not guarantee the accuracy of the data included in this publication and accepts no responsibility whatsoever for any consequence of their use. The boundaries, colors, denominations, other information shown on any map in this volume do not imply on the part of the World Bank Group any judgment on the legal status of any territory or the endorsement or acceptance of such boundaries.

**Photo Credits**

All photos Klas Sander, The World Bank

**Designer**

Petra Sutila, Graphic Design & Photography

**Technical Editors**

Klas Sander  
Besnik Hyseni  
Waqar Haider

**Production Editor**

Marjorie K. Araya

# Wood-Based Biomass Energy Development for Sub-Saharan Africa

**ISSUES AND APPROACHES**



Africa Renewable Energy  
Access Program (AFREA)



THE WORLD BANK









# CONTENTS

|                                                                                    |           |
|------------------------------------------------------------------------------------|-----------|
| Foreword                                                                           | v         |
| Acknowledgements                                                                   | vi        |
| Abbreviations and Acronyms                                                         | vii       |
| Executive Summary                                                                  | ix        |
| <b>1. INTRODUCTION</b>                                                             | <b>1</b>  |
| 1.1 Context   Wood-Based Biomass and Energy Use                                    | 1         |
| 1.2 Objective of the Paper                                                         | 3         |
| 1.3 Structure of the Paper                                                         | 4         |
| <b>2. RATIONALE FOR ENGAGEMENT IN WOOD-BASED BIOMASS ENERGY SECTOR</b>             | <b>7</b>  |
| 2.1 Energy Security                                                                | 8         |
| 2.2 Poverty Alleviation and Economic Development                                   | 9         |
| 2.3 Climate Change and Greenhouse Gas (GHG) Emission                               | 10        |
| 2.4 Health and Gender Issues                                                       | 11        |
| <b>3. ISSUES AND APPROACHES</b>                                                    | <b>13</b> |
| 3.1 Fuelwood                                                                       | 13        |
| 3.2 Charcoal                                                                       | 18        |
| 3.2.1 Forest Management for Charcoal Production                                    | 20        |
| 3.2.2 Charcoal Production                                                          | 21        |
| 3.2.3 Transport, Trade, and Marketing                                              | 23        |
| 3.2.4 Demand-Side   Charcoal Consumption and Improved Cookstoves                   | 25        |
| 3.3 Alternative Fuels and Fuel Switching                                           | 29        |
| 3.4 Domestic Biogas                                                                | 30        |
| 3.5 Policy Design and Implementation                                               | 32        |
| <b>4. WORLD BANK INVESTMENTS IN WOOD-BASED BIOMASS ENERGY   STATUS AND OUTLOOK</b> | <b>35</b> |
| <b>5. CONCLUSION</b>                                                               | <b>41</b> |
| References                                                                         | 42        |
| Annex 1   The World Bank Biomass Related Projects in Africa (2000–2010)            | 46        |

## BOXES

|              |                                                                                                |    |
|--------------|------------------------------------------------------------------------------------------------|----|
| <b>Box 1</b> | Senegal Case Study: Supply-Side Intervention via Community-Based Sustainable Forest Management | 15 |
| <b>Box 2</b> | IBI Bateke, DRC   Tree Intercropping Afforestation in Degraded Savannah Lands                  | 16 |
| <b>Box 3</b> | Chad Differential Taxation                                                                     | 16 |
| <b>Box 4</b> | The Impact of Improved Cookstoves (ICS) on Particulate Matter (PM) Emissions                   | 17 |
| <b>Box 5</b> | Outgrower Schemes                                                                              | 22 |
| <b>Box 6</b> | The Experience of Energy Subsidies in Senegal                                                  | 30 |
| <b>Box 7</b> | Financing Mechanisms for Investments in the Wood-Based Biomass Energy Sector                   | 36 |

## FIGURES

|                 |                                                                                      |    |
|-----------------|--------------------------------------------------------------------------------------|----|
| <b>Figure 1</b> | World Bank Energy Access Investments (FY2000-2008; in US\$ million)                  | 2  |
| <b>Figure 2</b> | Total Energy Consumption, Biomass Energy Consumption and Population in Africa (2005) | 3  |
| <b>Figure 3</b> | Number of Deaths from Indoor Air Pollution-Related Health Complications              | 8  |
| <b>Figure 4</b> | Beneficiaries in the Charcoal Value Chain (before and after reform)                  | 19 |
| <b>Figure 5</b> | Charcoal Trade and Market Share of Consumption by End-Consumers in Tanzania          | 23 |
| <b>Figure 6</b> | Structure of Forest Exploitation for Charcoal Production and Trade                   | 24 |
| <b>Figure 7</b> | Framework for Charcoal Sector Policy Design and Implementation                       | 32 |

## TABLES

|                 |                                                                               |    |
|-----------------|-------------------------------------------------------------------------------|----|
| <b>Table 1</b>  | People Relying on Wood-Based Biomass (millions)                               | 1  |
| <b>Table 2</b>  | Summary of Issues and Approaches for Fuelwood Interventions                   | 18 |
| <b>Table 3</b>  | Summary of Issues and Approaches for Forest Management Interventions          | 21 |
| <b>Table 4</b>  | Efficiencies of Alternate Kiln Technologies                                   | 21 |
| <b>Table 5</b>  | Summary of Issues and Approaches for Advancing New Kiln Technologies          | 23 |
| <b>Table 6</b>  | Summary of Issues and Approaches for Transport, Trade, and Marketing          | 25 |
| <b>Table 7</b>  | Summary of Issues and Approaches for Demand-Side Interventions                | 28 |
| <b>Table 8</b>  | Reasons for Using Various Fuel Sources (multiple answers possible)            | 29 |
| <b>Table 9</b>  | Summary of Issues and Approaches for Domestic Biogas Interventions            | 31 |
| <b>Table 10</b> | Approaches to Supply-Side Intervention for Fuelwood and Charcoal              | 35 |
| <b>Table 11</b> | Approaches to Improved Kiln Technology for Charcoal Production                | 36 |
| <b>Table 12</b> | Approaches to Trade Intervention for Fuelwood and Charcoal                    | 37 |
| <b>Table 13</b> | Approaches to Demand-Side Interventions for Fuelwood and Charcoal Consumption | 38 |











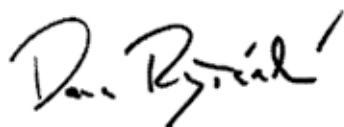
## FOREWORD

Wood-based biomass is the dominant source of energy for Sub-Saharan Africa (SSA), where about 81% of households rely on it—far more than in any other region in the world. However, despite its enormous social, economic and environmental significance, its development and efficient use has not been receiving the same attention as commercial forms of energy—namely oil, gas, coal and electricity—at national and international levels. This Paper argues that the creation of sustainable wood-based biomass energy sectors could help client countries in achieving the Millennium Development Goals, energy security, low-carbon growth and sustainable nature resources management. Achieving these goals is at the core of the World Bank’s mission of alleviating poverty and promoting economic development.

Against this background, this Paper, *Wood Based Biomass Energy Development for Sub-Saharan Africa: Issues and Approaches*, reviews the ways the resource is developed and how supply and demand issues can be managed, particularly with respect to household energy use. The Paper also set out a framework outlining how the World Bank can assist Sub Saharan countries with resolving issues related to wood fuel biomass energy in SSA.

The Africa Energy Unit has been taking a leading role in moving the biomass agenda forward in SSA drawing on the expertise of a multi-disciplinary team from the Sustainable Energy Department within the World Bank. This approach reflects the multi-sectoral characteristics of biomass energy issues.

We hope that this Paper will not only draw renewed attention to the need to develop the wood fuel biomass energy sector in SSA in a sustainable way, but also help to facilitate the dialogue and partnership on policies and reforms with client countries, and enable Bank staff to actively engage more development partners and the private sector, and build bridges for emerging financing mechanisms related to climate change.



Dana Rysankova  
Program Manager  
Africa Renewable Energy Access Program (AFREA)



# ACKNOWLEDGEMENTS

The principal authors of the report are Klas Sander (Environment Department, ENV), Syed Waqar Haider, and Besnik Hyseni (Africa Energy Group, AFTEG). Rogerio Carneiro de Miranda (Consultant) and Jing Li (Africa Energy Group, AFTEG) provided input to earlier versions of this paper. Guidance and inputs were provided by Tjaarda P. Storm Van Leeuwen, Dana Rysankova and Juliet Pumpuni (Africa Energy Group, AFTEG), and Koffi Ekouevi (Energy Unit, SEGEN).

The team gratefully acknowledges the support from the Sector Manager of the World Bank Africa Energy Group (AFTEG), Subramanian V. Iyer. Particular support and guidance was provided from Jamal Saghir, Director of Sustainable Development for the Africa region and Daniel Kammen, the World Bank's Chief Technical Advisor on Renewable Energy.

Peer reviewers included Vivien Foster (Sustainable Development, AFTSN), Christian Peter (Environment and NRM, AFTEN), and Venkata Ramana Putti (Energy Sector Management Assistance Program (ESMAP), SEGES) of the World Bank.

The team benefited from numerous consultation and review meetings. Special thanks are given for the advice and contribution by Peter Dewees (Agriculture and Rural Development Department, ARD), Masami Kojima (Oil, Gas and Mining, SEGOM), Stephen D. Mink, (Sustainable Development, AFTSN), Lucio Monari (Energy Unit, SEGEN), Sameer Akbar (Environment Department, ENV), Bienvenu Rajaonson, James Michael Acworth, Paola Agostini, Simon Rietbergen, and Steven Danyo (Environment and NRM, AFTEN), Richard Hosier (GEF Coordination Team, ENVGC), Brice Quesnel (Carbon Finance, ENVCF), Rasmus Heltberg (SDN), Kaoru Suzuki and Katherine Deaton Steel (Africa Energy Group, AFTEG), Hannah Behrendt (ENV), and Marjorie K. Araya (ESMAP/AFREA).

Funding was provided by the Africa Renewable Energy Access Grants Program (AFREA), which is financed by the Netherlands through the Clean Energy Investment Framework (CEIF), Multi Donor Trust Fund (MDTF), recipient-executed and technical assistance (TA) window established by the Energy Management Assistance Program (ESMAP). These funds are earmarked to help the World Bank Africa Energy Group (AFTEG) carry out analytical and advisory activities and also provide recipient-executed TA and pre-investment grants that will accelerate the development of renewable energy systems. AFREA supports activities under the CEIF's Pillar 1, which is meeting the energy needs of developing countries and widening access to energy services for their citizens in an environmentally responsible way. All AFREA-supported activities are designed to promote AFTEG's mission, specifically its activities that support and/or create the conditions to increase renewable energy investments and expand access to modern energy services in Sub-Saharan Africa (SSA); also, they aim to expand recipient-executed pre-investment activities that could accelerate the development of renewable energy systems based on hydro, wind, geo-thermal, solar, and biomass energy resources.

The financial and technical support by the Energy Sector Management Assistance Program (ESMAP) is gratefully acknowledged. ESMAP is a global knowledge and technical assistance program administered by the World Bank to assist low- and middle-income countries increase knowledge and institutional capacity to achieve environmentally sustainable energy solutions that can reduce poverty and stimulate economic growth. ESMAP is governed and funded by a Consultative Group (CG) of official bilateral donors and multilateral institutions, representing Australia, Austria, Denmark, Finland, Germany, Iceland, Lithuania, Netherlands, Norway, Sweden, United Kingdom, and The World Bank Group.

# ABBREVIATIONS AND ACRONYMS

|                       |                                                                                                   |                |                                                                                                    |
|-----------------------|---------------------------------------------------------------------------------------------------|----------------|----------------------------------------------------------------------------------------------------|
| <b>ABPP</b>           | Africa Biogas Partnership Programme                                                               | <b>IFC</b>     | International Finance Corporation                                                                  |
| <b>AFREA</b>          | Africa Renewable Energy Access Program                                                            | <b>IMF</b>     | International Monetary Fund                                                                        |
| <b>AFTEG</b>          | Africa Energy Unit, The World Bank                                                                | <b>JFM</b>     | Joint Forest Management                                                                            |
| <b>AFTEN</b>          | Africa Sustainable Development, Energy, The World Bank                                            | <b>Kg</b>      | Kilogram                                                                                           |
| <b>AFTSN</b>          | Africa Sustainable Development, The World Bank                                                    | <b>KCJ</b>     | Kenya's Ceramic Jiko                                                                               |
| <b>ARD</b>            | Agriculture and Rural Development                                                                 | <b>LPG</b>     | liquefied petroleum gas                                                                            |
| <b>BC</b>             | black carbon                                                                                      | <b>MDGs</b>    | Millennium Development Goals                                                                       |
| <b>BEIA</b>           | Biomass Energy Initiative for Africa, The World Bank                                              | <b>MDTF</b>    | Municipal Development and Lending Fund                                                             |
| <b>BioCF</b>          | Bio Carbon Fund                                                                                   | <b>NGOs</b>    | non-governmental organizations                                                                     |
| <b>CASCADE</b>        | Carbon Finance for Agriculture, Silviculture, Conservation, and Action against Deforestation      | <b>PFM</b>     | Participatory Forest Management                                                                    |
| <b>CBFM</b>           | community-based forest management                                                                 | <b>PM</b>      | particulate matter                                                                                 |
| <b>CDM</b>            | Clean Development Mechanism                                                                       | <b>PoA</b>     | program of activities                                                                              |
| <b>CG</b>             | consultative group                                                                                | <b>PROGEDE</b> | Senegal Sustainable and Participatory Energy Management Project, The World Bank                    |
| <b>CIF</b>            | Climate Investment Fund                                                                           | <b>R&amp;D</b> | research and development                                                                           |
| <b>CIFOR</b>          | Center for International Forestry Research                                                        | <b>REDD</b>    | Reducing Emissions from Deforestation and Forest Degradation                                       |
| <b>CO</b>             | carbon monoxide                                                                                   | <b>REDD+</b>   | REDD plus multiple co-benefits in conservation and livelihoods                                     |
| <b>CO<sub>2</sub></b> | carbon dioxide                                                                                    | <b>RPTES</b>   | The Regional Program for the Traditional Energy Sector, The World Bank                             |
| <b>CSOs</b>           | civil society organizations                                                                       | <b>SDN</b>     | Sustainable Development Network, The World Bank                                                    |
| <b>DALY</b>           | disability-adjusted life year                                                                     | <b>SEGES</b>   | Sustainable Energy Department, Energy Sector Management Assistance Program (ESMAP), The World Bank |
| <b>DRC</b>            | Democratic Republic of Congo                                                                      | <b>SEDP</b>    | Sustainable Energy Department                                                                      |
| <b>ENV</b>            | Environment Department, the World Bank                                                            | <b>SEGES</b>   | Sustainable Energy Department, Energy Sector Management Assistance Program (ESMAP), The World Bank |
| <b>ENVCF</b>          | Environment Department, Carbon Finance                                                            | <b>SEGOM</b>   | Sustainable Energy Department, Oil, Gas and Mining, The World Bank                                 |
| <b>ENVGC</b>          | Environment Department, GEF Coordination team                                                     | <b>SESA</b>    | Strategic Environmental and Social Assessments                                                     |
| <b>EREDPC</b>         | Ethiopian Rural Energy Development and Promotion Center                                           | <b>SEWA</b>    | Self-employed Women's Association, India                                                           |
| <b>FAO</b>            | Food and Agriculture Organization of the United Nations                                           | <b>SREP</b>    | Scaling-up Renewable Energy Program, The World Bank                                                |
| <b>FCPF</b>           | Forest Carbon Partnership Facility                                                                | <b>SSA</b>     | Sub-Saharan Africa                                                                                 |
| <b>FIP</b>            | Forest Investment Program                                                                         | <b>TA</b>      | technical assistance                                                                               |
| <b>GEF</b>            | Global Environmental Fund                                                                         | <b>TWI</b>     | Transport, Water, Information and Communication Technology, The World Bank                         |
| <b>GHG</b>            | greenhouse gases                                                                                  | <b>UN</b>      | United Nations                                                                                     |
| <b>GTZ</b>            | GTZ is now GIZ - Deutsche Gesellschaft für Internationale Zusammenarbeit                          | <b>UNDP</b>    | United Nations Development Programme                                                               |
| <b>IBRD</b>           | International Bank for Reconstruction and Development                                             | <b>UNEP</b>    | United Nations Environment Programme                                                               |
| <b>IAP</b>            | indoor air pollution                                                                              | <b>UN-REDD</b> | UN Program on REDD                                                                                 |
| <b>ICRAF</b>          | International Centre for Research in Agroforestry (is now known as The World Agroforestry Center) |                |                                                                                                    |
| <b>ICS</b>            | improved cookstoves                                                                               |                |                                                                                                    |
| <b>IDA</b>            | International Development Association                                                             |                |                                                                                                    |
| <b>IEA</b>            | International Energy Agency                                                                       |                |                                                                                                    |





# EXECUTIVE SUMMARY

Nearly half the world's population and about 81% of Sub-Saharan African (SSA) households rely on wood-based biomass energy (fuelwood and charcoal) for cooking. This degree of reliance is far greater than in any other region. While the use of biomass fuels in China, India and much of the developing world has peaked or will do so in the near future, SSA's consumption will either remain at very high levels or even grow over the next few decades.

Population growth, coupled with strong urbanization dynamics and relative price changes of alternative fuels, offset the important achievements made over the past decade by significant investments in energy access, rural and urban electrification, off-grid energy developments, and the promotion of alternative energy sources. With increasing economic development, the demand for energy is increasing as well and consumers depend on a broader portfolio of energy sources to satisfy growing energy needs. While electricity and other energy sources are needed to satisfy additional energy needs emerging with economic development, a vast majority of Sub-Saharan African consumers continue to use woodbased biomass energy for cooking. Especially electricity is not regarded a suitable alternative for cooking given equipment and use costs. According to the World Energy Outlook, the number of wood-based biomass energy consumers in Sub-Saharan Africa will reach almost one billion by 2030 (IEA, 2010).

In most SSA countries, the wood-based biomass energy sector employs a significant workforce, providing regular income to tens—if not hundreds—of thousands of people. Those who rely on it for their livelihood strategies tend to be poor and work as small-scale producers/collectors, traders, transporters, or retailers; often, they have few alternatives to earn cash income. Despite the importance of woodfuels for local economic development, its contribution to government revenues and the broader tax base is limited due to widespread evasion of licensing fees and transport levies. National and local governments estimate they lose several tens and even hundreds of millions of dollars annually because the sector is not effectively governed.

Complementary to creating important employment for the poor segments of society that generally do not have access to formal employment, the contribution of the wood-based biomass energy sector to the national economy is significant and can easily surpass other economic sectors. Extrapolating to the whole of Sub-Saharan Africa, rough estimates indicate that the charcoal industry in Sub-Saharan Africa was worth more than US\$8 billion in 2007, with more than seven million people dependent on the sector for their livelihoods. In line with consumption predictions of the IEA, the economic value of the charcoal industry in SSA may exceed US\$12 billion by 2030, employing almost 12 million people.

Given the continued importance of wood-based biomass energy in SSA, a sustainably designed and operated sector could significantly reduce GHG emissions and help launch low carbon-growth strategies. At present, some sources estimate that cooking with traditional biomass fuels contributes about 18% of current global GHG emissions when forest degradation and deforestation is included in the equation (SEI, 2008). For example, if charcoal was sustainably produced it would be carbon neutral since this emitted carbon could be sequestered by trees that are planted. In this scenario, one ton of sustainable charcoal would offset one ton of non-sustainable charcoal or nine tons of carbon dioxide (GEF, 2010).

Targeting the wood-based biomass energy sector is vital if emerging financial mechanisms, such as REDD, REDD+, and the Forest Investment Program (FIP), are to succeed. Most—if not all—REDD strategies developed by SSA countries contain actions that will make the extraction of wood-based fuel sustainable, and enable countries achieve low-carbon growth while simultaneously satisfying basic energy needs of rapidly growing populations. Voluntary markets have, in many instances, shown a preference for forestry credits due to the potential co-benefits generated, especially the conservation of biodiversity. Already, pilot forestry projects are supported by the Biocarbon Fund, Forest Carbon Partnership Facility (FCPF), UNEP program CASCADE, and UN-REDD. Expanding these activities beyond the pilot phase should both deliver benefits for climate change mitigation and provide new means to finance forest management. Programs targeting improved cookstoves (ICS) promotion and dissemination can also benefit from carbon finance, once the methodologies have been developed (GTZ, 2011).

**> THE ECONOMIC  
VALUE OF THE  
CHARCOAL INDUSTRY  
IN SUB-SAHARAN  
AFRICA MAY EXCEED  
US\$12 BILLION BY  
2030, EMPLOYING  
ALMOST 12 MILLION  
PEOPLE >**



Improved cookstoves, manufactured more recently and based on higher performance standards, are also very important for reducing GHG emissions from wood-based biomass use; they display triple win characteristics: efficiency of fuel use, additional reduction of GHG emission by an enhanced combustion process, and the reduction in air pollutants affecting the health of mainly women and children. Further, more efficient stoves can also off-set the negative income effect resulting from woodfuel price increases that are expected with a modernization of the policy framework governing woodfuel consumption. By 2030, it is estimated that over 4000 people will die prematurely every day from indoor air pollution. Programs promoting alternative fuels as well as the adoption of fuel-efficient charcoal stoves should thus have a very high priority.

Biomass burning in cookstoves also emits black carbon (BC) as part of visible smoke, which is particulate matter that results from incomplete combustion. Climate science now views BC as the second or third largest warming agent after carbon dioxide, alongside methane. In the case of biomass cooking, the warming effects of BC and the cooling effects of organic carbon that is also emitted during the burning appear to be closely balanced. Given the present uncertainty about the net impact, additional research is currently underway. Black carbon has also an impact at the regional level: it accelerates melting of ice and snow, and contributes to regional pollution which can alter climatic conditions and precipitation patterns over a wide area.

Despite its social, economic and environmental significance, biomass energy planning does not receive the attention it deserves at national and international policy levels. To correct this would require a major shift both inside and outside governments with regard to how wood fuels are viewed and managed from a policy perspective, requiring a regularizing and formalizing of the currently informal sector. Currently, the sector is viewed almost entirely negatively, and as a result, policies and laws tend to focus on a “command and control” type regulation, enforcement, restriction, and, where possible, moving completely to other energy sources. This report will argue that this perception needs to change and an enabling environment should be created that allows for responsible, sustainable, and profitable enterprises to develop from within the sector.

>BIOMASS ENERGY  
PLANNING DOES  
NOT RECEIVE  
THE ATTENTION  
IT DESERVES AT  
NATIONAL AND  
INTERNATIONAL  
POLICY LEVELS>

The wood-based biomass energy sector in SSA operates within a complex and multi-layered regulatory context, often resulting in an unclear framework for stakeholders operating in the sector. The people and processes involved interact with several government bodies and must adhere to various policies and laws at the national, local and village levels. Although there often is no comprehensive, targeted policy, strategy or legal framework addressing the charcoal sector, there is an existing set of policies, legislation, and regulations which influences how wood-based biomass exploitation, production, and consumption is managed. These policies are executed by different ministries or government agencies and have at times been even observed to be conflicting.

This paper advocates that any policy reform should entail a combination of clear rules, transparent enforcement, strong incentives and awareness-creation/capacity development. Key stakeholders and the general public need guidance by way of information campaigns, training, and demonstration projects to ensure that awareness-deficits or false perceptions do not curtail policy implementation. The bureaucratic and administrative barriers e.g. overcomplicated forest management planning requirements, complex fiscal systems and land tenure procedures may inhibit development and thus warrant critical reflection. The regulatory framework needs to integrate externalities in order to promote adequate pricing of charcoal, and thus enhance regional economies.

Wood-based biomass energy sector strategies are specific to framework conditions at national, regional and local levels. This will require addressing several issues simultaneously, such as building technical capacity, disseminating information, and enforcing regulations/laws. To promote substantial, sustainable growth in the wood-based biomass energy sector, policies must offer certainty for the long term, and promote concrete local projects that incorporate principles of local control and participation in the planning process. Further, the responsibilities of national public agencies (e.g. the national forest service) may need to be partly transferred to private institutions, non-governmental organizations (NGOs) and local governments (e.g. districts and villages).

Fuel switching, targeted at better-off segments of the society, must be an integral part of policy measures to achieve sustainable wood-based biomass energy sectors in SSA. While this practice will not be economically feasible for most urban dwellers due to the initial investment costs in new cooking equipment and other economic constraints (such as unreliable and fluctuating income streams), the better-off segment of urban households with the means to switch could be encouraged to use gas and electricity for some specific purposes (e.g. heating water for tea)—which could stabilize or even

reduce wood fuel consumption. Even in rural areas, the use of alternate energy should be promoted; a promising option could be biogas produced from animal and human waste.

**There are various ways how the World Bank—together with other development partners, CSOs, and the private sector—could assist client countries.** These include, but are not limited to: (a) promoting secure and long-term tree- and land tenure rights for communities as essential prerequisites for (b) implementing and sustaining community-based forest management, including agroforestry systems, approaches for wood-based biomass production, a decentralized management transferring rights and responsibilities of wood-based biomass production to local community meeting their priorities and needs; (c) modernization of wood-based biomass markets for both fuelwood and charcoal as an opportunity for stakeholders to engage formally in the sector; (d) application of improved kiln technologies to enhance the efficiency of charcoal production; (e) reforms of taxation and revenue systems providing fiscal incentives supporting sustainably produced wood-based biomass; (f) promotion of improved cookstove interventions; and (g) facilitate private sector investments in the sector, e.g. through harmonization of technology and production standards. To introduce any of these policies, authorities must avoid top down command and control systems and instead involve local stakeholders throughout the process. Thus, they will need to launch communications campaigns to inform people and communities of the new policies, as well as their rights and responsibilities.

**In addition to the Africa Energy Unit, other World Bank sectors and departments implement investment operations and analytical work that relate to wood-based fuels. Any engagement in the wood-based biomass energy requires close coordination among the units of the Africa Region Sustainable Development Network to enhance activity coordination and knowledge exchange across the Bank.** For example, the environment and rural development sectors both are leading the operational and analytical work on sustainable forest management and agro-forestry. While climate change related activities related to forest management are predominantly led by the environment sector, the community driven development agenda is often part of the work programs of the social development and health sectors. Given the importance of facilitating private sector activities, collaboration with IFC—the private sector arm of the World Bank Group (WBG)—is expected to yield additional benefits.<sup>1</sup> Within the Sustainable Development Network reaching out to other World Bank regions as well as to external partners such as in the recently launched Global Alliance for Clean Cookstoves to foster capacity building and knowledge exchange widely.

---

<sup>1</sup> The collaboration between the World Bank and the International Finance Corporation (IFC) has already demonstrated tangible benefits in other priority areas; for example, the *Lighting Africa* program targeted at promoting off-grid electricity access in Sub-Saharan Africa. In India, IFC announced its support to the purchase of improved cookstoves by guaranteeing loans from local banks.



# 1

**>81% OF AFRICAN HOUSEHOLDS  
BURN SOLID FUELS, WITH ABOUT  
70% DEPENDING ON WOOD-  
BASED BIOMASS AS THEIR  
PRIMARY COOKING FUEL>**



# INTRODUCTION

## 1.1 CONTEXT | WOOD-BASED BIOMASS AND ENERGY USE

Globally, two billion people live on less than US\$1/day, about the same number as those lacking access to commercial energy (FAO COFO, 2005). Four out of five people without electricity live in rural areas in developing countries, mainly South Asia and Sub-Saharan Africa. The problem is that extending an electric grid to just a few households in rural areas can cost up to seven times the amount as in urban areas. Thus, wood-based biomass in Africa, Asia and Latin America accounts for 89%, 81%, and 66%, respectively, of total wood consumption. In Bangladesh, Cambodia, Nepal and Pakistan, the share goes up to 98% (IEA 2006 and 2010).

**Table 1 | People Relying on Wood-Based Biomass (millions)**

|                         | 2004         | 2015         |              | 2030         |              |
|-------------------------|--------------|--------------|--------------|--------------|--------------|
|                         | A            | A            | B            | A            | B            |
| Sub-Saharan Africa      | 575          | 627          | 741          | 720          | 918          |
| North Africa            | 4            | 5            | 4            | 5            | 4            |
| India                   | 740          | 777          | 863          | 782          | 780          |
| China                   | 480          | 453          | 393          | 394          | 280          |
| Rest of developing Asia | 645          | 692          | 688          | 741          | 709          |
| Latin America           | 83           | 86           | 85           | 85           | 79           |
| <b>TOTAL</b>            | <b>2,527</b> | <b>2,640</b> | <b>2,774</b> | <b>2,727</b> | <b>2,770</b> |

Source: (A) World Energy Outlook, 2006; (B) World Energy Outlook, 2010.

A striking difference between SSA and other countries is that the use of wood as an energy source has generally peaked or will do so in the near future, while in Sub-Saharan Africa it is predicted to remain at current levels and may even continue to grow. For example, the use of wood-based biomass is assumed to have peaked in China and is expected to start to decline soon, whereas for India it is expected to peak in the near future as their economies further develop.

In the 47 SSA countries, most rural and urban residents rely on wood-based biomass to satisfy their energy needs, especially for cooking.<sup>2</sup> About 81% of households burn solid fuels, far more than any other region in the world, with about 70% depending on wood-based biomass as their primary cooking fuel (Figure 1). Nearly 60% of urban dwellers also use biomass for cooking (IEA, 2010). A large number of traders are generally involved in buying, transporting, and re-selling wood-based biomass and this is often where most of the value-added is obtained in the informal sector. In contrast, in all of Asia (excluding China) biomass represents about 25% of the primary energy supply and in Latin America less than 20%. While it is predicted that by 2030 energy derived from wood in Africa will still account for an estimated three quarters of total residential energy consumption serving about 1 billion people, it currently only accounts for about 10% of the global energy supply<sup>3</sup> (IEA 2006 and 2008).

<sup>2</sup> This includes island states such as Comoros, Madagascar, and Sao Tome and Principe.

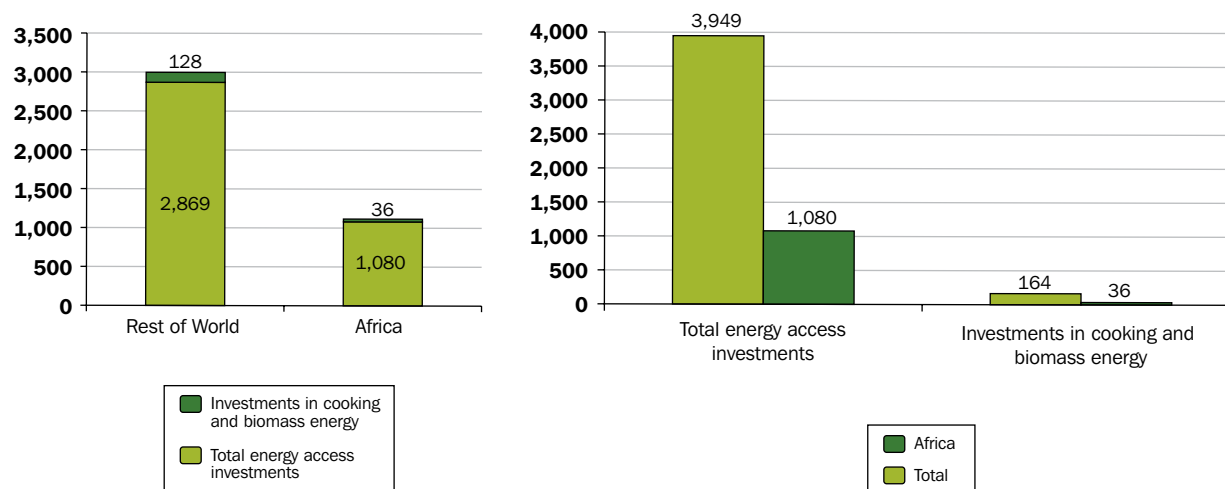
<sup>3</sup> However, wood-based energy is one the fastest growing renewable energy sources in Europe and North America (Bakhareva, 2008). Likewise, the use of wood for cooking and heating has significantly increased in many European and Central Asian countries after cost-recovery policies were introduced in the energy sector (ESMAP, 2007).



Given current trends of population growth, urbanization, economic growth, and relative price developments of other energy sources, it is likely that wood-based biomass will remain an important source of energy—especially for cooking—for many decades. Over 95% of the population in countries such as Burundi, Central African Republic (C.A.R.), Chad, Liberia, Rwanda, The Gambia and Sierra Leone lack access to modern energy, with the rural population relying almost exclusively on wood-based biomass energy for cooking (UNDP, 2009). Wood-based biomass as the main source of energy is reported at 68% in Kenya, 95% in Eritrea, 94% in Ethiopia, while Zambia and Uganda indicated 70% and 92%, respectively (van Beukering, 2007). In some African countries, the proportion of people with access to electricity is actually declining (VENRO, 2009). Access to electricity is not expected to replace wood-based fuel use for cooking as the cost of cooking using electricity or other alternatives such as liquefied petroleum gas (LPG) is often prohibitive.

Despite its great social, economic and environmental importance, wood-based biomass energy planning does not receive the attention it warrants at the national or even international policy agendas. A 2009 UNDP/WHO publication noted that 35 governments in SSA have set targets to increase access to electricity, but only 13 for modern fuels and just seven for improved stoves (UNDP, 2009). This demonstrates that wood-based biomass is typically viewed as energy of the past, considered dirty and inefficient, and expected to be replaced it as quickly as possible by alternative energy sources. Even where biomass is gaining attention in the national energy and economic policy debate, policies that regulate the market are often conflicting, unrealistic, or ineffective, because biomass energy is governed by different sectors, ministries and agencies. Also, the sector suffers from a lack of market incentives, steady support from financial institutions, and proper oversight (GTZ, 2007).

**Figure 1 | World Bank Energy Access Investments (FY2000-2008, US\$ million)**



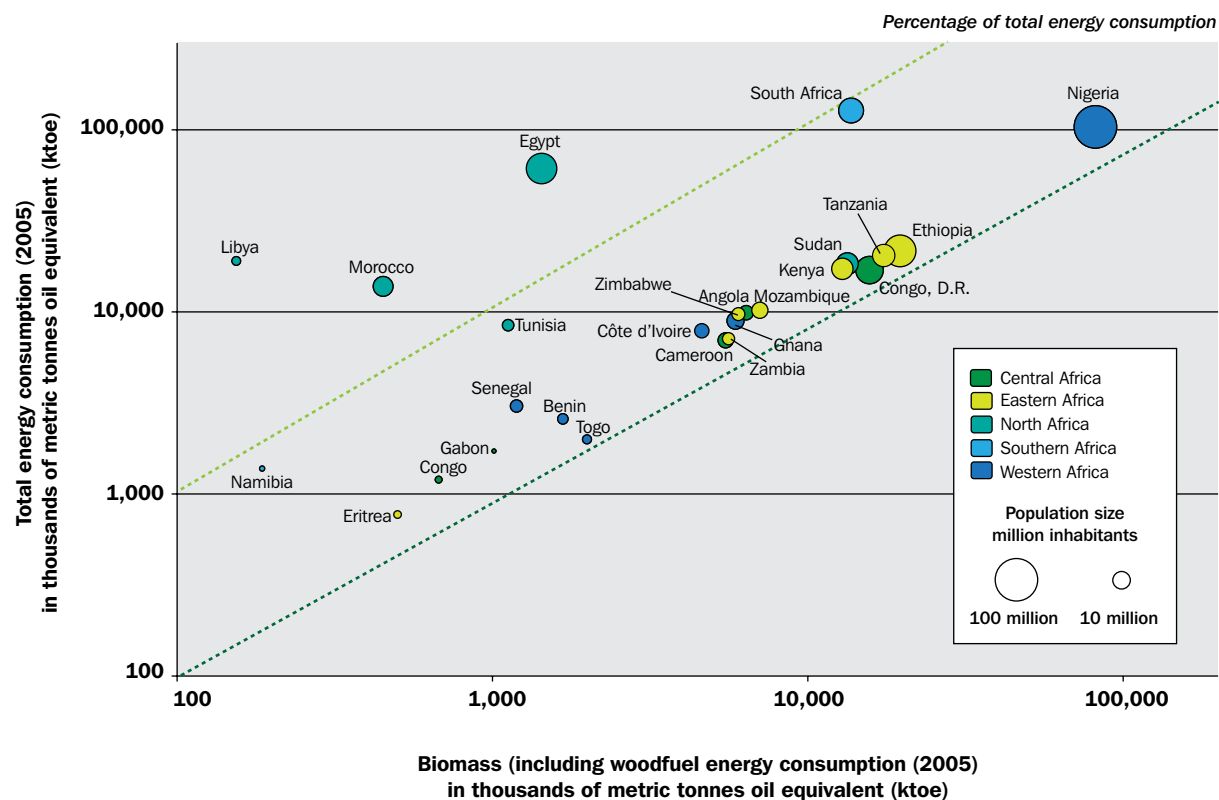
Source: World Bank Portfolio Review, Barnes et al., 2010.

**At present, biomass energy accounts for a very small percent of the World Bank's total energy portfolio.** From FY2000–2008, Africa energy investments were about US\$4.6 billion, with roughly US\$1.1 billion for energy access. Of this amount, only US\$36 million were classified as investment in cooking and biomass (Barnes et al., 2010)—just 3% of SSA energy access investments and less than 1% of total SSA energy investments. Operations in the SSA energy sector are high and growing, both in the size of investments and breadth of issues covered. Given the potential of sustainable biomass energy to contribute to poverty alleviation and sustainable management of natural resources, this form of modern energy is expected to be given more emphasis in the coming years.

**If the sector was modernized, it could become an integral part of the households' energy portfolio to satisfy increasing energy needs while promoting economic development and low-carbon growth.** With economic development, the demand for energy is increasing. Thus, investments are needed to accelerate access to electricity and other additional energy

sources. However, even if households have a wider range of energy sources from which to choose; such access will not necessarily substitute for wood-based biomass, which is mainly used for cooking. Studies show that households' fuel choices tend to be more complex and may consist of more than one type of fuel (Masera et al., 2000). Hence, some households may be inclined to gradually switch to other fuel types using several types of fuels in parallel in the transition period.

**Figure 2 | Total Energy Consumption, Biomass Energy Consumption, and Population in Africa (2005)**



Source: World Resources Institute. EarthTrends (<http://earthtrends.wri.org>) Searchable Database Results.<sup>4</sup>

Note: Data not available for Central African Republic and Equatorial Guinea.

## 1.2 OBJECTIVE OF THE PAPER

This approach paper discusses the current state of the wood-based biomass energy sector in Sub-Saharan Africa in order to identify issues and possible approaches to energy sustainability, which includes ways to modernize the sector and establish a dialogue on policy reforms and potential investment areas. In so doing, it aims to include biomass energy as a key part of the countries' overall energy strategies.

The paper also describes cross-sector links, the potential to further enhance collaboration across the Africa Region Sustainable Development Network, and the role of other stakeholders and partners in strengthening the policy dialogue on biomass energy—listing the opportunities for new financial instruments related to climate change. It highlights the role of the private sector as well as other development partners, for example in research and development, community engagement, or advocacy.

<sup>4</sup> Population, Health and Human Well-being – Population: Total population, both sexes, Units: Thousands of people; Energy and Resources – Energy Consumption: Total energy consumption, Units: Thousand tonnes of oil equivalent (ktoe); Energy and Resources – Energy Consumption by Source: Solid biomass (includes fuelwood), Units: Thousand tonnes of oil equivalent (ktoe).



**Given the fundamental role of wood-based biomass in satisfying SSA households' basic energy needs for cooking, the paper will focus on fuelwood and charcoal.** The former is primarily used in rural areas, and the latter is the primary energy source for cooking in urban areas. While other types of biomass could be used by households—for example biofuels derived from cultivated agricultural crops, such as jatropha or ethanol (Mitchell, 2011; Cushion et al., 2010)—the paper focuses only on wood-based biomass energy.

**The paper also describes the issues and opportunities for substituting energy sources (fuel switching).** Given the emerging challenges of relative energy price changes and policy developments aiming at low-carbon growth and climate change mitigation, the framework for economic and policy incentives targeted at fuel-switching is currently changing. In the 1980s and 1990s, it was expected that economic development would prompt consumers to easily adopt other fuel options. However, it has been recognized that even when fuel-switching can be promoted and the relative share of wood-based biomass consumers is falling, the amount of wood-based biomass consumed is likely to remain stable or even grow.

### **1.3 STRUCTURE OF THE PAPER**

**In the next section, the paper offers the rationale for addressing the issues with respect to the wood-based biomass energy sector.** It will discuss the changing context of wood-based biomass energy use that is currently observed in SSA and it will outline future scenarios of biomass energy development by drawing attention to the key attributes determining this change. **Following, the paper will portray potential approaches to the modernization of the biomass energy sector in SSA.** This section will not only differentiate by biomass energy use in rural and urban areas, but will also highlight the key characteristics of supply- and demand-side interventions. Supply-side interventions will focus on modernizing fuelwood and charcoal supply systems while the demand-side will discuss the potential of improved cooking technology in enhancing the efficiency of wood-based biomass use. This part of the paper will also discuss economic and policy incentives of switching to alternative fuels. Each section will elaborate distinct recommendations for engagement of the World Bank Group—particularly of the Africa Region Energy Unit. **Lastly, some more general recommendations will be drawn relevant to the sector as well as providing final recommendations for supporting wood-based biomass energy development.**



**>THERE IS A WELL-ESTABLISHED  
LINK BETWEEN ENERGY FOR COOKING  
AND THE MILLENNIUM DEVELOPMENT  
GOALS (MDGs), WITH MEASURES FOR  
INCREASING SUSTAINABLE BIOMASS  
PRODUCTION AND IMPROVING COOKING  
TECHNOLOGY BOTH CITED AS BEING  
MDG CONSISTENT TARGETS>**



# 2

**> IN SUB-SAHARAN AFRICA,  
ENERGY SECURITY IS AFFECTED  
BY SEVERAL KEY DEVELOPMENTS:  
POPULATION GROWTH,  
ACCELERATED URBANIZATION,  
ECONOMIC DEVELOPMENT AND  
RELATIVE PRICE CHANGES OF  
OTHER ENERGY OPTIONS >**



# RATIONALE FOR ENGAGEMENT IN WOOD-BASED BIOMASS ENERGY SECTOR

Wood-based biomass energy is and has been the most important energy source for hundreds of millions of rural and urban dwellers in all social segments. Despite its economic and environmental relevance, it seems to be politically neglected and even seen as a negative element. While the sector often employs tens of thousands of rural and urban poor, its potential to achieve long-term sustainable development is ignored. For example, coherent policies governing charcoal production, trade and use do not exist, and reliable statistics on the sector are generally not available in most countries. Consequently, the sector remains highly informal with regulations either unclear, not or only partially enforced, or easily bypassed due to pervasive corruption. In contrast to its “shadow” existence, the estimated total annual value of the charcoal sector exceeds other sectors, such as agricultural crops for export that are generally looked at for accelerating economic development and having a greater potential to contribute to economic development and poverty alleviation (World Bank, 2009).<sup>5</sup>

There is a well-established link between energy for cooking and MDGs, with measures for increasing sustainable biomass production and improving cooking technology both cited as being MDG consistent targets (UN Millennium Project, 2005). Freeing up time and lessening drudgery can allow more time to engage in income-generating activities while increased employment in the biomass sector can provide poverty relief to numerous households, helping in achieving poverty reduction targets. Availability of affordable cooking fuels and better cooking efficiency can help reduce hunger while lower time pressure on children to collect fuels has potential to increase possibilities for higher school enrollment and better education. Enabling productive work that is primarily undertaken by women can contribute to greater gender equality by reducing time and effort required for women and young girls to gather solid fuels. Reducing indoor air pollution (IAP) can lead to improving health outcomes for those exposed to IAP, with a particularly important objective to reduce child mortality. Indoor air pollution from solid biomass burning is responsible for diseases that cause more deaths globally than malaria and tuberculosis (IEA and WHO, 2010), so tackling IAP would also help with the target of combating major diseases. Finally, sustainable harvesting of wood can help ensure environmental sustainability and protect against damage caused by land and forest degradation.

It is now acknowledged that providing incentives to households to switch from wood-based energy sources—mainly through investments in alternate energy sources coupled with other policy measures, such as subsidy programs—has not yielded the desired results. In contrast, rapidly changing political and economic realities result in a stable or even increasing consumption of wood-based energy in SSA. This observation does not contradict the rationale for increasing investments in other energy sources, especially electricity, but underscores the manner in which they can be complementary, satisfying increased energy needs triggered by economic development. Rather than relying on one primary source of energy, households can choose from various types, optimizing their energy consumption against the two key constraints of affordability and reliability. In this regard, it is not expected that electricity will replace wood fuel for cooking, although it will be used to satisfy new energy needs, for example, for lighting, cooling and communications.

Beyond strengthening consumers’ energy security, modernizing the charcoal sector and changing its largely “informal” status produces other important benefits: First, many people are generally involved in producing, buying, transporting, and re-selling wood-based biomass; thus, the potential for poverty alleviation and the contribution to the domestic economy cannot be underestimated. Second, revenue collection could be significantly enhanced to leverage much needed resources for investments in sustainable natural resource management and other aspects of economic development. Third, the charcoal sector displays many possibilities for major investments in GHG emission reductions on a large scale. With appropriate policies—which require major reforms in almost all SSA countries—investments in forest management, fuel wood, charcoal production and stove technology could be linked with carbon finance options. Last, pro-actively promoting and distributing improved cookstoves<sup>6</sup> should be mandatory. In 2008, more people died from smoke due to cooking with wood-based biomass

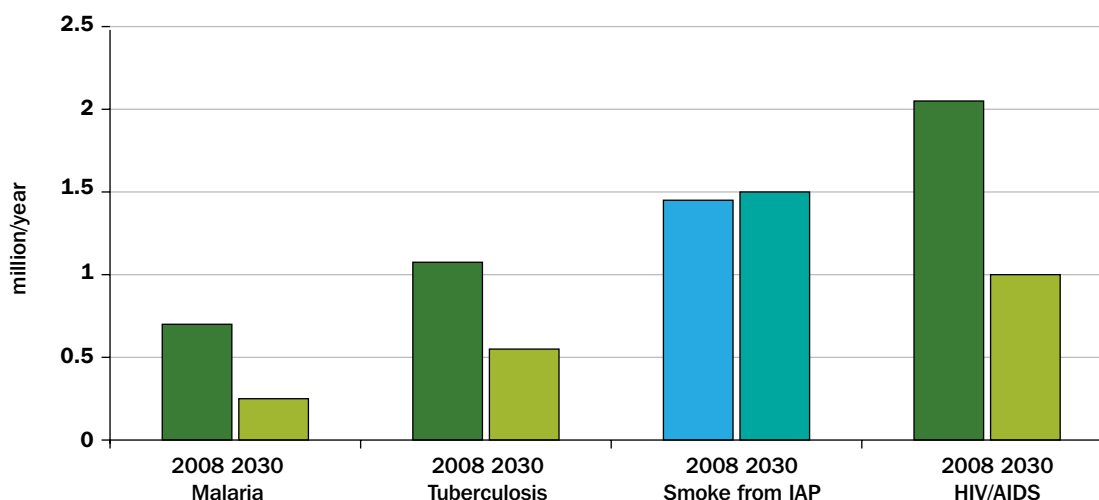
<sup>5</sup> For Tanzania, it was found that the economic contribution of the charcoal sector for Dar es Salaam alone exceeded the coffee and tea sectors.

<sup>6</sup> Throughout the paper, the term *improved cookstove* will be used to refer to either the *advanced biomass cookstoves* or the *effective improved cookstoves*, as defined in a forthcoming World Bank publication (World Bank, 2011a). The advanced biomass cookstoves were developed more recently with the help of the private sector and technical research centers; these cookstoves are generally more expensive, and are based on higher but as yet not well-defined standards that include safety, efficiency, emissions, and durability; among others. The *effective improved cookstove* is cheaper but close in performance to advanced biomass cookstoves; it is assembled on-site by qualified installers adhering to standards. Finally, the term *traditional cookstove* refers to either open fires or cookstoves constructed by artisans or household members that are not energy efficient and have poor combustion features.



than from malaria or tuberculosis (see Figure 3). By 2030, it is estimated that over 4,000 could die prematurely every day from indoor air pollution (IEA and WHO, 2010) if no measures are taken.

**Figure 3 | Number of Deaths from Indoor Air Pollution-Related Health Complications**



Source: IEA and WHO, 2010.

Since these conditions point to the need to strengthen engagement in the biomass energy sector, the following paragraphs will offer comprehensive details that support these assumptions.

## 2.1. ENERGY SECURITY

**In SSA, energy security is affected by several key developments: population growth, accelerated urbanization, economic development and relative price changes of other energy options.** Studies show a positive relationship between population growth rates and energy demand (Kebede et al., 2010). Projections suggest that the consumption of wood-based biomass by SSA households will increase in relative terms over the next 30 years as demographic growth continues to outstrip access to other modern fuels (IEA, 2009). Even an efficiency increase in per-capita wood-based biomass consumption is not likely to off-set this development in absolute terms; thus, the quantity of wood and wood-based biomass used to satisfy energy demand will remain at high levels and probably grow.

**Increased urbanization is also accelerating the demand for wood fuel—especially charcoal—which is the fuel of choice for most SSA urban residents.** In 2009, Africa’s population exceeded one billion, of which 395 million (or 40%) lived in urban areas. By 2030, the urban population is expected to reach about 780 million (UN Habitat, 2010). In Dar es Salaam (Tanzania), it has been observed that a 1% increase in urbanization can lead to an increase of up to 14% in charcoal consumption (Hosier et al., 1993). This multiplier effect results from the fact that urbanization leads to smaller household size, more frequent cooking activities, and significantly increased consumption by businesses and public facilities, such as small restaurants and hospitals, schools, universities, prisons, and for brick burning for housing construction (GTZ, 2010).

**Although most SSA countries experienced strong price hikes for commercial wood-based biomass over the past years, prices of other energy sources also increased, which meant there was little incentive to switch away from wood-based biomass.** For example, from 2001-2007, the number of households in Dar es Salaam using charcoal for cooking increased from 47% to 71%, while use of LPG declined from 43% to 12%. In other urban areas of Tanzania, the share of the population cooking with charcoal remained at 53%, while the share of those using fuelwood rose from 33% to 38%. At the same time, the use of electricity for cooking is below 1% (World Bank, 2009). In Senegal, consumers returned in large numbers to wood-based biomass for cooking after subsidies for LPG were eliminated, causing its price to increase significantly (IISD, 2010).

The reliability of supply is another issue that keeps consumers with wood-based biomass: not only can the quantity purchased be adjusted to a household's available cash, but it is also obtained through a wide network of retailers and there is never a shortage. In contrast, consumers report that the supply of other fuels—especially LPG—is unreliable and, thus, unattractive for regular use (World Bank, 2009).

## 2.2. POVERTY ALLEVIATION AND ECONOMIC DEVELOPMENT

**In contrast to fossil fuel-based energy sources, such as kerosene, paraffin, or LPG, that are often imported and negatively affect the countries' macro-economic balance sheets, wood-based biomass could create value-added, supporting economic development and poverty alleviation.** In most SSA countries, the wood-based biomass sector employs a significant workforce, generally providing regular income to tens – if not hundreds – of thousands of people. For example, the charcoal sector for Dar-es-Salaam (Tanzania) alone is estimated to provide opportunities for labor and cash income for several hundred thousand people, especially among the poorest, who have no other alternative livelihood options. For Kenya, it is estimated that about 700,000 people work in the charcoal sector (Sepp, 2008a). For Malawi, two recent studies confirm similar trends: Kambewa et al., (2007) estimate that about 100,000 people regularly support their livelihoods through charcoal production, transport, and retailing, while Openshaw (2010) assumes that 93,500 and 133,000 were employed full-time in 1996 and 2008, respectively, in the biomass supply chain, compared to about 3,400 and 4,600 people employed in the supply chain of other fuels during the same period. In Uganda, around 200,000 permanently earn money from charcoal ESD (2007). Another study for Uganda found that if households are involved in charcoal production, it reduces their likelihood of falling below a poverty line by approximately 14% (Khundi et al., 2010). For Ghana, it is estimated that the charcoal sector employs 3 million people, of which 65% are women (Mombu and Ohemeng, 2008). However, it must be acknowledged that estimating employment in a largely informal sector is difficult and likely to lead to an undercount, which further confirms the potential of this sector for local employment and poverty alleviation.

**Due to its informal nature, the wood-based biomass energy sector is systematically neglected in formal economic analyses; thus, formal recognition of its role and potential for economic development is urgently needed.** In Rwanda, the charcoal sector is estimated to account for an annual volume of US\$77 million (van der Plas, 2008), while in Kenya, total income from charcoal is estimated at US\$450 million, equal to the country's tea industry ESD (2007). In Dar es Salaam, the total annual revenue generated by the charcoal sector alone is estimated at US\$350 million, exceeding sectors such as coffee and tea that are estimated to contribute only US\$60 million and US\$45 million to the national economy, respectively, but are traditionally considered as drivers of economic development (World Bank, 2009). In Malawi, the market value of traded fuel wood was US\$49 million in 1996 and US\$81 million in 2008—estimated at about 3.5% of GDP (Openshaw, 2010).

**Complementary to creating important employment for the poor segments of society that generally do not have access to formal employment, the contribution of the wood-based biomass energy sector to the national economy is significant and can easily surpass other economic sectors.** Extrapolating to the whole of Sub-Saharan Africa on the basis of three studies (in Kenya<sup>7</sup>, Malawi<sup>8</sup>, and Tanzania<sup>9</sup>), rough estimates indicate that the charcoal industry in Sub-Saharan Africa was worth more than US\$8 billion in 2007, with more than 7 million people dependent on the sector for their livelihoods. The International Energy Agency forecasts that by 2030 the number of people relying on the traditional use of biomass may increase to 918 million (IEA, 2010<sup>10</sup>). In line with this prediction, the economic value of the charcoal industry may exceed US\$12 billion by 2030, employing almost 12 million people.

**Modernizing the wood-based biomass energy sector has the potential of significantly increasing the revenue base of most SSA countries, unlocking resources urgently needed for investments in natural resources and other key areas for sustainable economic development and green growth.** For example, in Kenya, government revenue losses from clandestine charcoal production and trade are estimated at around US\$65 million (ESD, 2007), while in Tanzania, this amount is estimated to be around US\$100 million (World Bank, 2009). Indirect value-added, such as employment for government officials or taxes charged on production inputs, such as the use of mobile telephones or tools, are not even considered.

<sup>7</sup> Mutimba, Stephen. 2005. National Charcoal Survey: Summary Report June 2005 ESDA. Nairobi. Kenya. in: André Seidel. 2008. Charcoal in Africa: Importance, Problems and Possible Solution Strategies, On behalf of the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, Household Energy Programme – HERA.

<sup>8</sup> Government of Malawi. 2009. Malawi Biomass Energy Strategy.

<sup>9</sup> World Bank. 2009. Environmental Crisis or Sustainable Development Opportunity? Transforming the charcoal sector in Tanzania: A Policy Note. Washington, DC: World Bank.

<sup>10</sup> IEA. 2010. World Energy Outlook 2010. WEO. OECD/IEA Paris, France.



## 2.3. CLIMATE CHANGE AND GREENHOUSE GAS (GHG) EMISSIONS

Given the continuing importance of wood-based biomass to satisfy energy needs, a sustainable wood energy sector could reduce GHG emissions throughout its entire value chain and thus taking a key role for implementing low-carbon growth strategies in SSA. At present, cooking with traditional biomass fuels may account for approximately 18% of current global GHG emissions if forest degradation and deforestation are included in the equation (SEI, 2008), and it is estimated that traditional charcoal production emits nine tons of CO<sub>2</sub> for every ton of charcoal produced. However, if charcoal were to be sustainably produced, it would be carbon neutral—since the emitted carbon could be sequestered by trees that are planted: In this scenario, one ton of sustainable charcoal would offset one ton of non-sustainable charcoal or nine tons of carbon dioxide (GEF, 2010).

Sustainably produced biomass has minimal emission effects although, if taken into account, traditional uses of biomass energy may include transportation over long distances (especially in the case of charcoal), which uses fossil fuels (Cushion et al., 2010). Nevertheless, it must be acknowledged that Africa accounts for only 2%–3% of the world's CO<sub>2</sub> emissions from energy and industrial sources, and 7% if emissions from land use (forests) are considered (UNECA, 2002).

It is essential to target the wood-based biomass energy sector if recent financial mechanisms that support sustainable forest management programs to reduce GHG emissions are to succeed, such as REDD, REDD+, and the Forest Investment Program (FIP). At present, the often free and unregulated use of forests for wood-based biomass exploitation causes significant forest degradation and—coupled with other land-use changes—deforestation. Most—if not all—REDD strategies developed by SSA countries contain actions to make the extraction of wood-based fuel sustainable, helping countries achieve low-carbon growth while simultaneously satisfying the basic energy needs of rapidly growing populations. Voluntary markets have, in many instances, shown a preference for forestry credits (Chenost et al., 2010). Forestry projects are already supported in pilots by the Biocarbon Fund, Forest Carbon Partnership Facility (FCPF), UNEP program CASCADE, and UN-REDD. If they were expanded beyond the pilot phase, they should deliver benefits for both climate change mitigation and provide new sources of financing. Further, enabling local populations earn a steady income through wood-based biomass extraction has a direct economic value—as it reduces the incentive to convert forests into other land-use systems that deliver higher direct benefits.

The conversion of wood into charcoal is probably the step in the charcoal value chain with the highest potential for reducing GHG emissions. At present, however, the unregulated production of charcoal does not create an environment that promotes investments in better methods and technologies; hence, charcoal is still produced with very traditional processes.

### > THE CONVERSION OF WOOD INTO CHARCOAL IS PROBABLY THE STEP IN THE CHARCOAL VALUE CHAIN WITH THE HIGHEST POTENTIAL FOR REDUCING GHG EMISSIONS >

Thus, improvements would yield higher efficiencies—lowering GHG emissions per unit of charcoal produced—and would also further reduce emissions during pyrolysis. At present, the use of traditional pyrolysis methods along with unsustainable harvesting are probably the greatest contributor of GHG emissions along the charcoal value chain and improvements could help lower the amount. For example, a community producing 10 tons of sustainable charcoal could earn US\$450,000 selling carbon credits, in addition to the sale value of the charcoal, if efficient charcoaling techniques were introduced (GEF, 2010).

Improved cookstoves are also vital for reducing GHG emissions: They could improve the efficiency of the fuel, reduce GHG emissions through an enhanced combustion process, and lower air pollution that affects the health of mainly women and children. Given the importance of the last factor, the rationale for further distributing improved cookstoves is discussed under the issues and approaches section.

Unlike fossil fuel emissions which release higher quantities of CO<sub>2</sub>, fuelwood burning releases black carbon, which only remains in the atmosphere for several weeks instead of 50-100 years lifetime of CO<sub>2</sub>. Biomass burning in cookstoves emits black carbon (BC) as part of visible smoke. Black carbon is particulate matter that results from incomplete combustion. Black carbon absorbs heat from the Sun, and keeps it in the atmosphere. Climate science now views BC as the second or third largest warming agent after carbon dioxide, alongside methane. In biomass burning, BC is emitted together with large amounts of organic carbon particles, which exert a cooling influence on climate. In the case of biomass cooking, the warming effects of BC and the cooling effects of organic carbon appear to be closely balanced. There is thus some uncertainty at present about the net impact on global warming of smoke from cookstoves. Intensive research on this aspect of climate change is currently underway. However BC from biomass burning can have a large impact at the regional level: it accelerates melting of ice and snow, and contributes to regional pollution which can alter climate and precipitation over a wide area.

## 2.4. HEALTH AND GENDER ISSUES

**Traditional wood stoves commonly used in SSA burn fuel inefficiently, with smoke and gases produced by incomplete combustion that cause long-term respiratory health problems and deaths.** According to WHO reports, smoke from primitive indoor stoves fueled by wood, coal, crop waste, and dung, kills at least 1.5 million people worldwide per year, disproportionately affecting women and children (IEA and WHO, 2010). In fact, PM levels from solid biomass fuel use in households may be 10-50 times higher than the WHO guideline values (Pennise et al., 2009; WHO, 2005b). There is strong scientific evidence linking indoor air pollution (IAP) from the use of solid fuels to preventable diseases such as pneumonia in young children under 5 (Smith et al., 2000a; Dherani et al., 2008), accounting for an estimated 10% of disease-related deaths in Africa (Bruce et al., 2010) and to chronic obstructive pulmonary diseases such as chronic bronchitis and emphysema in women (American Thoracic Society, 2008). Further, daily discomfort in women from coughs, headaches, stinging eyes and backaches are commonly associated with traditional cooking methods (WHO, 2008). Moreover, the impact of IAP from solid fuels in SSA is even worse if the numbers of years lost due to ill-health, disability or early death are considered. Applying the disability-adjusted life year (DALY) as a recognized measure of overall disease burden, 44% of all the IAP-cased DALYs worldwide occur in SSA (UNDP, 2009).

**Besides these health impacts, women in rural areas usually spend long hours collecting wood-based biomass—time that would carry higher value-added to the household if it could be used for child-care, agricultural production, education and other activities.** While the distances traveled to collect fuelwood vary greatly depending on region and area of the country, distances in a Tanzania case study were up to 10 miles (IEA WEO, 2006).

This demonstrates that gathering fuelwood can be physically demanding and also accompanied by other negative attributes, such as sexual assaults and snake bites. However, it must be noted that collecting fuelwood often occurs as a “by-product” of other activities, e.g. walking to and from the fields, collecting water, and other daily tasks.

**If traditional biomass energy use in SSA was modernized, it could bring far-reaching benefits in both the short and long term and raise household living standards.** According to women using improved cookstoves in Kenya, time gained from faster cooking was used for farming, income-generating activities, girls' education and women's participation in community life (GTZ, 2009); 220 women interviewed said they highly valued the opportunity to save time, much more than saving fuel (Vermeulen, 2001). However, since this very much depends on opportunities available in the community, evidence from larger studies has shown mixed results when it comes to whether the time saved goes towards productive uses or income-generation, such as with improved access to water (Koolwal and van de Walle, 2010).

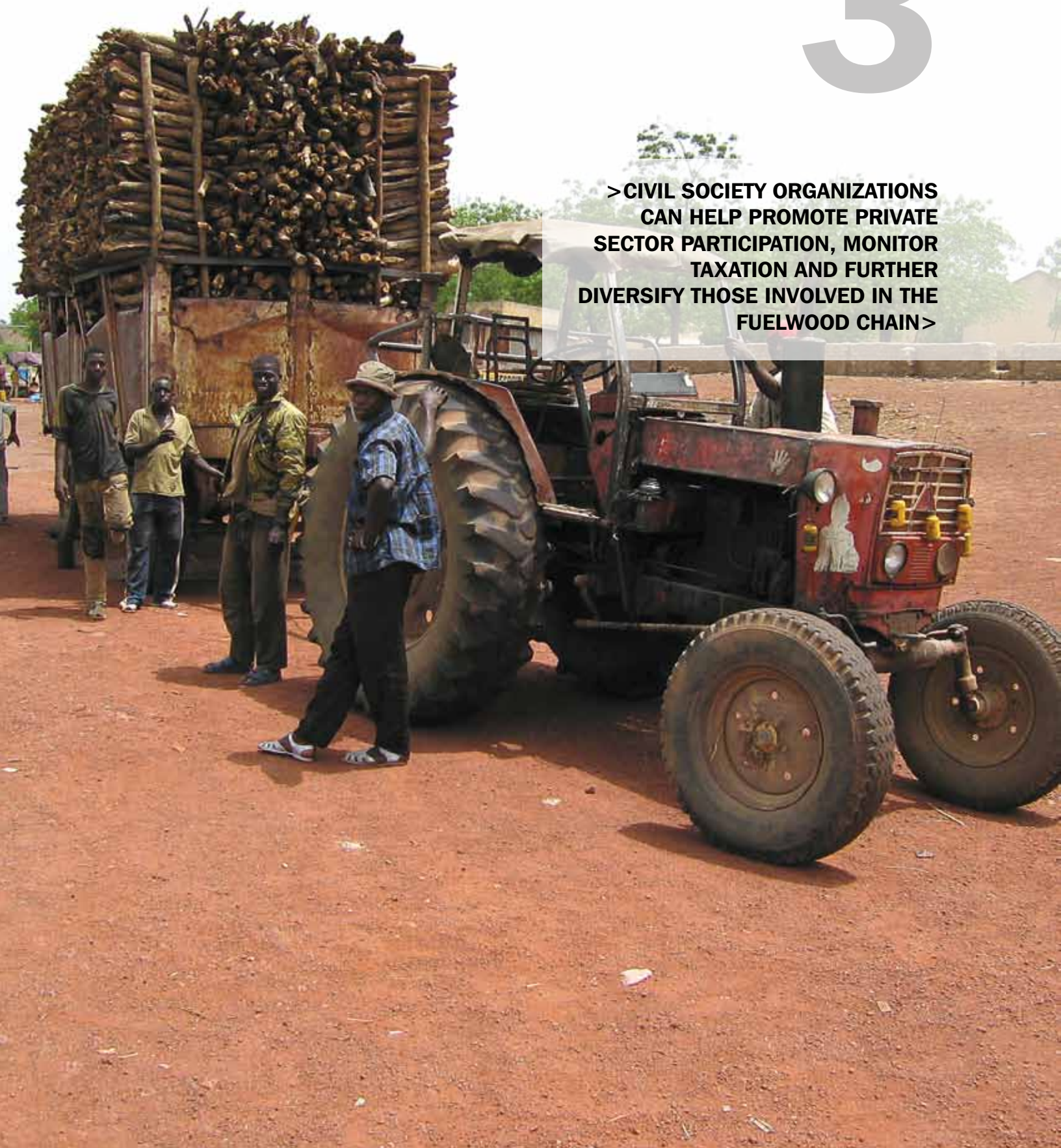
**Producing cookstoves can provide business opportunities for many entrepreneurs, while other operations— such as formalizing the charcoal sector and creating fuelwood markets—can bring a range of income generating benefits.** In Kenya, reports suggest that on average, 337 improved cookstoves were produced each month per producer, who earned an average monthly income of US\$120-US\$240 (GTZ, 2009). Moreover, fuel, time and money savings can also be a factor for some businesses such as restaurants that would be able to take advantage of newer technologies: For example, households can save an estimated half-ton of fuelwood each year if they own one of the new generation of improved stoves, which substantially affects their income (Adkins et al., 2010).

**>IF TRADITIONAL BIOMASS ENERGY USE IN SSA WAS MODERNIZED, IT COULD BRING FAR-REACHING BENEFITS IN BOTH THE SHORT AND LONG TERM AND RAISE HOUSEHOLD LIVING STANDARDS>**



# 3

**>CIVIL SOCIETY ORGANIZATIONS  
CAN HELP PROMOTE PRIVATE  
SECTOR PARTICIPATION, MONITOR  
TAXATION AND FURTHER  
DIVERSIFY THOSE INVOLVED IN THE  
FUELWOOD CHAIN>**



# ISSUES AND APPROACHES

The discussion of the issues related to modernizing wood-based biomass management in Sub-Saharan Africa and the approaches available for engagement are differentiated in two broad categories: **fuelwood**, predominantly used by rural people, and **charcoal**, the major cooking fuel for the urban population. Traditionally, fuelwood is characterized by subsistence collection, but the commercialization of rural fuelwood markets has increased significantly over the past decade. Charcoal is almost entirely commercialized and the associated value-chain involves a complex structure of many stakeholders. The issues surrounding the two fuels, including improved cookstoves, are discussed separately, particularly with respect to the options available for World Bank country dialogue, technical assistance (TA), and investment operations.

Given the large range of options available in the wood-based biomass energy sector, implementation is likely to involve not only the World Bank but also development partners and civil society institutions. Accordingly, this paper emphasizes the options where the World Bank could be considered to have a comparative advantage. However, cooperation with development partners is generally desired and needed. If, in specific cases, the paper mentions the particular role of certain development partners, it is acknowledged there are generally many others that could fill a similar role and serve as partners for the World Bank to meet its objectives.

Because wood-based biomass energy is multi-sectored, the issues and approaches also cross several World Bank units, most of which fall under the Sustainable Development Network. The discussion will indicate where certain sectors or units may have a comparative advantage and propose areas where further enhancing the cooperation and coordination across departments can create added benefits. It is expected that such efforts would strengthen the overall policy dialogue with client countries and thus avoid duplicated, conflicting, or even mutually exclusive investments or policy advice. It is further hoped this will facilitate similar cross-sectoral considerations by client countries and development partners, who are often faced with similar challenges regarding cross-sectoral or cross-ministerial communications and collaborations.

## 3.1 FUELWOOD

Fuelwood consumption by rural households is no longer considered a principal cause of forest degradation or deforestation. Nevertheless, fuelwood is often still portrayed as a fuel source associated with energy poverty and forest depletion, a remnant of the “fuelwood crisis” of the 1970s and 1980s (Hiemstra-van der Horst and Hovorka, 2009). But, information now available shows that fuelwood is seldom the primary source of forest removal. Rather, land clearing for agriculture, commercial and residential development, and other permanent land-use changes are the main contributors (Deweese, 1989; ESMAP, 2001; Arnold et al., 2005). Conversely, the harvesting of fuelwood for energy is most likely not depleting wood stocks beyond what would be cleared from these other activities. If fuelwood harvesting is the only objective for forest exploitation, the regeneration potential of the forest ecosystem may generally off-set the quantities extracted, thus, not causing a permanent decline in forest stocks. A 1996 production survey in Malawi showed that nearly 40% of fuelwood came from open land (such as farm land) and from roadside trees, grasslands and urban trees; 15% of the wood came from plantations and woodlots (Openshaw, 2010). If, in some areas, fuelwood collection is coupled with charcoal production, a higher degree of forest degradation may still be attributed to the harvesting of fuelwood for household consumption (Arnold et al., 2005; Mwampamba, 2007; van Beukering et al., 2007).

The use of fuelwood—especially the extraction from forest resources—tends to be characterized by poor policies that often follow a “command and control” structure rather than promote sustainable management of forests in collaboration with local stakeholders. Government institutions often try to limit access rights to local resources with the goal of regulating the use of woodlands (Hiemstra-van der Horst and Hovorka, 2009); this tends to be ineffective, costly, bureaucratic, and often even unenforceable given the limited means available to local governments. Consequently, this prevents communities from becoming involved in managing the local resources and benefiting from the forests and fuelwood trade.



**If the rights and responsibilities with respect to the forests were devolved to the local level, this could be an incentive to local stakeholders to manage the resource sustainably.** Under such a process, the role of central government would be mainly reduced to devising supportive policies, while local government institutions could concentrate on technical matters such as building capacities and providing advice on sustainable forest management, and enforcing progressive laws and revenue collection systems (Foley et al., 2002). However, such reforms are often obstructed by strong vested interests from stakeholders benefiting from oligopolistic market structures, extra-legal rent seeking, and corruption.

**At present, only small numbers of urban-based fuelwood traders are typically able to obtain exploitation permits, often resulting in an oligopolistic fuelwood industry.** Rural users often have to compete among themselves and well as with demands from urban and industrial users (Arnold et al., 2003). Also, besides creating oligopolistic market structures, current licensing systems are not related to sustainable harvests. As a remnant of colonial times, most license systems still operate merely for revenue collection, without the quantities of wood harvested linked to any measures of sustainability. Further, if existing laws and governance systems were strengthened, this would likely only result in more extra-legal behavior and stronger oligopolistic market structures. Therefore, enhancing Forest Law Enforcement and Governance (FLEG) requires a reform and modernization of the underlying policies (ESMAP, 2010).

**A key element of supportive policies is providing communities or individuals with long-term land- and tree tenure security to manage trees and forests for fuelwood production (ESMAP, 2010).** Without a clear assignment of land rights, local people have no incentive but to exploit woodlands for short-term benefits; even short-term tenure does not provide enough incentive to plant trees or invest in soil maintenance, which typically requires long-term investments and commitments (FAO, 2004). It is acknowledged that transaction costs for implementing the necessary laws and regulations to guarantee tenure rights may be a disincentive to implement such reforms (Hatcher, 2009).

**Enhancing supply-side interventions through community based forest management approaches have potential to be successful in the SSA context.** Rights and responsibilities associated with sustainable forest management are transferred to the local level, generally including the transfer of tree and/or land rights (de Miranda et al., 2010). Technical oversight, including capacity building, is ideally provided by community authorities who sign a contract with the forest service clearly defining rights and obligations and effectively restricting free access by outside loggers and traders. The model entails community involvement in the sustainable management of public forests and its subsequent use of sustainable resources for commercial purposes. A share of the taxes paid to the community or local government is designed to be reinvested in forest maintenance but also in social infrastructure such as education and health services, and those needed for economic development.

**Programs targeting community-level supply-side interventions can build on the experience and lessons from a wide range of successful projects and programs.** A successful Community-based Woodfuel Production (CBWP) project is in Senegal, where sustainable community-based forest management systems were successfully established (see case study in Box 1). Other countries established plans for Sustainable Forest Management (SFM), such as Benin, with 300,000 hectares of sustainable forest management systems, aiming to expand to 600,000 hectares, Mali where 1.4 million hectares will involve sustainably managed wood-based biomass approaches, and Burkina Faso, where 441,000 hectares are currently under SFM and 270,000 are to be added. In Ethiopia, it is the plan to bring a total of 300,000 hectares of natural forest under participatory management schemes for woodfuel production. In Madagascar, much of the charcoal consumed in the capital Antananarivo comes from sustainable eucalyptus plantations established around the capital since colonial times (ESMAP, 2010).

**Improving rural wood-based biomass markets can yield many benefits that extend beyond generating revenues for communities, such as maintaining an interest in sustainably managing forest resources.**<sup>11</sup> The creation of rural fuelwood markets is not typically a sign of peri-urban land degradation and fuelwood scarcity as it is more an opportunity for rural areas to respond to growing urban energy biomass needs (Hiemstra-van der Horst and Hovorka, 2009). Sales from fuelwood markets provide a critical source of support for rural incomes where employment opportunities are very limited. One way to improve these markets is by investing in scaling-up the infrastructure, such as trading sites, as well as promoting the development of forest management plans. One of the most important advantages of this process is that fuelwood trading can be better controlled and, thus, unsustainable management practices identified. The private sector can have an important role in establishing rural fuelwood markets since their rewards are directly linked to the markets' success. Civil society organizations can help promote private sector participation, monitor taxation systems and further diversify those involved in the fuelwood chain.

---

<sup>11</sup> Rural fuelwood markets are described according to their successful application in Niger (Foley et al., 2002).



### Box 1 | Senegal Case Study: Supply-Side Intervention via Community-Based Sustainable Forest Management

As in most of SSA, supply of woodfuel to the urban and peri-urban markets in Senegal was previously based on non-sustainable forest resource management practices such as clear cutting. Low wood-to-charcoal conversion efficiency and high overall charcoal consumption at about 1.2 times the total consumption of woodfuel put great pressure on the supply system. Forest service rights were given only to urban-based traders which resulted in vertically integrated and oligopolistic supply systems; the traders surpassed charcoal production quotas due to ineffective monitoring systems.

By providing *technical support* to participating rural communities, the World Bank's PROGEDE initiative helped 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 woodfuel, equal to about 67,400 tons of charcoal per year. Results greatly exceeded the goals at time of appraisal (with an average 215 achievement index figure compared to the appraisal report). In addition, PROGEDE supported the *establishment of community-based micro-enterprises* including beneficiary-operated improved carbonization units for charcoal development. Other successful accomplishments were the comprehensive *communication strategy* that supported the SFM implementation and capacity development for revitalizing dormant women's groups.

The lessons from PROGEDE are the following:

- Traditional energy supply systems can be sustainable and supply-side management (through community-based natural resource management) is an essential intervention.
- Legally enforceable forest tenure rights are important to provide incentives for the community to invest in the management of the resources.
- A clear and fair pricing system, which maximizes producer prices along with a transparent fiscal and taxation system, needs to be created.
- Gender investments should not be underestimated as they bring the most significant and tangible poverty alleviation impacts, especially in terms of educating the beneficiary population, particularly the children.

The reason this process was so successful involved the use of sustainable natural resource management methods and the findings of seminars dating back to 1994 that were sponsored by the Government Departments of Energy and Forestry and supported by RPTES (RPTES 1996).

A second phase of the program, PROGEDE II, aims to: (a) further reduce the loss of forest cover and the ecosystem's carbon sequestration potential and biodiversity, and (b) generate opportunities for employment and income generation in the participating communities.

*Source: PROGEDE Implementation Completion Report, World Bank, 2005.*

Despite the great potential, challenges regarding rural fuelwood markets remain that should be considered. Vested interests will continue to represent one of the greatest challenges when attempting to modernize rural fuelwood markets. Depending on the community's social structure, much of the revenues can go to specific individuals rather than the whole community. Moreover, certain groups can experience losses when fuelwood markets are established: In Niger, women may have been disadvantaged because men are the primary collectors of fuelwood revenue and women may have lost the little they earned from gathering fuelwood.

Supporting agro-forestry systems is a particularly suitable approach for maintaining sustainable wood-based biomass production, especially for rural households that collect fuelwood on a subsistence basis. In addition to promoting sustainable fuelwood production, agro-forestry systems create several benefits, such as soil conservation and increased agricultural productivity. By planting trees with agricultural crops on the same land, the soil's nutrient content can be preserved and even enhanced, making the land more suitable for agricultural production. Providing shade and protection against wind and heavy rain also contribute to agricultural productivity (Cushion et al., 2010). There appears to be scope in certain situations for interventions that could increase the range of low cost, multi-purpose wood species and husbandry options available to farmers, to help them increase fuelwood supplies as a co- or bi-product of managing on-farm trees and shrubs for other benefits (Arnold et al., 2005).

## Box 2 | IBI Bateke, DRC – Tree Intercropping Afforestation in Degraded Savannah Lands

In 2009, through its BioCarbon Fund, the World Bank began financing an afforestation and clean energy project in DRC that was based on inter-cropping techniques; it intended to purchase 500,000 tons of carbon credits to be generated by the project until 2017. The initiative is being carried out by a local DRC organization called NOVACEL, which has been exploring tree and agricultural inter-cropping and carbon sequestration techniques to be used in degraded savannah grasslands on the Bateke Plateau targeting some 4,220 hectares. The land has been legally titled by the government in the form of a 25-year lease to directors of NOVACEL.

The project uses forestry and agro-forestry plots to introduce cassava intercrops which have so far been successful. NOVACEL is also researching agro-forestry techniques for intercropping trees with manioc plantations, using various species of Acacia and Eucalyptus trees. The project serves multiple purposes, with the main goal of increasing the yield of fuelwood for charcoal supply to high demand markets in Kinshasa, while reducing degradation and deforestation of the remaining forests. Other important goals are to reduce water loss and improve soil fertility, promote carbon sequestration, create permanent and temporary employment (an estimated 55 to 60 permanent jobs and up to 400 temporary jobs), enhance community development and reduce poverty. The project has the potential to create a carbon sink capable of sequestering around 1 million of CO<sub>2</sub> until 2017 and 2.4 million of tons of CO<sub>2</sub> over 30 years.

Source: World Bank News, 2009.

Differential taxation of fuelwood is a means by which governments can introduce fiscal incentives to traders to use the fuelwood markets rather than obtain their supplies in an uncontrolled fashion from natural woodlands. The tax, collected by the government, is placed on resources taken from open woodlands and is designed to: (a) discourage traders from buying fuelwood extracted from natural woodlands; and (b) encourage the extraction of more distant fuelwood resources over those closer to the urban areas. Tax for sustainably produced fuelwood would be lower or abolished to encourage traders to buy it, and perhaps lower government administration costs if untaxed.

## Box 3 | Chad Differential Taxation

The World Bank Household Energy Project (Chad) pursued community-based woodfuel production scheme through: (i) strengthening community tenure and use rights and (ii) establishing differential taxation. Political and legal-regulatory frameworks were created during a preparatory phase (1998-2000). The operations phase (2000-2003) focused on practical implementation.

Differential taxation served to: (a) return 90% of tax revenues to communities and local management structures (LMS), and (b) discourage unregulated exploitation of open-access areas by means of a surcharge. Illegal logging and tax evasion carried a fourfold surcharge plus additional fines, and strict controls/law enforcement (at city-limit checkpoints) ensured the system would operate. This arrangement created a strong incentive for sustainable forest management, as illustrated by the participation of more than 100 villages (with a total area 450,000 ha) within just four years. The retail price of fuelwood increased by 20% after two years: Fuelwood gained its “true” price and communities were convinced to further invest in forest management. However, the project’s success alarmed certain interest groups, whose influence subsequently eroded policy commitment and national ownership. The government reversed its policy, enacted a blanket charcoal ban, and used force to nullify community tenure rights. The basis for operating differential taxation was thus lost, causing the newly introduced system to collapse. However, the model serves as an example of what can be accomplished with appropriate policies.

Source: ESMAP, 2010.

On the demand-side, people in rural areas often use traditional cookstoves, which are primitive, highly inefficient, and strongly polluting. Coupled with obvious income constraints, rural households most often use a three stone set-up—the simplest cookstove available. Consequently, there is an enormous potential for significant efficiency gains with regard to the quantity of fuel used, and reducing GHGs and other airborne particles such as black and brown carbon that cause both Indoor Air Pollution and contribute to climate change.

**Analogous to urban cookstove programs, recent field studies demonstrate the fuel-saving potential of improved cookstoves in rural areas.**<sup>12</sup> As part of the Millennium Villages Project (MVP), a multi-sectoral development project spanning 14 sites in 10 countries throughout SSA, cookstove research was carried out in Tanzania and Uganda in 2009 (Adkins et al., 2010). Households were randomly selected from the MVP databases and cooking tests were conducted in the rural kitchens with fuel obtained by households. Results from this study showed a substantial and statistically significant fuelwood savings relative to the three-stone fire, with average values from 22% to 46%, depending upon the stove and food combination. The imported stoves were generally seen as preferable to the three-stone fire.

#### **Box 4 | The Impact of Improved Cookstoves (ICS) on Particulate Matter (PM) Emissions**

Research over the last few years shows improved cookstoves reduce both particulate matter (PM) and carbon monoxide (CO) (Dutta et al., 2007; Roden et al., 2009; Pennise, 2009). Field tests from stoves in Maharashtra, India from 2004-2005 showed that 48-hour mean CO concentrations were reduced by an average of about 39%. The 48-hour mean PM<sub>2.5</sub> concentration was also reduced, from 24%-49%, depending on stove type (Dutta et al., 2007). Both stoves tested were two-pot stoves with the combustion chamber directly below the first pot, and a smaller second pot connected to the first chamber via a duct. They were constructed using a fabricated steel mold with a concrete mixture poured into it.

Regarding particulate matter (PM), (Roden et al., 2009) found emissions were reduced by an average factor of 4.5 g kg<sup>-1</sup> and 6.6 g kg<sup>-1</sup>, with and without chimneys, respectively, from an average factor of 8.2 g kg<sup>-1</sup> using traditional cookstoves. Field tests from five cookstoves with chimneys showed average PM emission reductions of over 70%.

Evaluations of wood burning rocket stoves in Ghana found that average 24-hour PM<sub>2.5</sub> concentrations dropped by 52% and average 24-hour kitchen CO concentrations by 40% (Pennise et al., 2009). In India (Chengappa et al., 2007) and Mexico (Maseru et al., 2007), studies showed that improved cookstoves reduced average carbon monoxide concentrations and PM<sub>2.5</sub> by 50%. From a survey in rural Kenya, (Ezzati and Kammen, 2002) estimated a reduction of 24%-64% for acute respiratory infections (ARI) and 21%-44% for acute lower respiratory infections (ALRI) in children under 5, all attributed to improved cooking technology.

Source: Authors' elaboration.

**In rural areas, improved stoves must be carefully tailored according to the consumers' needs, fuel availability, and socio-economic constraints.** In contrast to improved cookstoves used in urban areas (often designed for one specific type of fuel), rural stoves must be able to accommodate various types of biomass energy such as dung, dried agricultural waste, leaves, and woody biomass. The stoves should also be designed in way that they can be produced and repaired with local materials and technology, which will reduce initial purchase and maintenance costs. In Rwanda, for example, a project implemented by CARE International, successfully trained local manufacturers to produce rocket stoves and larger, fixed stoves, from clay. Both stoves, but especially the latter, have contributed to energy efficiency and significantly reduced IAP (authors' observations).

**Given the technology used in rural areas along with the obvious economic constraints, engaging the private sector for improved cookstove dissemination entails many challenges in rural SSA areas in the near future.** Thus, it will remain the responsibility of the public sector to push programs and projects that strengthen and accelerate capacity building and knowledge dissemination about these models in close cooperation with the private sector. While funding could come from institutions like the World Bank, local partners, such as environmental NGOs and other CSOs, may have a comparative advantage as implementation partners in the field. The involvement of local government institutions is equally important.

<sup>12</sup> Urban cookstoves are discussed on pages 25-28.



**Table 2 | Summary of Issues and Approaches for Fuelwood Interventions**

| Issue                                                                  | Approach                                                  | World Bank                                                                             | Key Partners                                                                                                                  |
|------------------------------------------------------------------------|-----------------------------------------------------------|----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| Supply-Side                                                            |                                                           |                                                                                        |                                                                                                                               |
| Unsustainable forest management<br>(forest degradation, deforestation) | Promoting sustainable forest management                   | Environment;<br>Agriculture and<br>Rural Development;<br>Social Development            | Development partners working on forestry, environmental NGOs, CSOs, research institutions (e.g. ICRAF, CIFOR), private sector |
|                                                                        | a. Agro-forestry                                          |                                                                                        |                                                                                                                               |
|                                                                        | b. Community-based forest management                      |                                                                                        |                                                                                                                               |
|                                                                        | c. Woodlots, plantations                                  |                                                                                        |                                                                                                                               |
|                                                                        | d. Modernize forest law enforcement and governance (FLEG) |                                                                                        |                                                                                                                               |
|                                                                        | e. Strengthen tree- and land-tenure                       |                                                                                        |                                                                                                                               |
|                                                                        | f. Build capacity                                         |                                                                                        |                                                                                                                               |
|                                                                        | g. Technical assistance                                   |                                                                                        |                                                                                                                               |
|                                                                        | h. Analytical and sector work                             |                                                                                        |                                                                                                                               |
| Trade                                                                  |                                                           |                                                                                        |                                                                                                                               |
| Overregulation, corruption, oligopolistic structures                   | Improve rural fuelwood markets                            | Environment, Energy, Social Development                                                | Development partners, CSOs                                                                                                    |
|                                                                        | a. Invest in infrastructure                               |                                                                                        |                                                                                                                               |
|                                                                        | b. Modernize the policy framework                         |                                                                                        |                                                                                                                               |
|                                                                        | c. Reform revenue collection systems                      |                                                                                        |                                                                                                                               |
|                                                                        | d. Improve law enforcement and governance                 |                                                                                        |                                                                                                                               |
| Demand-Side                                                            |                                                           |                                                                                        |                                                                                                                               |
| Inefficient cookstoves                                                 | Promote and adopt improved cookstoves (ICS)               | Energy;<br>Environment;<br>Agriculture and<br>Rural Development;<br>Social Development | Development partners, private sector, NGOs, CSOs                                                                              |
|                                                                        | a. Promotion campaigns                                    |                                                                                        |                                                                                                                               |
|                                                                        | b. Awareness raising                                      |                                                                                        |                                                                                                                               |
|                                                                        | c. Training and capacity building                         |                                                                                        |                                                                                                                               |
|                                                                        | d. Research and development                               |                                                                                        |                                                                                                                               |
|                                                                        | e. Technical assistance                                   |                                                                                        |                                                                                                                               |
|                                                                        | f. Analytical and sector work                             |                                                                                        |                                                                                                                               |

Source: Authors' elaboration.

### 3.2 CHARCOAL

**Charcoal is the primary cooking fuel for most households living in the rapidly growing urban centers in SSA.** Charcoal is usually produced by a process known as slow pyrolysis, the heating of wood or other substances in the absence of oxygen. Besides used by households, charcoal is also often the primary cooking fuel for many small road-side restaurants and in kitchens of larger public institutions, such as schools and universities, hospitals, and prisons. Charcoal is also widely used for cottage industries, for example, bread baking, cottage metal smelting operations, and brick kilns. Further, households in urban areas are often smaller than in rural areas which translates into a less efficient use of fuels for cooking per capita. These multiplier effects triggered by urbanization cannot be underestimated: One study for Dar es Salaam suggests that a 1% increase in urbanization leads to a 14% increase in charcoal consumption (Hosier et al., 1993).

**Due to the triple effect of population growth, increased urbanization, and relative price changes of alternate energy sources for cooking, it is expected that the consumption of charcoal will remain at very high levels or even increase in absolute terms over the next decades** (Arnold et al., 2005). A regional study for Southeast Africa estimated that charcoal consumption from 1990-2000 grew by about 80% in both Lusaka and Dar es Salaam (SEI, 2002). From 2001-2007, the number of Dar es Salaam households cooking with charcoal increased from 47% to 71%, while the use of LPG dropped from 43% to 12% (World Bank, 2009). In Senegal, consumers also massively switched back to wood-based biomass for cooking after subsidies were eliminated, caused LPG prices to increase significantly (World Bank, 2009). The reliability of supply is another issue that keeps consumers with wood-based biomass: Not only can the purchased quantity be adjusted to the households' amount of available cash, but wood-based biomass is also available through a wide network of retailers and there is never a shortage. In contrast, consumers report that the supply of other fuels—especially LPG—is unreliable and, thus, unattractive for regular use (World Bank, 2009).

In contrast to its economic potential, environmental implications, and importance for the energy security of a majority of the SSA population, the charcoal sector is currently viewed almost entirely negatively in most countries. Prevailing policies and laws tend to focus on regulations, enforcement, restrictions, and, where possible, moving from the sector altogether to other energy sources. However, if the sector was formalized, and involved modern, supportive policies, this could create employment opportunities and further broaden the revenue base for national and regional governments. Figure 4 illustrates the employment opportunities before and after such reforms. Secondary economic effects, such as income earned by providing food to charcoal transporters, cell phone merchants and users, and selling tools for the production process, were not even considered in this analysis.

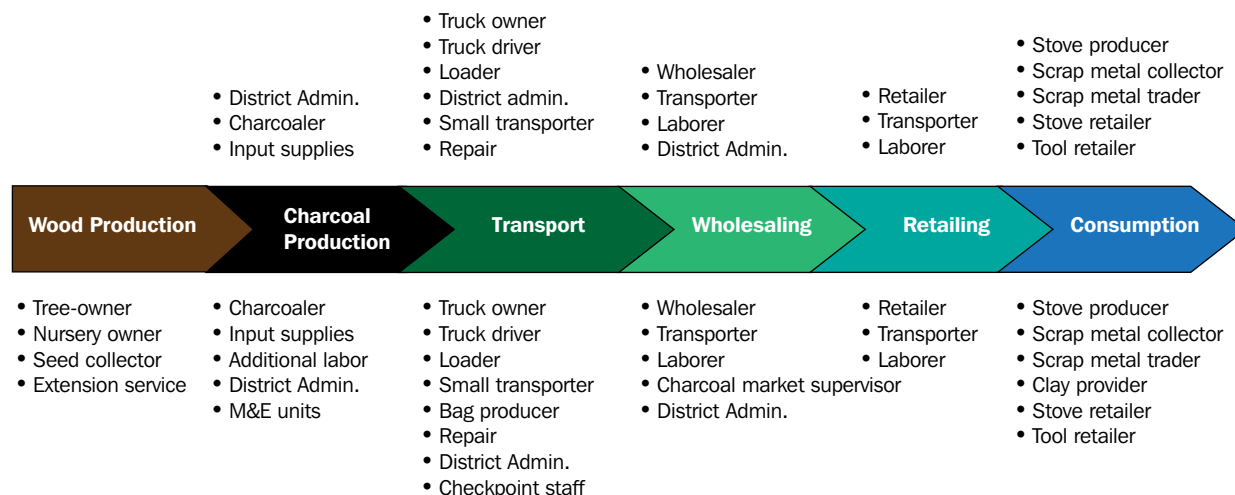
Some common issues characterizing the charcoal value-chain in many SSA countries include (World Bank, 2009; HEDON, 2010):

- No sustainable forest management plan exists to produce charcoal.
- Charcoal prices do not reflect their real value since wood is illegally harvested (as an open-access resource) and licenses and levies are largely evaded.
- Governance and law enforcement are weak, since the sector is unregulated.
- Conversion technologies are inefficient.
- The charcoal business is usually concentrated among a few powerful, politically connected entrepreneurs.

The next section reviews the charcoal value chain, which involves a complex structure of steps with regard to approaches and interventions the World Bank and other development partners might apply. These relate to sustainable wood production, which, while similar to what was discussed with respect to fuelwood (see section 3.2.1 of this paper), includes some elements unique to the charcoal sector and its production, and could be modernized. Also, the trade and transport of charcoal from rural production areas to urban retail markets is important for reforming governance, which will include modernizing fiscal policies. Last, the issues/approaches surrounding the consumption of charcoal and the role of improved cookstoves are highlighted. This is followed by a brief discussion of how new policies/approaches will be introduced.

**Figure 4 | Beneficiaries in the Charcoal Value Chain (before and after reform)**

#### Pre-Reform



#### Post-Reform

= > other indirect effects not accounted for: gas, food supply, and cell phone usage

Source: World Bank, 2009.

### 3.2.1 FOREST MANAGEMENT FOR CHARCOAL PRODUCTION

Wood for charcoal production is mainly harvested from natural forests under de facto open-access management regimes often leading to significant forest degradation and—when coupled with other land-use changes—to permanent deforestation. Harvesting wood from natural forests for charcoal production occurs mainly in three ways: (a) as a by-product of some other wood extraction, (b) when forests are converted to other land-uses, including shift and burn agriculture, or (c) when wood is removed specifically for charcoal production. Several analyses for SSA concluded that the scarcity of wood-based biomass occurred in very few and specific locales, and that its extraction rarely resulted in forest loss (Chidumayo, 1993; Munslow et al., 1988; Hosier, 1993). While Foley (1985) stated that the actual driving force behind deforestation was agricultural expansion, other added that aspect of socio-cultural, political and land tenure issues also need to be considered (Deweese, 1989; Hosier et al., 1990).

**Because most charcoal is harvested without anyone paying for the raw material (wood), and licenses and levies are largely evaded, the cost of charcoal to the consumer does not reflect its real value.** Thus, the lower costs undermine efforts by producers or traders to comply with the laws by paying for licenses and levies, or investing in efficiency savings through improved conversion technology, long-term sustainable forest management, or creating plantations/woodlots. Unless the sector's regulatory and fiscal frameworks are improved, the market price of legal, sustainably produced charcoal will always be undercut by unregulated and unsustainable products.

**Three broad policy options can be utilized to promote sustainable wood production for charcoal:** (a) Using the full potential of sustainable harvests from natural forests through decentralized forest management approaches involving local stakeholders, (b) increasing sustainable wood supply through tree-plantations; and (c) increasing incentives of Trees-Outside-Forests, for example through agroforestry systems. A necessary pre-condition that applies universally to all three policy options is that forest management plans must be simple and short and should be developed in a participatory fashion, so as to remain accessible for communities with low literacy levels. In order to foster local “ownership” of such a management plan, the contents of the plan must also include the knowledge, experience and expectations of the local community vis-à-vis their forest.

**Harvesting plans need to be developed for forest areas administered by central or local governments.** Due to a lack of reliable data on forest resources, harvesting and licensing decisions are made without accurate estimates of the standing stock or resources available; thus, it is vital to conduct more accurate assessments. Once this is accomplished and harvesting plans are developed, their implementation compliance (with the plans) must be continually monitored.

**With respect to fuelwood production, community-based forest management approaches can successfully expand the supply.** Under this management approach, rights and responsibilities associated with sustainable forest management are transferred to the local level, which generally includes tree and/or land rights (ESMAP, 2010). Ideally, technical oversight, including capacity building, is provided by community authorities. The model entails community involvement in the sustainable management of public forests and the use of sustainable resources for commercial purposes.

**Small-scale plantations and woodlots could increase supply of wood to produce charcoal and trigger economic opportunities and land-use planning in rural areas.** Although natural forests are expected to continue supplying much of the raw material for charcoal production, they will be unable to meet demand in a sustainable manner, since it is expected to increase substantially. Thus, private or group-based woodlots/plantations could, in the long term, complement supplies. Subsidies and incentive payments might be necessary in the early stages to trigger local-level investments in establishing planted woodlots. As farmers begin to secure financial benefits from the sale of wood for charcoal, it is likely that other farmers would engage in similar activities. In this context, the potential of carbon-finance opportunities need to be further explored.

**Two main principles must be followed to fully capture the potential of plantations for sustainable charcoal production.** First, no natural forest area should be converted to plantations. Even for degraded natural forests it is preferable to improve production through enrichment planting rather than full conversion to plantations or woodlots. Plantations should also provide direct pecuniary benefits to rural households in order to divert pressures from natural forests. One of the main reasons for rural households to engage in unsustainable charcoal production is their need for cash income, which is almost exclusively provided by the charcoal business. Whenever plantations are established through large-scale investments there is a danger that the income and livelihood opportunities of local people are “crowded-out” making the overall economic benefits of such investments questionable. Last but not least, plantations should preferably be established on degraded lands.



**Table 3 | Summary of Issues and Approaches for Forest Management Interventions**

| Issue                                                               | Approach                                                                                                                                                                                                                                                                                                                                                                                                   | World Bank                                                                                                          | Key Partners                                                                                                                           |
|---------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| Unsustainable forest management (forest degradation, deforestation) | <b>Promoting sustainable forest management</b><br>a. Agro-forestry<br>b. Community-based forest management<br>c. Woodlots, plantations<br>d. Out-grower schemes<br>e. Modernize forest law enforcement and governance (FLEG)<br>f. Strengthen tree and land tenure<br>g. Build capacity<br>h. Technical assistance<br>i. Introduce innovative financing (REDD, FIP, etc.)<br>j. Analytical and sector work | Energy; Environment; Agriculture and Rural Development; Social Development, International Finance Corporation (IFC) | Development partners working on forestry programs, environmental NGOs, CSOs, research institutions (e.g. ICRAF, CIFOR), private sector |

Source: Authors' elaboration.

### 3.2.2 CHARCOAL PRODUCTION

The conversion of wood to charcoal is a small but decisive factor in the charcoal value chain. Generally, traditional kilns are used, which result in low conversion efficiencies. A wide range of Interventions in many SSA countries have tried to overcome this challenge by promoting more efficient kilns for charcoal production, but the adoption rate has been limited. The reasons for this are mainly found in the informal—and often illegal—nature of charcoal production as frequently described throughout this paper. Higher material costs, increased labor input, but also lack of knowledge all represents disincentives for charcoal burners to adapt improved technologies in situations where they are not rewarded with increased prices or where the risk of discovery may require abandoning the production site (compare HEDON, 2010).

**Table 4 | Efficiencies of Alternate Kiln Technologies**

| Characteristics                                  | Traditional Kilns                                                                   | Improved Kilns                                                                      | Semi-industrial Kilns                                                                | Industrial Kilns                                                                      |
|--------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Conversion Technology                            |  |  |  |  |
| <b>Efficiency</b>                                | <b>8-12%</b>                                                                        | <b>12-18%</b>                                                                       | <b>18-24%</b>                                                                        | <b>&gt;24%</b>                                                                        |
| <b>Emissions (in g per kg charcoal produced)</b> | CO <sub>2</sub> : 450 - 550<br>CH <sub>4</sub> : ~700<br>CO: 450 - 650              | →                                                                                   |                                                                                      | CO <sub>2</sub> : ~400<br>CH <sub>4</sub> : ~50<br>CO: ~160                           |

Source: Adapted from Sepp, 2008b.

Besides organizational improvements and the formalization of charcoal production and marketing, charcoaling technologies are probably the key driving force to reduce the amount of woody biomass required per unit of charcoal produced. Policies that can promote improved kiln technologies are critical for sustainable charcoal production. Furthermore, if the entire charcoal chain is reformed in a comprehensive manner, adoption of improved and widely accepted kiln technologies should be part of revised regulatory frameworks in form of standards for kiln technology to be applied.

A core challenge when enhancing the kiln technology is that it would require a change in the socio-organization structure of charcoal production. At present, traditional and improved kilns are constructed in the forest where the wood is harvested; when improved kilns are used, producers need a small chimney that can be easily transported by bicycle or on foot. However,

semi-industrial kilns are more permanent structures that require the wood be transported to the kiln. Given already the challenges individual charcoal producers face for making minimal technology improvements such as chimneys, semi-industrial technology can only be established through larger scale private investments or when joint investments by former individual charcoal producers can be facilitated, for example by forming producer associations or cooperatives. If larger-scale private investors establish semi-industrial or industrial kiln technology, the wood-sourcing should preferably come through outgrower schemes or other benefit-sharing arrangements allowing the local population to continue earning a steady income through the charcoal sector.

**A key element for promoting improved kiln technology requires providing financial resources to potential investors.** Due to the increased costs of improved kiln technology, seed funding in form of “one-time” input subsidies may be a policy option, although subsidies are not preferred, given the need for external inputs and the risk that funds may be misallocated. If they are applied, however, they should not be a permanent element of any support system. Also, micro-credit schemes could provide cooperatives and individual producers with the finances needed.

**The potential for reducing GHG emissions by promoting the application of improved kiln technology is tremendous, not only due to higher charcoaling efficiencies, but also due to the application of GHG reducing technologies and the possibility of electricity co-generation.** A coupled effect of enhanced transforming efficiency and better GHG management reduces GHGs significantly. For example, current industrial type kilns have only less than 10% of methane emissions compared to traditional kilns. In addition, larger-scale charcoaling facilities can also the energy generated during the charcoaling process to co-generate electricity—a concept that could potentially contribute further to extending off-grid electricity generation in rural areas of many Sub-Saharan African countries (ESMAP, 2010).

#### **Box 5 | Outgrower Schemes**

Through outgrower schemes companies (or other entities) with inadequate forest holdings or access to public forests seek to secure additional supplies to meet their demand for raw material. Forestry outgrower arrangements between growers (or co-operatives) and processors may be characterized as:

- Partnerships in which growers are largely responsible for production, with company assurance or guarantee they will purchase the product;
- Partnerships in which the company is largely responsible for production, paying landholders market prices for their wood allocation;
- Land lease agreements in which landholders have little involvement in plantation management; and
- Land lease agreements with additional benefits for landholders.

Under outgrower partnerships, growers allocate land and other resources to the production and management of trees and sometimes other forest products, for a processing company, with the company providing a guaranteed market. The varying responsibilities of each partner are defined by contract.

The incentives for forest processors to develop outgrower schemes include increased supply of wood resource, access to productive land, resource security without the need to purchase land, diversification of supply, and increased co-operation with local communities. For growers, the advantages include an alternate and additional source of income, a guaranteed market for products, reduced market risks and, in some cases, financial support for enterprise development.

Existing outgrower arrangements vary considerably in their ability to be mutually beneficial, achieve sustainable forest management, and meet the social, technical or economic goals of the partners. Not all out-grower partnerships are viewed as successful and poor grower industry links are regularly identified as one of the major constraints to forestry development throughout the world.

*Source: FAO, 2001.*

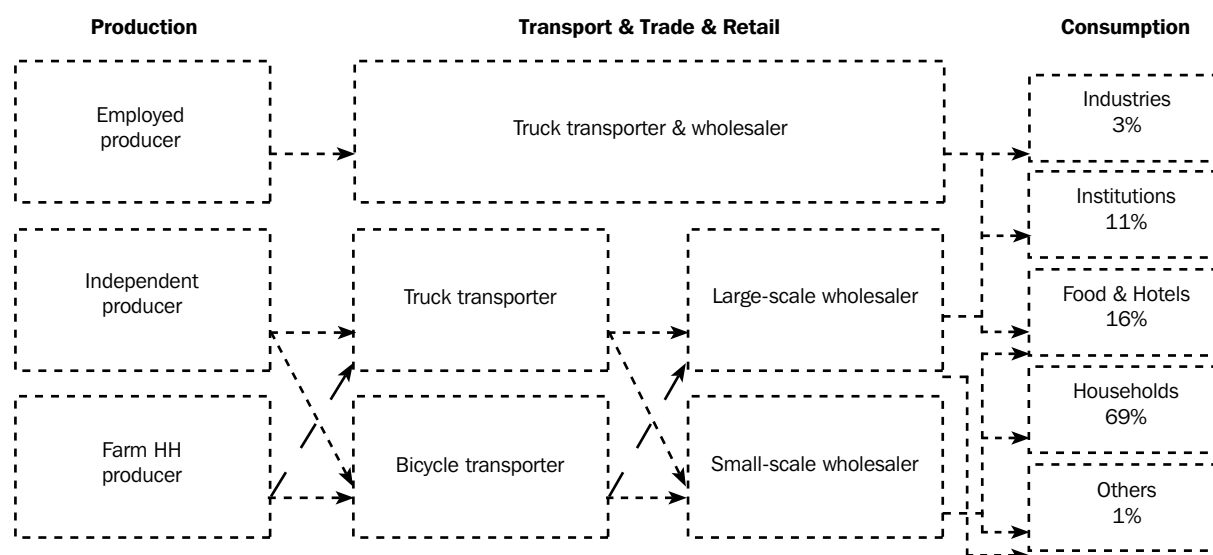
**Table 5 | Summary of Issues and Approaches for Advancing New Kiln Technologies**

| Issue                                                                                  | Approach                                                                                                                                                                                                                                                                                                       | World Bank                                                                       | Key Partners                                                                                                                   |
|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| Inefficient charcoaling techniques lead to low conversion rates and high GHG emissions | <b>Advance new kiln technology</b><br>a. Improve kiln management<br>b. Pilot semi-industrial and industrial kiln technology<br>c. Create charcoal producer groups<br>d. Facilitate innovative finance (carbon finance)<br>e. Pilot electricity co-generation<br>f. Analytical work and knowledge dissemination | Energy; Environment; Social Development; International Finance Corporation (IFC) | Development partners working on kiln technology, environmental NGOs, CSOs, research institutes and think tanks, private sector |

Source: Authors' elaboration.

### 3.2.3 TRANSPORT, TRADE, AND MARKETING

The charcoal trade—i.e. the transport of charcoal from rural areas to urban centers and the distribution through a chain of wholesalers to consumers—is similar in most of Sub-Saharan Africa. It generally involves an interaction between large-scale and small-scale transporters and wholesalers. Especially large-scale wholesalers are often also transporters at the same time. Producers are often dependent on powerful agents who employ them as laborers.

**Figure 5 | Charcoal Trade and Market Share of Consumption by End-Consumers in Tanzania**

Source: van Beukering et al., 2007; own adaptations.

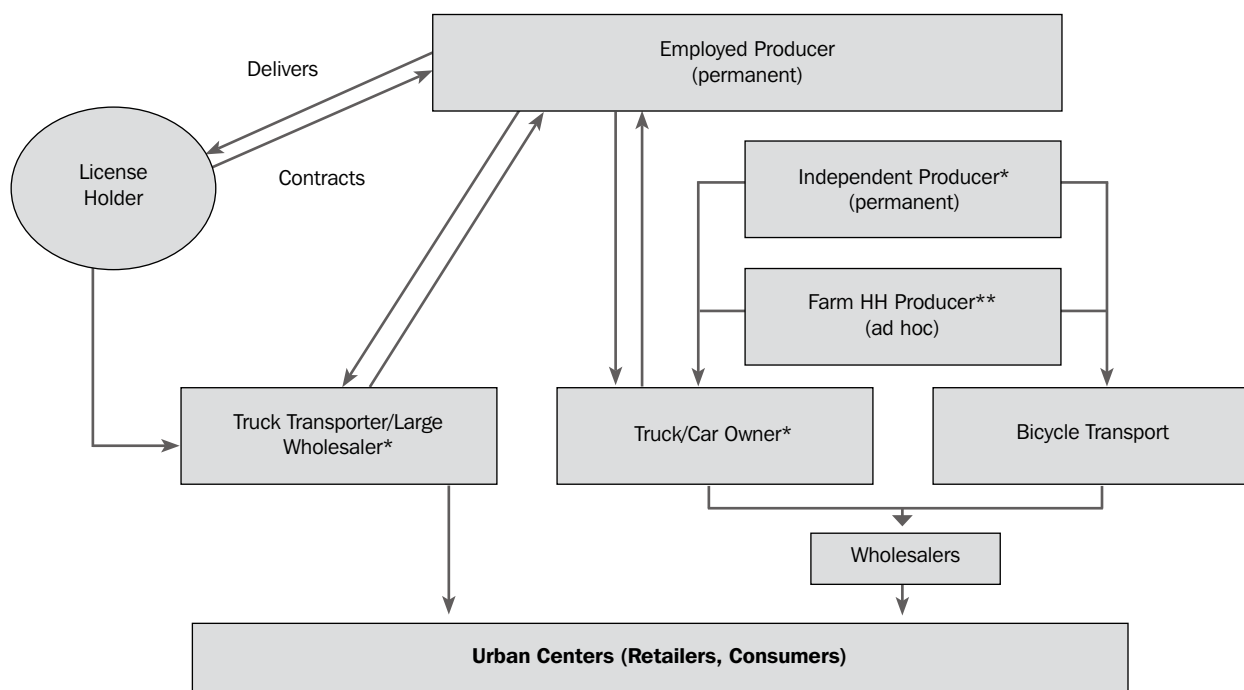
Charcoal trade often displays an oligopolistic structure: Profits are usually concentrated in the hands of a few intermediaries who are mainly engaged as transport agents or wholesalers. This arrangement is heavily biased against women, who often bear the largest workloads (harvesting/collecting wood, operating kilns, engaging in small-scale retailing). Instead of equitable revenue-sharing along the entire value chain, revenue circulates in a loop between traders and consumers; only marginal amounts of cash flow to the charcoal burners—and virtually none to communities whose forest areas are being depleted. Such conditions are often caused—or reinforced—by local elites who are active in the charcoal sector.



Anecdotal evidence for many SSA countries shows that few traders routinely obtain the papers required and that bribes are offered whenever controls are executed. This may be caused by: (a) high transaction costs connected with traveling to the nearest forest service representative and waiting for a license to be issued; (b) a lack of resources to obtain the license; and (c) potential bribes to the license issuing public service representative who issue the licenses. Difficulties in obtaining licenses seem to lead to illegal production and marketing of charcoal. However, it should be acknowledged that at present, the current licensing system is not related to sustainable yields obtained through management plans. Therefore, a modernization of the licensing system can only be successful if coupled with sustainable forest management practices as discussed in Section 3.2.1. above. For a case study in Tanzania, Figure 6 illustrates how the licensing process influences the structure and interdependencies of actors in the charcoal trade (World Bank, 2009).

Laws and regulations are not enforced largely because the sector operates within a complex and multi-layered regulatory context. The people and processes along the value chain interact with several government bodies, policies and laws at the national, local and village levels. Although there is often no comprehensive policy, strategy or legal framework addressing the charcoal sector, policies, laws and regulations exist that influence how wood-based biomass exploitation, production, and consumption are managed. These policies are executed by different ministries or government agencies and have at times been observed to be conflicting.

**Figure 6 | Structure of Forest Exploitation for Charcoal Production and Trade**



Source: World Bank, 2009.

\* Can be a license holder; there is evidence that they often don't hold a license

\*\* Generally does not have a license

Trade and marketing are probably the least regulated aspect of the charcoal value chain, although they provide a good opportunity to introduce financial incentives and regulatory mechanisms. In most SSA countries, this is due partly to the limited capacity at local and district levels to address the situation. Also, district officials responsible for levying fines and penalties for transporting and trading charcoal without the required licenses have no incentive to do so—since the total charges obtained must generally be submitted to the central Government.

In the context of a modern and legalized charcoal sector, facilitating charcoal producer associations or cooperatives, as known from the agricultural sector, can result in several benefits. Not only would it provide an enabling framework for investments in modern kiln technology as described above, but it could equally strengthen the position of rural stakeholders in the charcoal value chain. Charcoal Producers Association in Sudan, for example, are recognized by the government and can expel members who fail to pay taxes or engage in corruption. In return, the government reinvests taxes and royalties in establishing plantations (Mugo and Ong, 2006).

Investments in infrastructure, information technology, and capacity building can accelerate the impact of policy reforms and other efforts to modernize the charcoal trade and marketing. For example, fixed trading sites, as operate in the agricultural and other sectors, could help enforce modern licensing and fiscal arrangements. These sites should be located in urban areas and serve as reloading and wholesaling points, formalizing the interactions between transporters, traders and retailers. Since charcoal is not perishable, it might be useful to introduce fixed transport times—i.e. certain days of the week (World Bank, 2009).

**Table 6 | Summary of Issues and Approaches for Transport, Trade, and Marketing**

| Issue                                                                                             | Approach                                                                                                                                                                                                                                                                                                                                                                                                                 | World Bank                                                                                                                    | Key Partners                                                                                                                 |
|---------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| Unregulated, oligopolistic market structures lead to corruption and a failure to collect revenues | <b>Reform and modernize the fiscal and governance framework</b><br>a. Formalize charcoal trade<br>b. Link fiscal policies to sustainable harvests and sustainable charcoal<br>c. Enhance and modernize law enforcement<br>d. Invest in infrastructure (trading sites)<br>e. Promote the use of information technology<br>f. Pilot sustainable charcoal certification<br>g. Foster analytical work and knowledge exchange | Energy; Environment;<br>Social Development;<br>Transport and<br>Infrastructure;<br>International Finance<br>Corporation (IFC) | Independent forest<br>monitors, environmental<br>NGOs, CSOs, research<br>institutes and think<br>tanks, private sector, etc. |

Source: Authors' elaboration.

Information technology has great potential to unleash a wide variety of applications for modernizing the charcoal sector. Value chain tracking technology could be applied to: (a) facilitate the marketing of charcoal certified as sustainably produced; (b) enhance government officials' daily efforts to introduce modern regulatory framework, e.g. through mobile monitoring units; or (c) build capacity, disseminate knowledge, and implement promotion campaigns; these are only a few examples how information technology can profoundly affect charcoal sector reforms. In Rwanda, a pilot was initiated to include charcoal in a *mobile market information platform* created for use within the agriculture sector in response to the explosive growth of cellular services in Africa. Mobile market data updates, such as current retail prices and buy/sell offers, are delivered to producers and traders by SMS. This is expected to make market and price information more transparent and thus strengthen rural producers' market power and reduce their dependency on individual wholesale traders.

### 3.2.4 DEMAND-SIDE | CHARCOAL CONSUMPTION AND IMPROVED COOKSTOVES

The benefits of improved cookstoves range from increasing energy efficiency (saving fuel) to reducing emissions that affect health and climate change. Traditional cookstoves commonly used in SSA burn inefficiently, with smoke and gases produced by incomplete combustion causing long term respiratory health complications and deaths. Particulate matter levels from solid biomass fuel use—especially fuelwood—in households may be 10-50 times higher than the WHO guideline values (Pennise et al., 2009; WHO, 2005a). Also, strong evidence links IAP to preventable diseases such as child pneumonia (Smith, et al., 2000a; Dherani et al., 2008), which accounts for an estimated 10% of disease-related deaths in Africa (Bruce et al., 2010) and to chronic obstructive pulmonary diseases such as chronic bronchitis and emphysema among women (American Thoracic Society, 2008). Other routine problems for women, such as coughs, headaches, stinging eyes and backaches, are commonly associated with traditional cooking methods (WHO, 2008).

**Combustion of solid biomass for cooking is a very complex process involving different factors such as variations in the fuels' energy content, moisture content, size of the solid fuel, the cooks' skills in operating the stoves and weather conditions.** These factors must be incorporated into the design of cookstoves. Higher quality stoves typically include better grates, insulation, induced draft and forced air flow, and are built with more resistant materials.

**Research on improved cookstoves shows that some programs did not include adequate standards for performance and were not sufficiently based on household preferences.** This raised questions about whether the improved stoves could translate performance standards from the laboratory to the field (Quadir et al., 1995; Bailis et al., 2007) and meet the expectations of households introducing them. Two major differences between the test conditions are the fuel variability (described in the paragraph above) and the fire tending (Roden et al., 2009). Past research even found that some "improved cookstoves" could produce more particulate emissions per mass of wood than traditional cooking methods (Smith et al., 2000b; Zhang et al., 2000). The lesson was that performance requirements need to be more stringent and based on field experiments as well as cooking preferences, to encourage users to change their prevailing cooking methods.

**A new generation of improved cookstoves was recently developed through private sector initiatives.** While the stoves are often more expensive than previous models, they have higher standards of energy and combustion efficiency, durability, and other attributes. In the past five years, a growing number of national and multinational companies have been involved in industrial manufacturing of the new generation biomass energy cookstoves. However, while private manufacturers focus their commercial marketing of these cookstoves on South and East Asia, the commercialization in Sub-Saharan African countries is almost non-existent. It is not only existing market barriers, such as import taxes, lack of local financing, and low awareness of local populations of the advantages of modern stoves, but socio-economic constraints may be even more important.

**The main reasons the improved stoves are not readily used include: socio-cultural barriers, affordability and relatively high operational expenses for using the stove especially if charcoal is to be purchased.** Inability to redirect household expenditure from other sources for purchasing of improved cookstoves and absence of microloans present financial constraints for families potentially interested in obtaining improved stoves. Even when the improved models are affordable and available, their acceptance and popularity may depend on the communities' or households' cultural and social perceptions; thus, changing long-standing cooking practices is difficult. Moreover, households may perceive that the smoke produced from burning biomass is positive, as it repulses snakes that live in the thatched roofs, and malaria-carrying mosquitoes or termites, which also avoid the fumes (WHO, 2005).

**It is critical that gender aspects be considered when modern stoves are promoted.** For example, in Zimbabwe, men rejected their wives' using or developing solar cookers, since the technology is seen traditionally as a male preserve. Some men were also concerned about the way their wives would use the time saved, while others saw it as an opportunity for their wives to conduct added productive activities (Clancy, 2002). Further, acceptance may depend on women's roles in the household decision-making structure (UNESCAP, 2003). Because women are often not included in these processes, the male members of the household probably will not see cleaner-cooking stoves as a top priority for a poor family (Shepherd, 1990). On the other hand, since it is women who typically use them, addressing and informing their consumption choice should not be neglected.

**Targeting communities should be strategic to determine which households may have higher tendency to switch to an improved cookstove.** Households in arid areas, in areas where deforestation is more prevalent, where walking distances for collecting biomass are long, or where they switched to crop residues or dung for fuel tend to have more incentives to save fuel and perceive a real utility from adopting a more efficient technology. In areas with abundant and cheap biomass, people may not perceive shortages and would be less likely to perceive a pressing need to switch (PESD, 2009). However, it is important to distinguish between economic and physical scarcities, with the former measured by the opportunity cost of collecting fuelwood (Palmer and MacGregor, 2009).

**Previous large-scale successful programs show that introducing stoves gradually—through a period of testing—allows the adoption process to grow organically, slowly building local demand.** Many studies independently conclude that the improved stoves' higher cost is the most important reason why households still do not buy them or contemplate switching fuels (eg. compare Schlag and Zuzarte, 2008; CHAPOSA, 2002; Gill, 1985). Two often cited examples of successful commercialization of cookstoves are that of China's National Improvements Stove Programs (NISP) and Kenya's Ceramic Jiko (KCJ). Both examples show that external support is imperative for large-scale programs to thrive, become sustainable and ultimately operate with little or no external aid (Bailis et al., 2009). Early support may include basic R&D, technical advice, entrepreneurial training, public education, and quality assurance. In China, substantial support came from the state for over a decade, while in Kenya, it was from external donors, over seven to eight years (Bailis et al., 2009).



**> IT IS CRITICAL THAT  
GENDER ASPECTS BE  
CONSIDERED WHEN MODERN  
STOVES ARE PROMOTED >**



Best-practice ICS promotion programs typically include significant interaction and data exchange among those who design, produce and use the stoves. This interaction can involve several forms, including formal surveys, focus groups to identify problems and prospects for a particular stove design, and household testing of models. Information gathered in household surveys may include: (a) the food cooked most often; (b) the amount cooked per typical meal and the duration of

cooking; (c) the approximate amount of fuelwood consumed; (d) whether households use more than one fire or stove when cooking multiple dishes; (e) the dimensions of the pot most often used; (f) the frequency of tending the fire; and (g) willingness to pay different prices (Adkins et al., 2010). Those responsible for cooking should also be asked to rank their stove preferences—not only compared to the three-stone fire, but also relative to other stoves available locally or considered for the market.

**> PREVIOUS LARGE SCALE SUCCESSFUL PROGRAMS SHOW THAT INTRODUCING STOVES GRADUALLY—THROUGH A PERIOD OF TESTING—ALLOWS THE ADOPTION PROCESS TO GROW ORGANICALLY, SLOWLY BUILDING LOCAL DEMAND >**

If the promotion and distribution of ICS were linked with funding for climate-related projects, it could reduce the cost of the stoves and create added economic incentives to replace old, inefficient cookstove models. This would require standardization, as it would then be easier to link a certain type ICS with specific emission reduction levels and carbon payments. Given that current cookstove production in SSA is mainly artisanal—even for improved cookstove models—meeting production standards is difficult to achieve in the short-term. Capacity building and training should help overcome this challenge, complemented by pilot carbon finance programs to distribute the stoves (GTZ, 2011). Some technical support will be needed to certify or qualify the stoves—guaranteeing that they perform as advertised. Once certified, the stoves could be eligible for government financing or partial grants to support their distribution (GTZ, 2011). The high performance

standard is also important in order to achieve a high level of confidence in the market for cookstoves and to provide incentives for established manufacturers to expand into SSA.

Advocating partnerships and joining forces with other development partners, the private sector, NGOs, CSOs, and other stakeholders will create necessary synergies needed to move ICS to the next level. Since the new technology is now available, as are lessons from previous programs and new financing mechanisms, there is now a global effort to promote improved cookstoves. For example, the Global Alliance for Clean Cookstoves, a new public-private partnership that aims for 100 million households to adopt clean, efficient stoves and fuels by 2020, was established in September 2010.<sup>13</sup>

Monitoring and evaluation of programs targeted at supporting ICS promotion and dissemination can be challenging. For example, it is difficult to determine whether the purchased ICS replaced an old stove; in some cases, cooks still use the three-stone fire for some tasks, for preparing multiple dishes that require more than one fire, or when using pots that do not fit the new stove. Monitoring and impact evaluation is thus important to determine the extent to which the ICS is adopted and the impact of programs dedicated to promoting and distributing ICS.

**Table 7 | Summary of Issues and Approaches for Demand-Side Interventions**

| Issue                  | Approach                                                                                                                                                                                                                                                                                                                                    | World Bank                                                                          | Key Partners                                               |
|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|------------------------------------------------------------|
| Inefficient cookstoves | <b>Promotion and adoption of improved cookstoves (ICS)</b><br>a. Facilitate promotion campaigns<br>b. Introduce uniform standards<br>c. Finance training and capacity building<br>d. Promote research and development<br>e. Improve technical assistance<br>f. Foster analytical work and knowledge exchange<br>g. Establish M&E frameworks | Energy; Environment;<br>Agriculture and Rural<br>Development; Social<br>Development | Development partners,<br>private sector, NGOs,<br>and CSOs |

Source: Authors' elaboration.

<sup>13</sup> To read more about the initiative please visit: <http://www.cleancookstoves.org>

### 3.3 ALTERNATE FUELS AND FUEL SWITCHING

The conventional view is that economic growth will trigger a reduced demand for wood and other biomass energy, with consumers—and countries—shifting towards the use of commercial fuels, such as LPG, natural gas, and other fossil fuels. This behavior is generally referred to as the energy ladder. However, evidence exists that does not support this model, but that, in contrast, the fuel transition for households in developing countries follows a more complex course, where they switch and use fuels from different categories on the energy ladder at the same time (Masera et al., 2000; Spreng and Pachauri, 2003). As a result, the energy stack theory was introduced, which better reflects this complexity (Schlag and Zuzarte, 2008).

**Table 8 | Reasons for Using Various Fuel Sources (multiple answers possible)**

|                                 | Fuelwood | Charcoal | Kerosene | LPG | Electricity |
|---------------------------------|----------|----------|----------|-----|-------------|
| Inexpensive                     | 89%      | 71%      | 23%      | 53% | 2%          |
| Easy to purchase                | 33%      | 52%      | 27%      | 22% | 28%         |
| Easy to use                     | 19%      | 28%      | 71%      | 42% | 70%         |
| Traditionally used by household | 19%      | 12%      | n/a      | n/a | 9%          |
| Low initial investment costs    | 15%      | 12%      | 21%      | 8%  | 2%          |
| Gives high heat/cooks fast      | 15%      | 5%       | 48%      | 61% | 48%         |
| Safe to use                     | n/a      | 20%      | 2%       | 8%  | 26%         |
| Food tastes better              | n/a      | 10%      | n/a      | n/a | 4%          |
| No negative health effects      | n/a      | 6%       | n/a      | 14% | 26%         |
| Clean to cook with              | n/a      | 2%       | 6%       | 47% | 59%         |

Source: Palmula and Beaudin, 2007.

**Because income effects are often off-set by rising prices of alternate fuels, the energy stack model may need to be adapted further.** Energy consumption tends to follow a more complex course, as noted above. Thus, the use of alternative modern fuels should not be equated with fuelwood substitution, since urban households use modern energy sources in addition to rather than instead of solid fuels (Hiemstra-van der Horst and Hovorka, 2008). For example, half the total firewood demand in Harare is from households with access to electricity (Chambwera and Folmer, 2007), while in Uganda, 83% of the top quintile in urban areas use biomass as the primary cooking fuel (Bacon et al., 2010). This demonstrates that biomass consumption often continues to increase under conditions of economic development and fossil fuels are simply added to the energy mix, satisfying additional energy demand, but not substituting for wood energy (compare Matthews, 2000).

**Switching away from wood-based energy will not necessarily be only a matter of improving the economic situation of consumers.** In fact, if the price of alternative fuels continues to rise and supply remains erratic, households have little incentive to switch. It is also not only the amount of household available income that determines such choices but rather how the income stream is structured, i.e. how frequent and reliably income is generated. Given the often erratic and unreliable income streams to urban households in SSA, it is generally more rational to buy small quantities of fuel with the cash available even if an ex-post analysis of total fuel expenses per month reveals higher expenses for charcoal compared to alternative fuel, such as LPG. Due to the complexity of the optimization decision, a doubling of typical incomes would only reduce the number of those depending on biomass energy for cooking by 16% (World Bank, 2011a, forthcoming).

**Analogous consumption behavior can be observed for cellular phone usage in developing countries:** while consumers in industrialized countries—who can rely on steady income streams—favor long-term contracts, those in developing countries generally prefer to use cell phones on a pre-paid basis, although costs over a given time may exceed the monthly upfront costs of a longer-term contract. Thus, the flexibility of the pre-paid model is better suited to uncertain, oscillating income streams of many income groups, such as taxi drivers, traders, small restaurant owners, and even government officials who can better economize their cell phone use.



## Box 6 | The Experience of Energy Subsidies in Senegal

The case of LPG subsidies in Senegal demonstrates that managing the uptake and retention of LPG using subsidies is costly and difficult to phase out for a low-income SSA country. The LPG promotion program was launched in the early 1970s to reduce charcoal consumption in urban areas (Sokona and Deme, 2004). At first, it was subsidized through exemptions of customs duties on cooking equipment designed to operate LPG, but in 1987, a program was introduced to subsidize the fuel itself (Laan et al., 2010). While this considerably increased the adoption of LPG, the subsidies came with a tremendous cost and fiscal burden and much variability in the total annual subsidy. In 2005 and 2006, the cost of subsidizing the consumption of LPG was 0.2% and 1.4% of GDP, respectively (Laan et al., 2010). Moreover, according to the IMF, the poorest 40% gained only 19% of the total improvement in welfare, while the richest 40% gained 61% (IMF, 2008).

The government made repeated commitments to phase out the subsidies over several years, and finally did so from 2005-2009. Based on study conducted by TOTALGAZ, it is estimated that per capita LPG consumption dropped from the peak of 11.7 kg per person in 2005, to 8.6 kg in 2008 (Bee, 2010). Recent evidence suggests the demand for charcoal in Dakar and other urban areas has increased (World Bank, 2011b, forthcoming). While LPG subsidies in Senegal did bring many benefits to consumers, substantially reducing charcoal and fuelwood consumption while helping reduce damage to the environment, they raise questions as to whether such interventions are the best means to achieve this end.

Source: Authors' elaboration.

Nevertheless, fuel switching targeted at better-off segments of society must continue as an integral part of policies to achieve a sustainable energy supply in Sub-Saharan Africa. Switching fuels will not be economically feasible for most SSA urban groups due to high initial investment costs and other economic constraints, such as unreliable and fluctuating income streams. However, households with the means to use a wider range of fuel sources and gas or electricity for specific purposes (e.g. heating water for tea) could stabilize or even reduce their absolute wood-based biomass consumption quantities. Thus, policies aimed at these households need to be strengthened.

The three main factors affecting the transition to modern fuels are convenience, price, and reliability of supplies (Gupta and Kohlin, 2006). LPG is less attractive for most SSA households even when available because it is typically more expensive than solid biomass fuels, especially the upfront costs for a cylinder. Secondly, LPG can rarely be purchased in small amounts and the cost of using the cylinders rises with declining cylinder size. Since larger cylinders means larger refill payments, this creates problems for households with irregular incomes (Bacon et al., 2010). Indeed, households using LPG sometimes revert to biomass once a cylinder is empty. Thirdly, LPG deliveries can be unreliable in low-volume markets and remote destinations and prices can fluctuate based on global market price developments.

Price subsidies are frequently demanded to promote alternate fuels, although they create a burden for already constrained government budgets. In recent years, several SSA countries eliminated energy subsidy programs due to ever-growing budget demands; this led to a massive return to traditional fuels for cooking—especially charcoal (IISD, 2010). The G-20 is leading global efforts to phase out fossil fuel subsidies that encourage wasteful consumption. Moreover, several studies and reports demonstrate that LPG subsidies have often been poorly targeted and tend to be regressive, disproportionately benefiting the better-off consumers in developing countries (Coady, et al., 2010; Bacon et al., 2010a; Victor, 2009). As an alternative, some authors propose kerosene subsidies, which appear somewhat better targeted to poorer households (Chambwera and Folmer, 2007).

## 3.4 DOMESTIC BIOGAS

Household biogas is considered a clean and affordable substitute for traditional biomass fuels, and even for kerosene in case of lighting. Through a composting process, bio-digesters produce methane that can be used for cooking and lighting. Other benefits include improving agricultural productivity and household sanitation. For a biogas plant to be economically attractive to a household it should provide at least 0.8 - 1 m<sup>3</sup> biogas daily. To produce this amount, households need 20-30 kg of fresh dung every day, which, in the African context, translates into 3 or 4 heads of cattle. Further, water must be available near the bio-digester. To manage the bio-digester, owners often require some training and a continuous commitment.

**At present, biogas technology in SSA has not been significantly developed, but shows reasonable potential.** According to estimates by Winrock International, 18.5 million SSA households have both access to water and 3-4 heads of cattle. While it is East African countries that especially qualify for a biogas program, West African countries such as Burkina Faso and Mali, and South Africa, could also meet the criteria.

**Despite the obvious potential for developing biogas in SSA, several obstacles need to be considered:**

- a. High upfront investments
- b. Limited access to adequate financing, such as micro-credit
- c. Animals mainly graze extensively in open spaces, making dung collection difficult
- d. Water is not readily available in some areas
- e. Lack of appreciation of the fertilizer value of composted manure
- f. Inadequate technical skills and management capacities

**The relatively high upfront construction costs are probably the greatest disincentive for consumers to invest in biogas:** The cost of an average plant of 6m<sup>3</sup> is about US\$750, household annual maintenance costs are about US\$11, and the average cost of a latrine is about US\$200 (Winrock, 2007). Since annual maintenance costs are relatively low, a targeted intervention aimed at reducing the substantial upfront capital investment could yield the highest potential. One-off subsidies in the form of installation subsidies could provide enough incentive for households to pursue the biogas option. Microfinance institutions, renewable energy funds and carbon credit financing could possibly provide finance for developing the option of biogas further. An integrated biogas, latrine, and hygiene program for SSA could yield a financial internal rate of return (FIRR) of 7.5% and an economic internal rate of return (EIRR) of 178% (Winrock, 2007). The large difference in rates is due to the relatively high capital costs but substantial non-market benefits linked to health benefits, reduced physical effort and more time saved, along with less environmental damage.

**>HOUSEHOLD BIOGAS IS CONSIDERED A CLEAN AND AFFORDABLE SUBSTITUTE FOR TRADITIONAL BIOMASS FUELS>**

**Given such barriers and technical requirements, biogas investments in SSA may be more feasible with institutional partners and other investors such as schools, hospitals, and prisons, as well as industrial-scale livestock installations or slaughterhouses.** Conversely, household-level investments need to be piloted further with enhanced technical assistance to analyze how to improve and scale-up such programs and thus yield the desired results.

**Partnerships may provide a supporting context to further advocate the idea of biogas energy generation, facilitate knowledge exchange—especially with other regions where biogas has already been mainstreamed.** They could also help with distribution, improve training and build capacity. For example, the Africa Biogas Partnership Programme (ABPP), created by SNV and HIVOS, aims at constructing 70,000 biogas plants in Ethiopia, Kenya, Tanzania, Uganda, Senegal and Burkina Faso, providing about half a million people access to a sustainable source of energy by 2013. Estimates suggest that Rwanda could have 100,000 installations, Ethiopia 1.1 million, and Kenya 320,000 (Winrock, 2007). Nigeria is aiming for 14,000 biogas digesters by 2025, through its Renewable Energy Master Plan.

**Table 9 | Summary of Issues and Approaches for Domestic Biogas Interventions**

| Issue                                                  | Approach                                                                                                                                                                                                                                                                                                                                                                                  | World Bank                                                                 | Key Partners                                         |
|--------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|------------------------------------------------------|
| Low adoption rates of domestic biogas in SSA countries | <b>Promotion and adoption of domestic biogas energy</b> <ol style="list-style-type: none"> <li>a. Facilitate start-up financing, e.g. through micro-credit or subsidies</li> <li>b. Promote innovative carbon finance Establish pilots with institutional clients</li> <li>c. Provide capacity building and training</li> <li>d. Foster analytical work and knowledge exchange</li> </ol> | Energy; Environment; Agriculture and Rural Development; Social Development | Development partners, private sector, NGOs, and CSOs |

Source: Authors' elaboration.

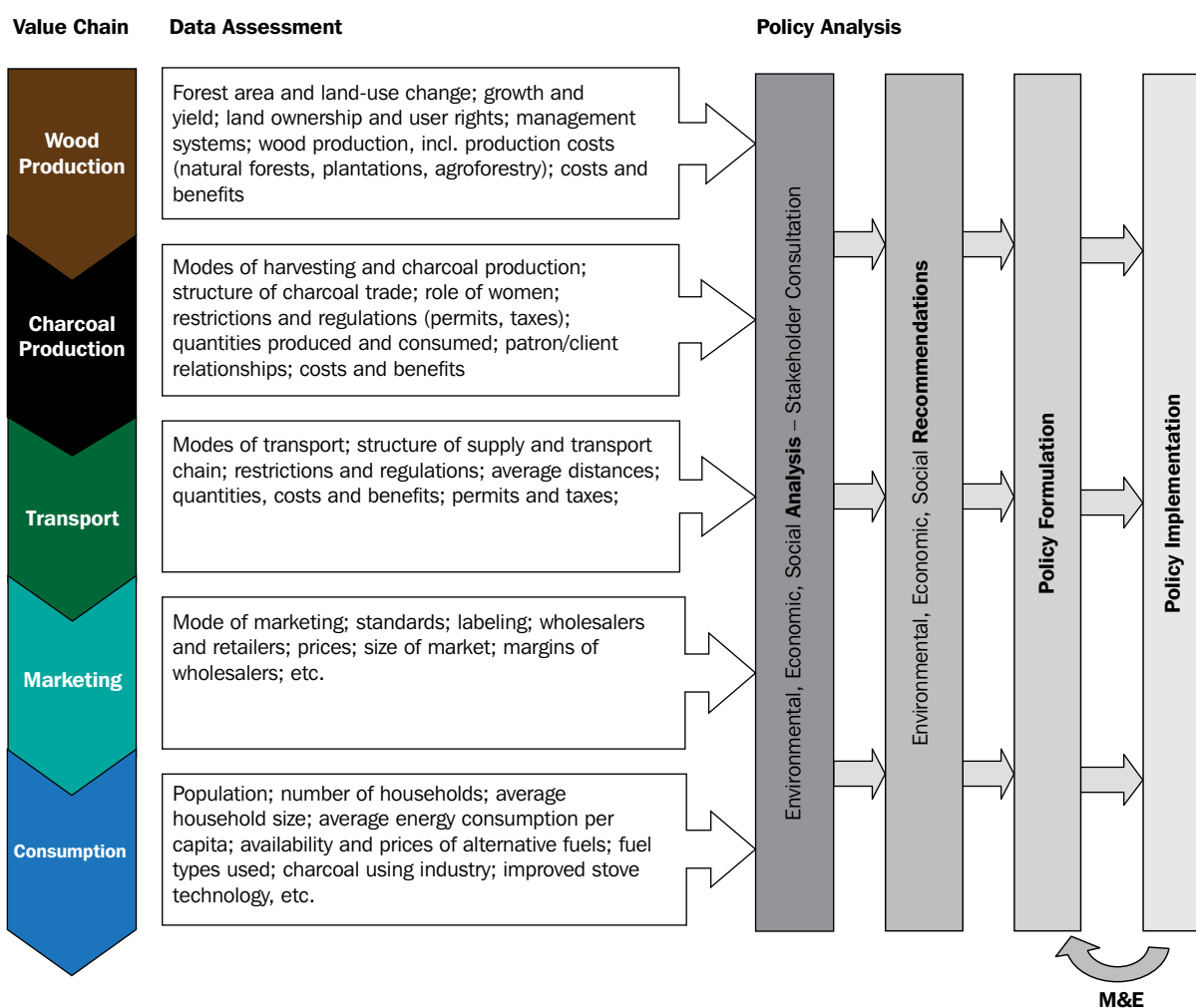
### 3.5 POLICY DESIGN AND IMPLEMENTATION

Banning charcoal as a way to persuade households to stop using charcoal and switch to cleaner fuels is typically counterproductive and has pushed the industry further into the informal sector (Seboka, 2009). For example, in February 2006, Tanzania attempted to ban the transport of charcoal, but producers continued regardless and charcoal stocks/prices even increased. Moreover, payouts to officials along transit routes increased corruption and the government lost all revenue from charcoal commercial activities (van Beukering, 2007).

With a rapidly changing context for wood-based biomass energy in SSA, policy makers need reliable baseline data to design appropriate measures (Sepp, 2008b). Such data include population growth, urbanization dynamics, and consumers' fuel switching behavior. Unsustainable charcoal use is increasingly seen as rooted in more systemic, site-specific deficits related to land tenure, fiscal and incentive policies, urban energy markets, and misallocation of forests and crop-land—problems that occur along the entire charcoal production chain.

The collection and management of data along the biomass value chain provides an excellent entry-point for shaping sound policies. Such efforts help stakeholders add knowledge, innovation capital and technology at each step in the chain. Figure 7 presents a framework for developing and evaluating various policy options that address the charcoal challenge (Sepp, 2008b).

**Figure 7 | Framework for Charcoal Sector Policy Design and Implementation**



Source: Sepp (2008b); own adaptations.



**Advocating partnerships and joining forces with other development partners, the private sector, NGOs, CSOs, and other stakeholders will create a supporting framework to achieve necessary policy reforms.** Without such a concerted approach it is likely that policy reforms will be incomplete, or fall short of the necessary scope needed to achieve lasting impact. Also, given the complex and multi-layered challenges entailed in the wood-biomass energy sector, individual approaches have a higher probability of failure.

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

**Designing successful policies also means to give attention to the views and opinions of the various actors involved in and affected by the policy at different levels, the roles they play, the ways they relate to each other, and their networks of information exchange and learning.** Under such a process, it is acknowledged that a policy in general is not only formulated and implemented, but also interpreted, contested and resisted, repelled and potentially modified. This underlines the characteristics of a policy process rather than being a single standing, one-time intervention.

**Various tools are available to support policy analysis, design, and implementation.** These include, for example, Strategic Environmental and Social Assessments (SESA), Poverty and Social Impact Analyses (PSIA) and Political Economy (PE) Analyses. PSIA help identify possible negative poverty and social impacts due to proposed policy reforms, while PE analyses can determine potential political barriers that might hamper reforms. For example, a 2010 World Bank combined PSIA and PE study of Tanzania's charcoal sector identified vested interests that could resist proposed reforms in the charcoal sector (World Bank, 2010). While their existence is often reported as anecdotal evidence in many SSA countries, such formal documentation—obtained through endorsed methodologies—helps strengthen the policy dialogue.



# 4

**> ADVOCATING PARTNERSHIPS  
AND JOINING FORCES WITH OTHER  
DEVELOPMENT PARTNERS, THE  
PRIVATE SECTOR, NGOS, CSOs, AND  
OTHER STAKEHOLDERS WILL CREATE  
NECESSARY SYNERGIES NEEDED TO  
MOVE IMPROVED COOKSTOVES TO  
THE NEXT LEVEL>**





# WORLD BANK INVESTMENTS IN WOOD-BASED BIOMASS ENERGY | STATUS AND OUTLOOK

The World Bank's Africa Energy Unit already manages several activities designed to improve the use of wood-based energy. For example, in Senegal, the second phase of the Sustainable and Participatory Energy Management project (PROGEDE II) recently became operational, with an investment of US\$15 million to support the fuelwood and charcoal sectors. In Rwanda, a US\$1.3 million biomass energy component was introduced and supported by funding from the Global Environment Facility (GEF) and the Africa Renewable Energy Access (AFREA), a trust-funded program. From 2000-2009, 18 projects were identified in 13 SSA countries that have a biomass energy component (see Annex 1) However, in terms of financing, this was only a small fraction of investments totaling US\$135 million, including the contribution from other donors, which is less than 8% of total financing (Barnes et al., 2010).

**Table 10 | Approaches to Supply-Side Intervention for Fuelwood and Charcoal**

| Issue                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Approach                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | World Bank                                                                                                                 | Key Partners                                                                                                                                                                 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Supply-Side (fuelwood and charcoal)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                            |                                                                                                                                                                              |
| <b>Unsustainable forest management (forest degradation, deforestation)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Promoting sustainable forest management</b> <ol style="list-style-type: none"> <li>(Agro-forestry</li> <li>Community-based forest management</li> <li>Woodlots, plantations</li> <li>(Outgrower schemes</li> <li>Modernizing forest law enforcement and governance (FLEG)</li> <li>Strengthening tree- and land-tenure</li> <li>Capacity building</li> <li>Technical assistance</li> <li>Innovative financing (REDD, FIP, etc.)</li> <li>Analytical and sector work</li> </ol> | Environment;<br>Agriculture and<br>Rural Development;<br>Social Development;<br>International Finance<br>Corporation (IFC) | Other development<br>partners working on<br>forestry, environmental<br>NGOs, CSOs,<br>specialized research<br>institutions (e.g. ICRAF,<br>CIFOR), private sector<br>and FAO |
| <b>Examples:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                            |                                                                                                                                                                              |
| <ul style="list-style-type: none"> <li>Forest Investment Program (FIP) under the Climate Investment Funds (CIF)</li> <li>REDD and REDD+ implemented through the Forest Carbon Partnership Facility (FCPF); Community-based Forest Management (CBFM) approaches, such as Participatory Forest Management (PFM) or Joint Forest Management (JFM)</li> <li>Afforestation and reforestation activities supported through BioCarbon Fund (BioCF) of the World Bank, such as Ibi Bateke reforestation in Congo, DRC</li> <li>GEF-supported investments in sustainable forest management</li> <li>Conventional IDA and IBRD operations</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                            |                                                                                                                                                                              |

Source: Authors' elaboration.

**Various projects or components have been launched with regard to biomass energy.** The most common focused on cookstoves (11 projects). Others included the development of national biomass energy policies and building institutional capacity (7 projects), woodfuel and charcoal production (7 projects), and bio-electricity (5 projects). The least common have focused on bio-fuels and biogas, with only 3 and 1 projects, respectively. Recently, the Injera Improved Cookstoves project was launched in Ethiopia, where one million stoves have been installed in rural areas, to date; its success is linked to the World Bank's Energy Access Project's implementing agency—Ethiopia Renewable Energy Development and Promotion Center (EREDPC)—which involves women going door to door to promote the new stove, resembling a “training of trainers” approach.



**Table 11 | Approaches to Improved Kiln Technology for Charcoal Production**

| Issue                                                                                                                                                                                                                                                                                                                                             | Approach                                                                                                                                                                                                                                                                                             | World Bank                                                                       | Key Partners                                                                                                                          |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| Inefficient charcoaling techniques leading to low conversion rates and high GHG emissions                                                                                                                                                                                                                                                         | <b>Advance new kiln technology</b><br>a. Improve kiln management<br>b. Pilot semi-industrial and industrial kiln technology<br>c. Create charcoal producer groups<br>d. Facilitate innovative carbon finance<br>e. Pilot electricity co-generation<br>f. Analytical work and knowledge dissemination | Energy; Environment; Social Development; International Finance Corporation (IFC) | Other development partners working on kiln technology, environmental NGOs, CSOs, research institutes, think tanks, and private sector |
| <b>Examples:</b>                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                      |                                                                                  |                                                                                                                                       |
| <ul style="list-style-type: none"> <li>Rwanda: Sustainable Energy Development project (SEDP) that promotes improved kiln technology through training and capacity building</li> <li>Biomass Energy Initiative for Africa (BEIA) program: Innovative approaches to charcoal production, such as improved kilns and briquette production</li> </ul> |                                                                                                                                                                                                                                                                                                      |                                                                                  |                                                                                                                                       |

Source: Authors' elaboration.

**Building on this experience, approaches for future engagement can be generically identified.** Aspects of wood-based biomass consumption and production have been described throughout this document. This section will summarize the findings and link them to selected examples of past and ongoing operations to demonstrate that future projects can apply their experiences and lessons. For example, for issues relating to fuelwood consumption in rural and peri-urban areas, experiences from Senegal (PROGEDE I & II) and Rwanda (Sustainable Energy Development project (SEDP) can be utilized.

**Many activities currently developed and implemented with respect to demand are managed by units other than Africa Energy.** For example, most—if not all—investment plans developed for the pilot countries that received allocations from the Forest Investment Program (FIP) under the Climate Investment Funds (CIF), such as Ghana, Burkina Faso, and Congo DR, consider sustainable wood-based biomass management as a priority investment area. Further, almost all SSA countries participating in the REDD program (Reduced Emissions from Deforestation and Forest Degradation) implemented by the World Bank's Forest Carbon Partnership Facility (FCPF), identified wood-based biomass as a key sector to improve forest management and avoid further degradation of forest resources (Box 7). Given the new financing mechanisms and prioritization of forest management by different sectors, there is increasing potential to build strong partnerships among different units within the Africa Regions Sustainable Development network. While the comparative advantage of any supply-side intervention may not necessarily be with the Africa Energy unit, the areas where it can develop a strong investment portfolio include promoting improved kiln technology, building producers' capacity, improving the development and distribution of cookstoves, and developing strategies for other areas where the Africa Energy unit has a potential to develop a strong investment portfolio.

#### **Box 7 | Financing Mechanisms for Investments in the Wood-Based Biomass Energy Sector**

Considerable potential exists to finance biomass energy in Africa, through mechanisms that already fund forestry projects and mitigate climate change, **REDD** and **REDD+**, and various funds and facilities designed to implement such projects. Hence, there is considerable potential for financing biomass energy development in Africa.

The **Strategic Climate Fund** (part of the greater **Climate Investment Funds**) contains two programs that may be used to scale up forestry and other biomass energy projects: The **Forest Investment Program (FIP)** and the **Scaling-up Renewable Energy Program (SREP)**. The FIP supports developing countries' efforts to reduce deforestation and forest degradation (REDD).

The World Bank's Carbon Finance Unit houses three funds that are particularly relevant to biomass energy: These include the **BioCarbon Fund (BioCF)**, the **Community Development Carbon Fund (CDCF)**, and the **Forest**

**Carbon Partnership Facility (FCPF).** The first two focus on land use-based credits and rural community-based projects, respectively. The third supports Bank's efforts to address REDD.

**The Clean Development Mechanism (CDM),** which is part of the Kyoto Protocol, established a framework to support the international trading of carbon credits. However, in practice, the volume of carbon emissions that were avoided has not been sufficiently high to offset the CDM transaction costs, making many small off-grid projects ineligible for such financing. By simplifying and clarifying the CDM's **Programme of Activities (PoA)**, it is becoming easier to develop smaller-scale biomass energy projects such as those with improved cookstoves, which have so far sought carbon finance opportunities in the voluntary carbon market. The CDM has already approved 26 household energy-efficiency projects and registered six more (UNEP Risoe Center, 2010).<sup>14</sup>

The GEF has several grant mechanisms to promote better biomass stoves and improve the sustainability of household biomass use. These include: (i) **the Earth Fund** (and other private-sector development funds); (ii) **the Sustainable Forest Management program**; and (iii) **the Small Grants Program**. The IFC also helped develop a large number of financial products for businesses and consumers to support biomass energy and has also recently agreed to provide financing support for improved cookstoves.<sup>15</sup>

Source: Authors' elaboration.

<sup>14</sup> UNEP Risoe Centre, 2010. "CDM/JI Pipeline Analysis and Database." Available at <http://cdmpipeline.org/>

<sup>15</sup> IFC announced loan guarantees from local banks for the distribution of up to 200,000 energy efficient cookstoves and solar lanterns to members of the Self-Employed Women's Association (SEWA) in India (primarily in Gujarat and Rajasthan) over a three year period. To find out more: <http://www.ifc.org/ifcext/southasia.nsf/Content/ProjectInformationIndia>

**Table 12 | Approaches to Trade Intervention for Fuelwood and Charcoal**

| Issue                                                                                                                                                                                                                                                                                                                                                                                                                 | Approach                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | World Bank                                                                                                                 | Key Partners                                                                                                  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| <b>Trade (FUELWOOD and CHARCOAL)</b>                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                            |                                                                                                               |
| Unregulated, oligopolistic market structures leading to corruption and failed revenue collection                                                                                                                                                                                                                                                                                                                      | <b>Reform and modernize the fiscal and governance framework</b> <ol style="list-style-type: none"> <li>Formalize charcoal trade</li> <li>Link fiscal policies to sustainable harvests and charcoal</li> <li>Enhance and modernize law enforcement</li> <li>Invest in infrastructure (trading sites)</li> <li>Facilitate the use of information technology</li> <li>Pilot sustainable charcoal certification programs</li> <li>Foster analytical work and knowledge exchange</li> </ol> | Energy;<br>Environment;<br>Social Development;<br>Transport and Infrastructure;<br>International Finance Corporation (IFC) | Independent forest monitors, environmental NGOs, CSOs, research institutes and think tanks and private sector |
| <b>Examples:</b>                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                            |                                                                                                               |
| <ul style="list-style-type: none"> <li>Senegal PROGEDE I &amp; II</li> <li>Analytical work by the Forest Law Enforcement and Governance (FLEG) team supported through the Program on Forests (PROFOR) in the SDN anchor</li> <li>Rwanda: Analytical work "Green Charcoal Chain"</li> <li>Tanzania: Analytical work on the charcoal sector (Policy Note) and a Stakeholder-based Political Economy Analysis</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                            |                                                                                                               |

Source: Authors' elaboration.

In addition to the biomass energy-related lending operations, the World Bank's Africa Energy Group is implementing the Biomass Energy Initiative for Africa (BEIA), a program designed to pilot innovative approaches to the wood-based biomass energy sector. As part of the Africa Renewable Energy Access (AFREA) Program, BEIA is co-financing pilot biomass energy projects that could be incorporated in the Bank's future lending operations throughout SSA. This initiative aims to address some fundamental issues through innovative approaches. The task team issued a Call for Proposals in July 2009: 100 proposals were received from 23 SSA countries. In October 2009, 10 projects were selected to be implemented in 2011, with a total funding of US\$1.3 million for the following areas:

- Improving market conditions for high quality and high performance stoves.
- Modernizing the charcoal industry: improving its environmental sustainability and energy efficiency, both for producing and using charcoal.
- Demonstrating the feasibility of social bio-fuels.
- Increasing power capacity with bio-electricity—using biomass as a fuel to generate power for off-grid or add-on capacity.

Programs like BEIA have a strong potential to generate, disseminate and exchange information, as well as build capacity and develop new, innovative approaches that would not occur under conventional lending programs. For a list of World Bank biomass related projects in SSA (2000-2010), please see Annex 1.

**Table 13 | Approaches to Demand-Side Interventions for Fuelwood and Charcoal Consumption**

| Issue                                                                                                                                                                                                                                                                                                                                                                                 | Approach                                                                                                                                                                                                                                                                                                | World Bank                                                                 | Key Partners                                              |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-----------------------------------------------------------|
| Demand-Side (FUELWOOD)                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                         |                                                                            |                                                           |
| Inefficient cookstoves                                                                                                                                                                                                                                                                                                                                                                | <b>Promotion and adoption of improved cookstoves (ICS)</b> <ol style="list-style-type: none"> <li>Promotion campaigns</li> <li>Awareness raising</li> <li>Training and capacity building</li> <li>Research and development</li> <li>Technical assistance</li> <li>Analytical and sector work</li> </ol> | Energy; Environment; Agriculture and Rural Development; Social Development | Development partners, private sector, NGOs, CSOs, and FAO |
| <b>Examples:</b>                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                         |                                                                            |                                                           |
| <ul style="list-style-type: none"> <li>• Senegal: PROGEDE I &amp; II</li> <li>• Ethiopia: Injira improved cookstove development and dissemination</li> <li>• Rwanda: Sustainable Energy Development Project (SEDP) supporting the dissemination of improved cookstoves in urban and rural areas; analytical work on biomass energy use through detailed household surveys.</li> </ul> |                                                                                                                                                                                                                                                                                                         |                                                                            |                                                           |

Source: Authors' elaboration.







# 5

**>BIOMASS ENERGY CONTAINS  
TREMENDOUS POTENTIAL FOR  
CONTRIBUTING TO ECONOMIC  
DEVELOPMENT, ALLEVIATING  
POVERTY, AND MANAGING THE  
ENVIRONMENT SUSTAINABLY>**



# CONCLUSION

**Population growth, accelerated urbanization, and relative price changes of internationally traded energy sources has resulted in a rapidly changing framework of biomass energy use in SSA.** In this context—and coupled with emerging demands for assisting client countries in developing and implementing low-carbon and green growth strategies—the focus on biomass energy has recently been sharpened. Wood-based biomass energy is acknowledged as an important source for meeting the most basic energy needs of most Sub-Saharan African consumers. Further, creating sustainable biomass energy sectors helps client countries meet their Millennium Development Goals and is at the core of the Bank’s mission of alleviating poverty.

**Against this background, this paper reviewed the issues related to household biomass energy in SSA and described ways the World Bank—especially the Energy Department of the Africa Region—can strengthen and extend its work program in this area.** Until now, the sector has been neglected in most Sub-Saharan African countries and the potential for building a strong analytical and operational portfolio is tremendous. The approaches suggested range from scaling-up investments for physical infrastructure for wood-based biomass markets to promoting innovative approaches linked to the financing of climate-related opportunities. Also, analytical and cooperative efforts are key to building a supportive framework for expanding investments in operations.

**Biomass energy issues require cross-sectoral, interdisciplinary approaches within the Africa Sustainable Development Network.** For example, interventions designed to improve the production of fuelwood and charcoal should be closely coordinated with Environment and Agriculture and Rural Development departments. Further, Social Development can support the design and introduction of community-level interventions. Beyond coordinating within the Africa region, ways should be explored to build on existing collaborations with the International Finance Corporation (IFC), to focus on engaging the private sector. Similar cross-sectoral and cross-ministerial work needs to be advocated at the country level, involving collaboration with other institutions and development partners.

**Although the paper describes various problems within the sector, it demonstrates that biomass energy contains tremendous potential for contributing to economic development, alleviating poverty, and managing the environment sustainably.** Future country dialogue and operations should place a high priority on establishing a formal sector for an area that is now largely informal, modernizing the fiscal and governance framework, decentralizing forest management rights to community levels, and engaging the private sector. At the technical level, it focuses on promoting community-based forest management and improved kiln technology—which include socio-organizational changes, strengthening the use of modern information and communication technology, investing in infrastructure, and promoting the distribution of improved cookstoves.

**Policy makers as well as practitioners can benefit by reviewing the growing body of experience from past and ongoing country dialogues and projects.** The current portfolio of World Bank investments in wood-based biomass energy entails many different activities ranging from support to community-based forest management for wood-based biomass production to enhancing the promotion of improved cookstove interventions that are already known in other parts of the world. With such a broad range of experience to draw upon, task leaders can proactively engage in policy dialogue with their counterparts in the respective ministries, to demonstrate what significant value-added investments in the wood-based biomass energy sector can achieve.

**While many of the issues are similar across countries, there is no single approach to promote change and achieve sustainable use of wood-based biomass energy.** In this context, strengthening the policy dialogue through economic and sector work is always a valuable entry point to determine the specific issues in a particular country. Based on such analyses, the key areas for improving the woodfuel sector can be identified: In one country, these may be the wood production systems (e.g. the need to strengthen local community rights with regard to forest management), while in another, they may relate to the overall regulatory framework. Complemented by lessons-learned from interventions made under similar circumstances countries can develop investment plans with the support of the World Bank and other development partners. In this regard, enhancing knowledge management, dissemination, and exchange is essential to improving this key energy sector.

**With its multi-sectoral capacity, the World Bank is well placed to move this important issue higher on the international development agenda—not only within its own institution, but also with client countries and other development partners.** Strengthening those partnerships is vital to achieving this goal. Joint activities could involve its traditional development partners, as well as regional and local NGOs and CSOs that often have several years—if not decades—of experience in implementing biomass energy projects.



## REFERENCES

- Adkins, E., E. Tyler, J. Wang, D. Siriri, and V. Modi. 2010. *Field Testing and Survey Evaluation of Household Biomass Cookstoves in Rural Sub-Saharan Africa*. Energy for Sustainable Development 14, (2010). Pp. 172-185.
- American Thoracic Society. 2008. *Forum of International Respiratory Societies Report. Biomass Fuels and Respiratory Diseases, A Review of the Evidence*. American Thoracic Society, New York, NY. Proc Am Thorac Soc Vol 5. pp 577–590, 2008.
- Arnold, J.E. M., G. Köhlin, R. Persson, and G. Shepherd. 2003. *Fuelwood Revisited: What Has Changed in the Last Decade?* Center for International Forestry Research (CIFOR), Bogor, Indonesia.
- Arnold, J.E. M., G. Köhlin, and R. Persson. 2005. *Fuelwoods, Livelihoods, and Policy Interventions: Changing Perspectives*. World Development Vol. 34, No. 3, pp. 596–611, 2006.
- Bacon, R., S. Bhattacharya and M. Kojima. 2010. *Expenditure of Low-Income Households on Energy*. COCPO, The World Bank. Washington, DC.
- Bailis, R., A. Cowan, V. Berrueta, and O. Masera. 2009. *Arresting the Killer in the Kitchen: The Promises and Pitfalls of Commercializing Improved Cookstoves*. World Development Vol. 37, No. 10, pp. 1694–1705.
- Bailis, R., V. Berrueta, C. Chengappa, K. Dutta, R. Edwards, O. Masera, D. Still and K.R. Smith. 2007. *Performance Testing for Monitoring Improved Biomass Stove Interventions: Experiences of the Household Energy and Health Project*. Energy for Sustainable Development. Volume 11, Issue 2, pp 57-70.
- Bakhareva, A. 2008. Biomass—a Solid Outlook for the Growing Market. Frost and Sullivan, Green Energy. <http://www.frost.com/prod/servlet/market-insight-top.pag?docid=145919370>
- Banerjee, S., J.A. Lampietti and A. Branczik. 2007. *People and Power: Electricity Sector Reforms and the Poor in Europe and Central Asia*. ESMAP. Washington, DC.
- Barnes, D., B. Singh and X. Shi. 2010. *Modernizing Energy Services for the Poor: A World Bank Investment Review—Fiscal 2000-08*. ESMAP, Washington, DC.
- Bee. R.E. 2010. The Subsidy of LPG—Sharing Experiences. Totalgaz LPG Business Line. Presentation Marrakech 20 May, 2010. Available at: [http://www.worldlpgas.com/page\\_attachments/0000/2578/RENZO\\_BEE.pdf](http://www.worldlpgas.com/page_attachments/0000/2578/RENZO_BEE.pdf)
- van Beukering, P., G. Kahyarara, E. Massey, S. di Prima, S. Hess, V. Makundi, and K. van der Leeuw. 2007. *Optimization of the Charcoal Chain in Tanzania*. Poverty Reduction and Environment Management (PREM) Programme. Institute for Environmental Studies, Amsterdam, The Netherlands.
- Chambwera, M. and H. Folmer. 2007. *Fuel Switching in Harare: An Almost Ideal Demand System Approach*. Energy Policy Volume 35, Issue 4, April 2007, Pages 2538-2548.
- CHAPOSA. 2002: Charcoal Potential in Southern Africa, Final Report. Stockholm Environment Institute.
- Chengappa, C., R. Edwards, R. Bajpai, K. Naumoff Shields and K.R. Smith. 2007. *Impact of Improved Cookstoves on Indoor Air Quality in the Bundelkhand region in India*. Energy for Sustainable Development Volume 11, Issue 2, June 2007, Pages 33-44.
- Chenost, C., Y. Gardette, J. Demenois, N. Grondard, and M. Perrier. 2010. *Bringing Forest Carbon Projects to the Market*. UNEP Nairobi, Kenya.
- Clancy, J. 2002. *Blowing the Smoke Out of the Kitchen: Core Issues in Household Energy and Gender*. The Knowledge Network on Sustainable Household Energy in Southern and Eastern Africa. Sparknet.info
- Coady, D., R. Gillingham, R. Ossowski, J. Piotrowski, S. Tareq, and J. Tyson. 2010. *Petroleum Product Subsidies: Costly, Inequitable, and Rising*, IMF Staff Position Note, SPN/10/05, IMF, Washington, DC.
- Cushion, E., A. Whiteman, and G. Dieterle. 2010. *Bioenergy Development: Issues and Impacts for Poverty and Natural Resource Management*. The World Bank, Washington, DC.
- Deweese, P. 1989. *The Woodfuel Crisis Reconsidered: Observations on the Dynamics of Abundance and Scarcity*, World Development 17 (8), pp. 1159–1172.
- Dherani, M., D. Pope, M. Mascarenhas, K.R. Smith, M. Weber and N. Bruce. 2008. *Indoor Air Pollution from Unprocessed Solid Fuel Use and Pneumonia Risk in Children Aged Under Five Years: A Systematic review and meta-analysis*. Bulletin of the World Health Organization, May 2008, 86.
- Dutta, K., K. Naumoff Shields, R. Edwards, K.R. Smith. 2007. *Impact of Improved Biomass Cookstoves on Indoor Air Quality Near Pune, India*. Energy for Sustainable Development. Volume XI No.2.

Energy for Sustainable Development (ESD). 2007. *Situation Analysis of Charcoal Dynamics, Energy Policies and Possibilities of Switching to Alternatives*. WWF-Tanzania Program Office.

ESMAP. 2001. *Sustainable Woodfuel Supplies from the Dry Tropical Woodlands*. Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP), Washington, DC.

ESMAP. 2010. *Sustainable Production of Commercial Wood fuel: Lessons and Guidance from Two Strategies*. Energy Sector Management Assistance Programme (ESMAP) report. Washington, DC.

Ezzati, M. and D.M. Kammen. 2002. *Evaluating the Health Benefits of Transitions in Household Energy Technologies in Kenya*. Energy Policy 2002; 30: 815–826.

FAO. 2004. *Forest Plantations in Sub-Saharan Africa: Lessons Learnt on Sustainable Forest Management in Africa*. African Forest Research Network-Royal Swedish Academy of Agriculture and Forestry. March 2004.

FAO COFO. 2005. Committee on Forestry; 17th Session; Rome, 15 - 19 March 2005.

FAO. 2010. *What Woodfuels Can do to Mitigate Climate Change*. FAO Forestry Paper 162. Food and Agriculture Organization of the UN. Rome, Italy.

Foley, G. 1985, *Exploring the Impact of Conventional Fuel Substitution on Woodfuel Demand*. In: Earthscan Working Paper, International Institute for Environment and Development, London., England.

Foley, G., P. Kerkhof and D. Madougou. 2002. *A Review of the Rural Firewood Market Strategy in West Africa*. Africa Region Working Paper Series No. 35. The World Bank, Washington, DC.

GEF. 2010. Project Identification Form (PIF), Sustainable Charcoal Program. The Global Environment Facility, Washington, DC.

Gill, J. 1985. *Stoves and Deforestation in Developing Countries*; paper presented to the UK-ISES Conference, Energy for Development—What Are the Solutions? Reading University, December 13, 1985.

GTZ. 2007. *Biomass Energy Strategy (BEST) Outline: A Guide for Policy Makers and Energy Planners*. GTZ, Eschborn, Germany.

GTZ. 2009. *Biomass Energy Strategy (BEST) Wood Fuel Supply Interventions: Lessons and Recommendations*. EUEI, GTZ, April 2009. Eschborn, Germany.

GTZ. 2010. *BEST Guide for Policy Makers and Energy Planners*. EUEI, GTZ. Eschborn, Germany.

GTZ. 2011. *Carbon Markets for Improved Cooking Stoves. A GTZ Guide for Project Operators*. GTZ-HERA – Poverty-oriented Basic Energy Services. Eschborn, Germany.

Gupta, G. and G. Köhlin. 2006. *Preferences for Domestic Fuel: Analysis with Socio-economic Factors and Rankings in Kolkata, India*; Ecological Economics, Elsevier, vol. 57(1), pages 107-121.

Hatcher, J. 2009. *Securing Tenure Rights and Reducing Emissions from Deforestation and Degradation (REDD)*. Social Development Papers. Paper No. 120. The World Bank. Washington, DC.

HEDON. 2010. Charcoal Production Chain. Household Energy Network. Available online: <http://www.hedon.info/CEC:CharcoalProductionChain>

Hiemstra-van der Horst, G. and A.J. Hovorka. 2008. *Reassessing the “Energy Ladder.” Household Energy Use in Maun, Botswana*. Energy Policy Volume 36, Issue 9, September 2008, pp. 3333-3344.

Hiemstra-van der Horst, G. and A.J. Hovorka. 2009. *Fuelwood: The “Other” Renewable Energy Source for Africa?* Biomass and Bioenergy, Volume 33, Issue 11, November 2009, pp. 1605-1616.

Hosier, R.H., M.J. Mwandosya and M.L. Luhanga. 1993. *Future Energy Development in Tanzania: the Energy Costs of Urbanization*. Energy Policy, 524–542.

IEA. 2006. World Energy Outlook. Chapter 15, Energy For Cooking in the Developing World. IEA/OECD Paris, France.

IEA. 2008. World Energy Outlook WEO. OECD/IEA Paris, France.

IEA. 2010. World Energy Outlook WEO. OECD/IEA Paris, France.

IEA and WHO. 2010. *Energy Poverty: How to Make Modern energy Access universal?* Special early excerpt of the World Energy Outlook 2010 for the 2010 UN MDG Review Summit.

IMF. 2008. *Senegal: Selected Issues*. Washington DC: International Monetary Fund.

IISD. 2010. *Strategies for Reforming Fossil-fuel Subsidies: Practical Lessons from Ghana, France, and Senegal*. The Global Subsidies Initiative| Untold Billions: Fossil-Fuel Subsidies, their Impacts, and the Path to Reform. International Institute for Sustainable Development, Manitoba, Canada.

- Kambewa, P., B. Mataya, K. Sichinga, and T. Johnson. 2007. *Charcoal, the Reality: A study of Charcoal Consumption, Trade and Production in Malawi*; Small and Medium Size Enterprise Series No. 21, IIED, London, England.
- Kebede, E., J. Kagochi and C.M. Jolly. 2010. *Energy Consumption and Economic Development in Sub-Sahara Africa*. Energy Economics Volume 32, Issue 3, May 2010, pp 532-537.
- Khundi, F., P. Jagger, G. Shively and D. Sserunkuuma. 2010. *Income, Poverty and Charcoal Production in Uganda*. Article in Press.
- Koolwal, Gayatri Dominique van de Walle. 2010. *Access to Water, Women's Work and Child Outcomes* World Bank, PREM, Gender and Development Unit. Washington, DC.
- Laan, T., C. Beaton and B. Presta. 2010. *Reforming Fossil-Fuel Subsidies: Practical lessons from Ghana, France and Senegal. Fossil-Fuel Subsidies, Their Impacts and The Path To Reform*. Global Subsidies Initiative (GSI) of the International Institute for Sustainable Development (IISD). Geneva, Switzerland.
- Masera, O.R., B.D. Saatkamp, and D.M. Kammen. 2000. *From Linear Fuel Switching to Multiple Cooking Strategies: A Critique and Alternative to the Energy Ladder Model*. World Development Volume 28, Issue 12, pp. 2083-2103.
- Masera, O., R. Edwards, C.A. Arnez, V. Berrueta, M. Johnson, L.R. Bracho, H. Riojas-Rodriguez, and K.R. Smith. 2007. *Impact of Patsari Improved Cookstoves on Indoor Air Quality Michoacan, Mexico*. Energy for Sustainable Development XI, pp. 45-56.
- Matthews, E. 2000. *Undying Flame: The Continuing Demand for Wood as Fuel*; excerpt from "Pilot Analysis of Global Ecosystems: Forest Ecosystems". World Resources Institute, Washington, DC.
- Mitchell, D. 2011. *Biofuels in Africa—Opportunities, Prospects, and Challenges*. The World Bank. Washington, DC.
- Mombu, V. and J. Ohemeng. 2008. *Towards Sustainable Charcoal Production in Ghana. Negotiating a Community-based charcoal Association in Nkoranza District*. Nature Conservation Research Centre, Ghana.
- Mugo, F., and C. Ong. 2006. *Lessons from Eastern Africa's Unsustainable Charcoal Trade*. World Agroforestry Centre. Nairobi, Kenya.
- Mwampamba, T.H. 2007. *Has the Woodfuel Crisis Returned? Urban Charcoal Consumption in Tanzania and Its Implications to Present and Future Forest Availability*. Energy Policy Volume 35, Issue 8, August 2007, pp. 4221-4234.
- Openshaw, K. 2010. *Biomass Energy: Employment Generation and its Contribution to Poverty Alleviation*. Biomass and Bioenergy 34, pp. 365-378.
- Palmer, C. and J. MacGregor. 2009. *Fuelwood Scarcity, Energy Substitution, and Rural Livelihoods in Namibia*. Environment and Development Economics, 14 (6). pp. 693-715.
- Palmula, S. and M. Beaudin. 2007. *Greening the Charcoal Chain—Substituting for Charcoal as a Household Cooking Fuel in Dar es Salaam*. Poverty Reduction and Environmental Management (PREM), Institute for Environmental Studies. Vrije Universiteit, Amsterdam, The Netherlands.
- PESD. 2009. *Three Key Obstacles to Cookstove Adoption (And How to Overcome Them)*. Global Village Energy Partnership International, pp 37-40.
- Pennise, D., S. Brant, S.M. Agbeve, W. Quaye, F. Mengesha, W. Tadele, and T. Wofchuck. 2009. *Indoor Air Quality Impacts of an Improved Wood Stove in Ghana and an Ethanol Stove in Ethiopia*. Energy for Sustainable Development. Volume 13, Issue 2, pp. 71-76.
- Plas van der, R. 2008. *Charcoal and Taxation in Africa*. Discussion Draft.
- Quadir, S.A., S. S. Mathur and T.C. Kandpa. 1995. *Barriers to Dissemination of Renewable Energy Technologies for Cooking*. Energy Conversion and Management. Volume 36, Issue 12, pp. 1129-1132.
- Roden, C.A., T.C. Bond, S. Conway, A. Benjamin Osorto Pinel, N. MacCarty and D. Still. 2009. *Laboratory and Field Investigations of Particulate and Carbon Monoxide Emissions from Traditional and Improved Cookstoves*. Atmospheric Environment Volume 43, Issue 6, pp. 1170-1181.
- RPTES. 1996. *Review of Policies in the Traditional Energy Sector*. The World Bank, Western Africa Department. Washington, DC.
- Schlag, N. and F. Zuzarte. 2008. *Market Barriers to Clean Cooking Fuels in Sub-Saharan Africa: A Review of Literature*. Working Paper, Stockholm Environment Institute (SEI), Stockholm, Sweden.
- Seboka, Y. 2009. *Charcoal Production: Opportunities and Barriers for Improving Efficiency and Sustainability*. Biocarbon Opportunities in Eastern and Southern Africa. UNDP and UNEP. New York, NY.
- SEI. 2002. *Charcoal Potential in Southern Africa, CHAPOS: Final report*. INCO-DEV, Stockholm Environment Institute (SEI), Stockholm, Sweden.



- SEI. 2008. *Household Energy in Developing Countries: A Burning Issue*. Policy Brief. SEI Stockholm, Sweden.
- Sepp, C. 2003. *Household Energy and Forestry: An Introduction*. ECO Consulting Group, Germany. Sparknet.info
- Sepp, S., 2008a. *Promotion of Sustainable Charcoal Production Through Community Level Approaches: Experiences and Lessons Learned from Selected Sub-Saharan African Countries*. Discussion paper.
- Sepp, S., 2008b: *The Way Ahead—Creating a Formal and Sustainable Charcoal Sector*. Discussion paper.
- Shepherd, G. 1990. *Forestry, Social Forestry, Fuelwood and the Environment: A Tour of the Horizon*. Rural Development Forestry Network paper 11a, Overseas Development Institute, London.
- Smith, K.R., J. Samet, I. Romieu, and N. Bruce. 2000a. *Indoor Air Pollution in Developing Countries and Acute Lower Respiratory Infections in Children*. Thorax, 55 (6), pp.518-532.
- Smith, K.R., R. Uma, V.V.N. Kishore, J. Zhang, V. Joshi, and M.A.K. Khalil. 2000b. *Greenhouse Implications of Household Stoves: An Analysis for India Annual Review of Energy and the Environment*. Vol. 25: 741-763.
- Sokona, Y. and P. Deme. 2004. *LPG Subsidies in Senegal*. In UNEP, 2003, *Energy Subsidies: Lessons Learned in Assessing their Impact and Designing Policy Reforms* (pp. 113-121). Geneva: United Nations Environment Programme and Greenleaf Publishing.
- Spreng, D.T. and S. Pachauri. 2003. *Energy Use and Energy Access in Relation to Poverty*. CEPE, Centre for Energy Policy and Economics, Swiss Federal Institute of Technology. Zurich, Switzerland.
- UN Habitat. 2010. *The State of African Cities 2010: Governance, Inequality and Urban Land Markets*. United Nations Human Settlements Programme (UN-HABITAT), Nairobi, Kenya.
- UN Millennium Project. 2005. *Energy and the Millennium Development Goals*. ESMAP, UNDP, UN Millennium Project, and World Bank. New York, NY.
- UNDP. 2009. *The Energy Access in Situation in Developing Countries: A Review Focusing on the Least Developed Countries and Sub-Saharan Africa*. UNDP, New York, NY.
- UNECA. 2002. *Africa Climate Change. Sustaining Natural Assets and Reducing Human Vulnerability*. UNECA, New York, NY.
- VENRO. 2009. *Rethinking Biomass Energy in Sub-Sahara Africa*. The VENRO Project on Africa-EU Partnership. Association of German Development NGOs.
- Vermeulen, S. 2001. *Fuelwood in Africa: Crisis or Adaptation?* Center for International Forestry Research (CIFOR), Indonesia.
- Victor, D. 2009. *Fossil-Fuel Subsidies Their Impacts and The Path To Reform: The Politics of Fossil-Fuel Subsidies*. Global Subsidies Initiative (GSI) of the International Institute for Sustainable Development (IISD). Geneva, Switzerland.
- WHO. 2005a. *Indoor Air Pollution and Household Energy Monitoring*. WHO Workshop Resources. Geneva, Switzerland.
- WHO. 2005b. *Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide: Global Update 2005*, World Health Organization, Geneva.
- WHO. 2008. *Evaluating Household Energy and Health Interventions: A Catalogue of Methods*. World Health Organization, Geneva, Switzerland.
- Winrock International. 2007. *A Cost-Benefit Analysis of National and Regional Integrated Biogas and Sanitation Programs in sub-Saharan Africa*. Winrock International, April 2007, Prepared for the Dutch Ministry of Foreign Affairs.
- World Bank. 2005. *Sustainable and Participatory Energy Management Project (PROGEDE). Implementation Completion Report*. World Bank, Washington, DC.
- World Bank. 2009. *Environmental Crisis or Sustainable Development Opportunity, Transforming the Charcoal Sector in Tanzania*. A Policy Note. The World Bank, Environment and Natural Resources Unit, Washington, DC.
- World Bank, forthcoming. 2011a. *Household Biomass Cookstoves, Environment, Health, and Climate Change: A New Look at an Old Problem*. The Environment Department (Climate Change). The World Bank, Washington, DC.
- World Bank, forthcoming. 2011b. *Household Energy for Cooking and Heating: Lessons Learned and Way Forward*. The World Bank, Washington, DC.
- World Bank News. 2009. *In the Democratic Republic of Congo, Planting Trees for a Better Environment and Healthier Citizens*. Available at <http://go.worldbank.org/K1U9VOJGG0>
- Zhang, J., K.R. Smith, Y. Ma, S. Ye, F. Jiang, W. Qi, P. Liu, M.A.K. Khalil, R.A. Rasmussen and S.A. Thomelee. 2000. *Greenhouse Gases and Other Airborne Pollutants from Household Stoves in China: a Database for Emission Factors*. Atmospheric Environment 34, 4537-4549.

# ANNEX 1 | THE WORLD BANK BIOMASS RELATED PROJECTS IN AFRICA (2000-2010)

|                 | Project Name                                                                             | Country       | Year | Total Cost (US\$ M) | Biomass Energy (US\$ M) | Fuelwood Production | Charcoal Production | Stoves | Indoor Air Pollution | Institutional Policy | Biofuel | Biogas | Bio-electricity |
|-----------------|------------------------------------------------------------------------------------------|---------------|------|---------------------|-------------------------|---------------------|---------------------|--------|----------------------|----------------------|---------|--------|-----------------|
| 1               | Benin - Energy Services Delivery Project                                                 | Benin         | 2004 | 95.7                | 6.2                     | x                   | x                   | x      |                      | x                    |         |        |                 |
| 2               | Benin - Forests and Adjacent Lands Management (GEF) Project                              | Benin         | 2006 | 22.35               | 1.89                    | x                   |                     |        |                      |                      |         |        |                 |
| 3               | Benin - Increased Access to Modern Energy Project                                        | Benin         | 2009 | 178.5               | 5.5                     | x                   |                     | x      |                      |                      |         |        |                 |
| 4               | Burkina Faso - Energy Access Project                                                     | Burkina Faso  | 2007 | 41                  | 6.7                     |                     |                     | x      |                      |                      | x       |        |                 |
| 5               | Chad - Community-Based Ecosystem Management Project                                      | Chad          | 2005 | 94.45               | 2.5                     |                     |                     | x      |                      |                      |         |        |                 |
| 6               | Ethiopia - Energy Access Project                                                         | Ethiopia      | 2002 | 216.2               | 30.9                    | x                   |                     | x      |                      | x                    |         |        |                 |
| 7               | Ghana - Energy Development and Access Project                                            | Ghana         | 2007 | 210.61              | 9.1                     |                     |                     |        |                      | x                    |         |        | x               |
| 8               | Guinea-Bissau Multi-Sector Infrastructure Rehabilitation Project                         | Guinea-Bissau | 2006 | 25                  | 0                       |                     |                     |        |                      | x                    |         |        | x               |
| 9               | Madagascar - Third Environment Program Support Project                                   | Madagascar    | 2004 | 148.9               | 2.5                     |                     | x                   |        |                      |                      |         |        |                 |
| 10              | Mali - Household Energy and Universal Access Project                                     | Mali          | 2003 | 53.35               | 11.2                    | x                   | x                   | x      | x                    | x                    |         |        |                 |
| 11              | Mozambique - Second Adaptable Program Loan for the Energy Development and Access Project | Mozambique    | 2010 | 80                  | 14.3                    |                     | x                   | x      |                      |                      | x       |        |                 |
| 12              | Rwanda - Urgent Electricity Rehabilitation Project                                       | Rwanda        | 2004 | 31.3                | 0.9                     |                     |                     | x      |                      |                      |         |        |                 |
| 13              | Rwanda - Sustainable Energy Development Project                                          | Rwanda        | 2009 | 8.3                 | 3.95                    |                     | x                   | x      |                      | x                    |         |        |                 |
| 14              | Senegal - Electricity Services for Rural Areas Project                                   | Senegal       | 2004 | 71.7                | 4.6                     | x                   | x                   | x      | x                    |                      |         |        |                 |
| 15              | Tanzania - Energy Development and Access Expansion Project                               | Tanzania      | 2007 | 148.6               | 32.7                    |                     |                     |        |                      |                      |         |        | x               |
| 16              | Uganda - Energy for Rural Transformation Project                                         | Uganda        | 2001 | 123.31              | 1                       |                     |                     |        |                      |                      |         |        | x               |
| 17              | Uganda - Second Energy for Rural Transformation (ERT II) Project                         | Uganda        | 2009 | 93                  | 0.4                     |                     |                     |        |                      | x                    |         |        | x               |
| <b>In Total</b> |                                                                                          |               |      | <b>1,642.27</b>     | <b>134.34</b>           |                     |                     |        |                      |                      |         |        |                 |







Africa Renewable Energy  
Access Program (AFREA)

1818 H Street, N.W.  
Washington DC 20433, USA  
Internet: [www.worldbank.org/afr/energy/afrea](http://www.worldbank.org/afr/energy/afrea)  
Email: [africaenergyunit@worldbank.org](mailto:africaenergyunit@worldbank.org)



Energy Sector Management Assistance Program

1818 H Street, N.W.  
Washington DC 20433, USA  
Internet: [www.esmap.org](http://www.esmap.org)  
Email: [esmap@worldbank.org](mailto:esmap@worldbank.org)



THE WORLD BANK

1818 H Street, N.W.  
Washington DC 20433, USA  
Internet: [www.worldbank.org/afr/energy](http://www.worldbank.org/afr/energy)  
Email: [africaenergyunit@worldbank.org](mailto:africaenergyunit@worldbank.org)