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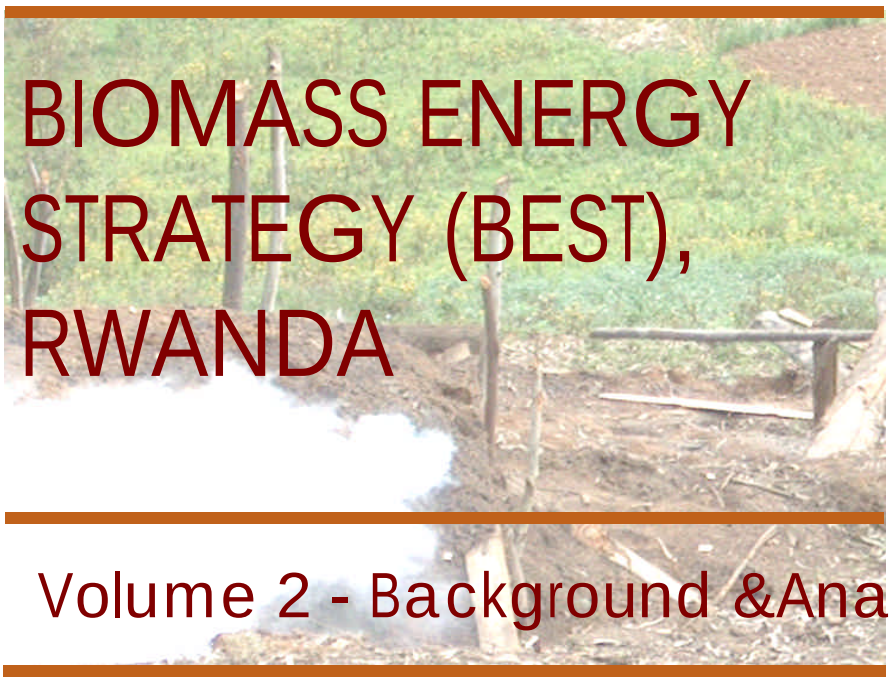
EUROPEAN UNION ENERGY INITIATIVE
for poverty eradication and sustainable development

Partnership Dialogue Facility (EUEI PDF)

REFERENCE NO.: 81098569
PROJECT NO.: 01.2457.8-007.24

# BIOMASS ENERGY STRATEGY (BEST), RWANDA



## Volume 2 - Background &Analysis

June 2009

MARGE

# Volume 2: Background and Analysis

**June 2009**

**EUEI-PDF** **GTZ** **MARGE**

## Preface

The Biomass Energy Strategy (BEST) that is described in this report is developed in the framework of the EUEI Partnership Dialogue Facility on request of the Government of Rwanda. The strategy mainly addresses charcoal supply sustainability issues, simply because charcoal is the main urban fuel for which not many acceptable alternatives exist. Rural biomass energy issues have now been included as well.

Two workshops were held, on April 30 and September 18, 2008. The first workshop was organized to discuss the main approach to the proposed strategy, to see whether there would be consensus among the participating agencies and organizations, and the second more to discuss and validate the results. The Minister in charge of Energy participated in both workshops and the Minister in charge of Natural Resources participated in the last workshop. Comments made by the various participants have been incorporated in the report. In addition, a meeting was held with district officials dealing with wood energy of the six districts that provide most of the wood, to discuss regulatory issues.

Finally, in January 2009 MININFRA carried out a rural energy survey among 3000 randomly selected households, 100 in each district. The results of this survey are analyzed and used to include the most important rural biomass energy issues.

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The Biomass Energy Strategy (BEST) that is described in this report is developed in the framework of the EUEI Partnership Dialogue Facility on request of the Government of Rwanda. The strategy mainly addresses charcoal supply sustainability issues, simply because charcoal is the main urban fuel for which not many acceptable alternatives exist.

The Biomass Energy Strategy has been developed jointly between the MARGE[1] team and a team of Rwandese specialists from MININFRA, MIRENA, and a number of other ministries, NGOs, private firms as well as selected individuals, some of whom have been heavily involved in the preparation of the strategy. It would go too far to express gratitude to all except a few without whom it would not have been possible to develop the strategy: Eng. Albert Butare, Minister of State in charge of Energy, without whom the study would never have materialized; Gerard Hendriksen, GTZ/Kigali; Yussuf Uwamahoro, Silas Ruzigana and Naceur Hammami, MININFRA; and, Claudien Habimana of MINIRENA, all of whom have been instrumental in shaping the proposed strategy.

[1] Marchéage et Gestion de l'Environnement S.A.R.L; (translated : Marketing and Management of the Environment), a consultancy firm dealing with rural energy and environment issues. Robert van der Plas (Team Leader) was responsible for the charcoal issues and writing the final document integrating the different parts; Gérard Madon was responsible for the woodfuel supply write-up; Michel Matley was responsible for the economic analysis of the strategy and the modeling. Anne Pirot of SHER was responsible for analysis and Sabin Murererehe for conducting the 2008 surveys. Emmanuel Gatera of Green and Clean was responsible for analysis and conducting the 2009 survey.

## Abbreviations and Acronyms

| | |
|---|---|
| DFP | District Forestry Plan |
| EDPRS | Economic Development and Poverty Reduction Strategy |
| EICV | Household Conditions Survey |
| EWB | Engineers without Borders |
| HERA | Household Energy for Sustainable Development |
| EUEI | European Union Intelligent Energy |
| GTL | Gas to liquid |
| NEDA | National Energy Development Agency |
| MINIRENA | Ministry of Natural Resources |
| MININFRA | Ministry of Infrastructure, Energy and Telecommunications |
| MSW | municipal solid waste |
| NAFA | National Forestry Agency |
| NFF | National Forestry Fund |
| NFP | National Forest Policy |
| ORTPN | Rwanda Office of Tourism and National Parks |
| PDF | Partnership Dialogue Facility |
| PO | Peasant Organizations |
| ProBEC | Programme for Biomass Energy Conservation |
| PRSP | Poverty Reduction Strategy Program |
| REMA | Rwanda Environmental Management Agency |
| RURA | Rwanda Utility Regulatory Agency |
| SPAT | Strategic Program for Agriculture Transformation |
| WSMP | Woodfuels Supply Master Plan |

## **Currency** (April 2008)

1 US$ = FRw 540

1 Euro = FRw 780

# Summary

Some 85% of the primary energy balance is made up of biomass and 11% of imported petroleum fuels. Households consume 81% of the final energy balance and most of this is in the form of biomass (85%). Therefore, biomass provides an important role in the energy supply and demand of the country and provides a relatively good energy security. In fact, biomass is important also because it creates rural employment, it provides a low-cost energy source for households and industries, and it avoids large-scale importation of alternative sources of energy. However, wood for producing charcoal consumes 23% of the primary energy balance, while charcoal only makes up 8% of the secondary energy balance. A special focus on charcoal is therefore warranted.

At the moment, the supply and demand balance is negative: the consumption of wood (firewood and charcoal) is larger than the estimated sustainable production. However, most if not all of the wood comes from man-made plantations. This is in sharp contrast to the past, when wood mainly came from natural forests; although today fully covered with *Eucalyptus* plantations, the Bugasera region became denuded in the early 80s because of the demand for charcoal in Kigali. Today charcoal comes from a different number of regions, where it is made from private plantations and from public District plantations. State plantations do not contribute as they are officially not exploited, but unofficially 80% show signs of illegal harvesting.

Two problems prevent a better supply of wood: (i) the current legislation is not appropriate any longer as it assumes that wood comes from natural forests rather than from (private) plantations. In addition, it is laborious and since farmers feel unnecessarily burdened to ask for approval to cut trees that they planted, they are no longer complying with the rules. In addition, some Districts banned the production of charcoal altogether, but surveys showed that this has no effect on the supply of charcoal from these districts – it does have an effect on the efficiency with which trees are cut and converted into charcoal, as it is now done illegally. Moreover, since some of the charcoal is produced illegally, transporters are harassed and transaction fees are extracted.

(ii) The output of plantations is lower than warranted; it could at least double if proper management techniques were employed and if certain plantations were rehabilitated. Farmers consider trees as just another perennial crop, not unlike the annual crop of maize, and they would like to see regulation reflect this. As it is now, they are less interested in planting more trees or in better maintaining existing trees. Nevertheless, since charcoalers have to pay for the wood they use, they have become more efficient over the years and an improvement of some 40% was observed over the past 20 years. The fact that they pay for their wood, or that charcoal comes from plantations for that matter, is a unique situation in Africa: in most other countries charcoal comes from natural forests and plantations have a hard time in getting their products to the market – it is almost as if they were located in Bugasera in the 1980s.

Alternative fuels do either not exist or are too expensive and as a result biomass will continue to be used for the foreseeable future. Briquettes that could replace charcoal, from *Papyrus* or *Typha*, are not produced, and peat is not available in an acceptable form. Solar or wind energy does not play a role in replacing cooking fuels. Petroleum fuels are far more expensive per energy unit than firewood and charcoal and with the present global price trends there is very little hope that this may change soon. At the moment, taxes and lack of scale-economies also play a role in these high prices to end-users. Electricity is also more expensive than biomass and even though quite a few new electricity generation plants will

come on line, it will remain too expensive for households to use for cooking. Methane gas is likely used for electricity generation and not for direct use such as for cooking.

Rural households mainly use low-grade fuels that they collect near their homes, and only 20% regularly buys firewood. The use of charcoal has been observed as well in some 5% of the households. It appears that the supply-demand balance in rural areas is about in equilibrium, but any increase in the use of purchased firewood or charcoal will upset this balance, with possible implications for the sustainable urban supply as well. Volume 3 will specifically look into rural biomass energy issues.

This document (Volume 2) analyzes the energy sector and its subsectors, reviews the present regulatory environment, and discusses the current main actors in this field. Then it identifies ways to intervene to render the biomass supply sustainable. There are many ways to intervene, but there is not one single magic solution and several of the interventions or "building blocks" will need to be implemented simultaneously.

Since intervention is needed at several fronts at the same time, different sets of building blocks are possible. The possibility that all charcoal is replaced by petroleum fuels is reviewed, the possibility to reduce the biomass energy demand is reviewed, and the Vision 2020 scenario is considered.

The 4th Volume, Proposed Strategy, elaborates the proposed strategy, its costs and its benefits.

## 1. Introduction

BEST is a joint initiative of the EUEI Partnership Dialogue Facility (PDF), GTZ's Energising Africa programme and the Household Energy for Sustainable Development (HERA) programme (both implemented on behalf of BMZ). It is based on the findings of a workshop which was hosted by the SADC-based Programme for Biomass Energy Conservation (ProBEC) in March 2004 and involved most SADC countries.

The BEST initiative supports African governments in developing national biomass energy strategies. The goal is to ensure a more sustainable supply of biomass energy, meeting the demand of the people and various sectors of the economy. The initiative aims at building awareness of biomass energy as the main source of primary energy in Africa and its relevance to poverty alleviation, in particular among decision makers at the policy level and other important stakeholders. The target is to finalise a strategy development process in a number of countries within two years (2007/2008), resulting in a draft strategy ready for Government approval. At the same time the BEST approach will be further developed and adapted for dissemination and application in other countries.

Rwanda is among the first countries to develop a BEST and the development of the Rwandan biomass energy strategy will thus provide useful lessons for other countries in the region. Biomass energy contributes over 92% of Rwanda's primary energy supply and is mainly used in the form of firewood and charcoal. About 99% of household energy demand is met by biomass as estimated by the Ministry of Infrastructure in 2007. The widespread and inefficient use of traditional biomass contributes to the overexploitation of forest stocks and causes other problems such as health problems from indoor air pollution. Upon request from the Ministry of Infrastructure of Rwanda, the EUEI Partnership Dialogue Facility (PDF) will support the development of a National Biomass Energy Strategy (BEST) in Rwanda with a particular focus on improvements to the charcoal supply chain.

The goal of the strategy is to ensure a more sustainable supply of biomass energy (e.g. firewood and charcoal) and to promote access to modern cooking fuels as well as to efficient biomass combustion technologies for households and small enterprises. The strategy development process was led by the Ministry of Infrastructure (office of the Minister of State for Energy) and cooperated closely with the Ministry of Land as well as all other relevant stakeholders. A workshop was held to discuss the draft BEST and obtain feedback from as many stakeholders as possible.

### 1.1 National Biomass Energy Environment

Biomass is the main source of primary energy in sub-Saharan Africa. In some countries wood fuels (firewood and charcoal) and agricultural waste account for more than 90% of total energy consumption. The wood fuel sector not only employs tens of thousands of people, it also contributes millions of dollars to local economies in the form of revenues, taxes, and incomes. However, as it is seen as "traditional", it is seldom given high priority in energy policies and poverty alleviation strategies. While comprehensive strategies have normally been prepared for the power and petroleum sectors in most countries, there are few comparable strategies for the traditional use of biomass in the energy sector, in particular in Eastern and Southern Africa. Some countries have implemented isolated projects to demonstrate action and some have given it new attention by assigning biomass to the "renewables" sector, but normally commitments remain verbal (appearing on the "last slide" of presentations at energy conferences). This is all the more precarious as in many African countries biomass energy supply and consumption are no longer in balance. In many regions the increasing wood fuel demand can no longer be satisfied as forest resources disappear. The

intra biomass transition from firewood to charcoal, on top of the low efficiency of carbonisation technologies, is accelerating this process: in many countries the "fuelwood gap" has become a reality or at least has appeared on the horizon. Moreover, as oil prices rise the heavy dependence on biomass is not expected to change dramatically over the next couple of decades.

### 1.2 Rational for a national biomass energy strategy (BEST)

A BEST elevates the priority for the main source of energy used in the country and brings it on par with modern energy policies. The development of a BEST is therefore expected to have the following impacts:

- A formal strategy development process will help to shift public attention to an issue that affects the majority of the population, thereby creating awareness with an ultimate goal of greater acceptance of the need for intervention.
- The biomass energy strategy should form the basis for long-term planning and cross-sectoral intervention, in particular on the supply side (e.g. reforestation), where results can be expected only after several years.
- Biomass in Rwanda is managed mainly by private actors who own the resources, reacting to market signals (e.g. by increasing prices for wood), but it remains questionable if they will do so before it is too late for substantive corrective action. A biomass energy strategy provides such preventive action as a sort of early warning system, using mid- and long-term development scenarios.
- Biomass energy is a cross-cutting issue; only by co-ordinating with all stakeholders and initiating strategic action in all relevant cross-sectors (e.g. energy, forestry, rural development, protection of natural resources and health) increase chances that policy interventions will eventually be accepted.
- Biomass energy can be a sensitive policy field. Radical interventions such as strict regulation for fuelwood supply or consumption (read: "ban") affect the poorest most, often leaving them with no alternatives than to move down the Energy Ladder. A biomass energy strategy has to pull resources and institutions together in order to provide sustainable and affordable options for the poor, and to demonstrate that energy policy does not only concern the richer parts of the population. This is particularly important in Rwanda, where energy prices are increasing more than rapidly.
- The introduction of new, efficient technologies and methods (e.g. improved stoves or kilns; better cooking techniques) and/or alternative fuels requires a supportive policy framework in order to reduce the incremental costs and promote sustainable options to the point where they can be disseminated by market mechanisms.

### 1.3 BEST process

A strategy describes the key interventions of an organisation or a government institution to achieve policy aims. While policies address challenges and set goals for change, strategies analyse the different options how to reach the goal, propose the appropriate intervention lines

and set out concrete actions by which the goals will be achieved. A strategy is not a blueprint but rather a set of concepts to facilitate decisions and take actions for implementing a policy.

A strategy answers the following questions:

- What is the final goal and who defines it? (vision and mandate)

- What is the problem and who is involved? (analysis of initial situation)
- Which way is the best to reach the goal? (scenario development)
- What has to be done? (decision on key interventions)
- Who does what by when and with which resources? (action planning)
- How can the results be measured? (monitoring and evaluation)

The development of a BEST follows a systematic approach which can be described as a cycle:

**Figure 1: BEST process**


Each step is crucial for the success of the process. If, for instance, the analysis of the actual situation has not been done carefully, actions might be developed which have no impact at all or even a negative impact. Without a proper development of scenarios it is difficult to define realistic targets for the future. And without a detailed planning of actions, involving relevant stakeholders and attributing sufficient resources, the strategy will never be implemented. Finally, without systematic monitoring and evaluation nobody will ever be able to state if the strategy has been successful or not.

The process of developing a BEST is at least as important as the final strategy paper. The aim should be to reach a common understanding amongst the stakeholders and a consensus on necessary actions. At each step, discussions should be organised between the actors concerned in order to collect their responses and observations.

### 1.4 BEST approach and methodology

In Rwanda, the following approach is followed:

- The major focus of the work is on the biomass supply; since some 80% or more are reported to come from private wood resources and 20% from public resources, the situation in Rwanda is quite different from other countries:
  - Main supply areas of fuelwood and charcoal have been reviewed, including imports from/exports to Congo and/or Tanzania. Review forest and plantation productivity, evolution of stocks, management practices, tree-harvesting (organization, labor, techniques, prices and costs);

- Quantified elements of environmental impact of forestry management « good practices » have been identified: increased forestry productivity, and to a limited extent other impacts on soils, water resources, biodiversity;
- Formal and informal charcoal production conditions have been reviewed (organization, labor, techniques and performances, production costs);
- Woodfuel rural trade, transportation to towns, wholesale and retail sale conditions; main actors involved, quantities, prices and costs;
- Existing regulatory framework, tax and control system: conditions and effectiveness.

Surveys have been carried out to obtain more details on the supply side of the charcoal chain, as these data are scarce, do not exist, or are changing rapidly. This gives (a) the complementary elements on the supply side for modeling baseline and alternative management and supply scenarios as well as (b) the elements to build up an economic analysis of all stages of the firewood and charcoal supply chain (production, transportation, wholesale, retail) and analyze price formation mechanisms.

Special attention have been given to the conditions of (a) planting and harvesting in small private plantations (need for cash, unprofessional cutting and transformation), State, District, or village owned plantations (valorization of thinning) and public natural forests (illegal logging), as well as (b) charcoal transformation (efficiency of present practices, possible gains with better training and technology, and better organization of charcoalers into associations).

- On biomass demand:
  - Existing use of wood and charcoal (consumption patterns and trends in urban, per-urban and rural areas, quantities in use, equipment used, stove efficiencies, price evolution, consumer preferences, health impacts) have been reviewed; since there are several recent and older studies, these were used primarily with some spot checks to verify continued compliance with established long-term patterns; the focus is on urban and peri-urban use, although it was inevitable to address some rural energy use issues as well to estimate the total wood fuel demand in the country;
  - Present, potential use and availability of alternative fuels: fossil fuels (petroleum products such as LPG, kerosene, natural gas, peat), agricultural residues and animal wastes, alternative fuels such as briquettes from wood, papyrus, or other sources.

This lead to the establishment of two major analysis tools: (a) a household energy consumption matrix (based on the share of households and small enterprises using different fuels) describing in principle demand aspects broken down by Kigali, other towns, and rural areas. This was used to build the baseline and other different strategy scenarios on demand; (b) a comparison of fuel prices (in terms of useful energy) for customers gives key information on consumer behavior and public leverage regarding taxes and prices. Most of this information came from existing sources, with quick cross-checks through concise survey tools, particularly on larger wood fuel consumers.

- On policies and programs:
  - Existing policy letters, strategies and major programs relevant to the biomass energy sector have been reviewed where necessary: Vision 2020, poverty reduction strategy (PRSP), national environmental strategy, Decentralization and community development project, etc;
  - Past and on-going actions on household energy demand (energy savings, interfuel

substitution, R&D): typology, size, actual results;

- Past and on-going actions on forestry (plantation, management) and household energy supply (charcoal-making, fuelwood transport and trade): typology, size, actual results.

This provides a comprehensive analysis of the political, institutional, legislative and regulatory context of the sector, as well as a thorough review of experience with government, donor and non governmental interventions to improve the supply of biomass energy and to improve access to modern fuels and efficient combustion technologies. We will point out the successes and difficulties of past actions, their external and internal reasons, the new factors (peace, policy and regulation, decentralization, etc) susceptible to consolidate the efficiency and enforce the impact of new actions as well as the main attached risks.

To gather the necessary information, the following was carried out:

- Collected available data by reviewing existing literature and statistics;
- Realized interviews with relevant stakeholders in order to understand their views on opportunities and constraints with regard to a more sustainable supply and demand of biomass energy and alternative fuels; and
- Undertook selected field visits and surveys on relevant biomass production, transformation and trade sites. In total, 8 specific surveys have been undertaken, with in total more than 1600 observations: farmers (500 interviews), charcoalers (375), transporters (120), large woodfuel consumers (460), retailers/distributers (145), alternative energy users (50), and import-export (19). In addition, specific case studies were made to describe interesting observations. A survey report is available in French[2].

[2] Enquêtes de terrain, situation actuelle et tendances dans le secteur de la biomasse Etude BEST, June 2008

## 2. Background

### 2.1 Population and economy

Rwanda is one of the most - if not *the* most - densely populated African countries. With a total of about 8 million persons and more than 350 persons per km² pressure on the land is already high and this is likely to intensify as result of a high population growth of 3.5% per year. The country faces the dual challenges to meet the growing wood energy demand and to continue to feed its population from the same limited land surface. Urbanization, although still low compared to some other African countries, is increasing rapidly as a result of active policy. This contributes to an increasing pressure on biomass resources, as a result of both the growing population size and a modernization process whereby urban households switch to charcoal.

Rwanda has been able to realize macro economic stability and implement substantial reforms that contributed to a strong economic growth. GDP growth rates over the past few years averaged 5 to 6 percent per annum. Economic growth is driven by the recovery in subsistence agriculture and a recent construction boom. Agriculture currently accounts for just fewer than 40 percent of GDP (in 2007 about $2.6 billion) and provides jobs to 90 percent of the population. Most Rwandans rely on subsistence agriculture but with limited participation in the market economy and 30% to 50% of the rural population in a given year may not produce a marketable surplus. The contribution of the private sector to the economy and poverty alleviation remains limited despite the active policy to promote private sector development.

The contribution of agriculture to the GDP is larger than that of services or industries; the value of the charcoal and woodfuel chain are estimated to be $122 million, or 5% of GDP. This is significant compared to the $55 million of electricity value and $38 million worth of coffee exports. The combination of rapid population growth and limited availability of new agricultural land in combination with low agricultural productivity has resulted in a number of reinforcing problems in Rwanda's rural sector: it is necessary to raise labour productivity and increase incomes, but this is hampered by limited chances for market development, whether for agriculture or for woodfuels. Although the woodfuel sector already provides opportunities for off-farm rural income generation, incentives to increase its productivity are low because of the prevailing ineffective regulatory environment.

### 2.2 Macro-economic policy framework

The Poverty Reduction Strategy Paper (PRSP) focused on six broad priority areas: (i) rural development and agricultural transformation, (ii) human development, (iii) economic infrastructure, (iv) good governance, (v) private sector development, and (vi) institutional capacity building. The recently completed and adopted second PRSP - the Economic Development and Poverty Reduction Strategy (EDPRS) focuses on growth through improved economic infrastructure and greater productivity of agriculture. The EDPRS pays particular attention to program implementation as a way to achieve the Government's long term development goals.

### 2.3 Poverty reduction strategy & Energy Sector

EDPRS (Economic Development and Poverty Reduction Strategy), adopted in 2007 by the Government includes the following energy sector targets, mainly focusing on access to electricity: within 5 years access is expected to increase from 5% to 16% of households connected to the grid.

The Government also actively encourages the use of energy other than biomass. Vision 2020 aims at a reduction of biomass from its current 85% contribution to only 50% of energy consumption in 2020. This can only be achieved if 35% of the population is connected to the grid and if they also can afford to use electricity. Therefore:

- The Government hopes to decrease the price of energy in the future; currently the cost of production is estimated at around 120 RWF/kWh mainly due to the high cost of diesel;
- Power generation should increase from 50 to 120 MW, when several planned power plants come on-line: Kivu gas, Nyabarongo and other hydropower plants, geothermal energy.

The Government is studying various ways to reduce the demand for energy such as promoting improved stoves, dryers and solar-powered water heaters, as well as the use of kerosene for cooking. Solar energy is expected to provide power to remote individual and institutional customers such as hospitals and schools. Biogas, already used in prisons, hospitals and schools is another option which should scale up in the coming years in order to decrease the wood consumption for cooking purpose. A major biogas program is underway to convince 15,000 rural households to start using biogas on private farms.

### 2.4 Linkages between energy supply and poverty reduction

The expected main impact of rural electrification on poverty will not be through its domestic utilisation but rather by encouraging the development of enterprises transforming agricultural or silvicultural products and other small-scale industries. At the moment, despite the active promotion of private sector development, there are not more than about 400 private firms in Rwanda of which half have less than 50 employees. However, there are numerous SME's in the informal sector of the economy that provide much of the services and products needed.

The woodfuel commodity chain appears to be a little known but active sector of the economy, providing jobs and income in rural areas: some 20% of the US$ 67 million charcoal value in Kigali corresponds to the wood cost and remains in rural areas; in addition, another 20% remains in rural areas as labour costs for charcoal making and transport.

According to the household condition surveys EICV1 and 2[3] (respectively held in 1999-2000 and 2005-2006), 96% of the Rwandese population depend on biomass for their daily energy supply: 88% use wood and a further 8% use charcoal as fuel whereby the poor essentially use wood and urban households more and more start using charcoal. See Table 1 for more details including the changes between 1999/2000 and 2005/06. In Kigali, 72% of the population uses charcoal. Improved stoves could help reduce the effect of raising energy prices and act as such as a safety net.

[3] "Enquête sur les conditions de vie des ménages »

**Table 1: Household use for cooking**

| | EICV1 | EICV2 | EICV1 | EICV2 | EICV1 | EICV2 | EICV1 | EICV2 |
|---|---|---|---|---|---|---|---|---|
| | City of Kigali | | Other urban | | Rural | | National | |
| Wood | 21.4 | 23.1 | 81.7 | 73.7 | 97.7 | 95.5 | 90.4 | 88.2 |
| Charcoal | 75.8 | 72.4 | 16.3 | 19.6 | 0.8 | 1.1 | 8.0 | 7.9 |
| Gas | 0.5 | 0.2 | 0.2 | 0.1 | 0.0 | | 0.1 | 0.0 |
| Electricity | 0.5 | 0.2 | 0.2 | 0.3 | 0.2 | 0.0 | 0.2 | 0.1 |
| Kerosene | 0.3 | 0.8 | 0.1 | 0.3 | 0.1 | 0.0 | 0.1 | 0.1 |
| Miscellaneous burning | 0.0 | 0.1 | 0.9 | 2.5 | 0.7 | 3.0 | 0.7 | 2.7 |
| Other | 1.5 | 3.3 | 0.6 | 3.4 | 0.5 | 0.4 | 0.6 | 0.9 |
| | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |

Source: EICV1 and EICV2, in EICV2. All Households.

Some of biggest industries rely now mostly on electricity and heavy fuel but are actively exploring the use of cheaper "alternative energy" such as peat (CIMERWA), briquettes (some tea factories, UTEXRWA), bagasse (sugar factory). Coffee husks, sawdust and recycled oils are now of use in the brick and tiles industries since burning of wood for this purpose is no longer allowed by the environmental authority.

The tea industry still heavily depends on off-factory purchased wood for its drying process. Nevertheless, different factories explore alternative solutions to avoid buying wood: Pfunda expects to start using methane gas soon and Sorwathé started using a modern multi-fuel (biomass) boiler and is actively increasing the productivity of its owned tree plantations with the expectation that these can supply all energy needs in a sustainable manner in the near future.

## 3. Current Status and Trends in the Biomass Energy Sector

### 3.1 National energy balance, trends and regional variations

Today charcoal is the main urban fuel; it is used by most city dwellers as a primary[4] and/or secondary fuel. Anecdotal reference is made to a 2007 newspaper article stating that even Ministers use charcoal at home for lack of alternatives. When charcoal became a mass product in the 70s and early 80s, it was first produced in the Kibungo area that was once surrounded by a savannah type forest with slow growing trees of dense wood that make excellent quality charcoal. Most of these trees have been cut around the mid-80s and the production then shifted to the more densely forested South: Butare, Gikongoro region and to a lesser extent the North (Byumba). Users did not like to switch from dense savannah charcoal to lighter eucalyptus, but accepted it anyway simply because there were no alternatives. Today they are fully used to this type of charcoal but still do not want to accept charcoal made from pine trees that is even lighter than *Eucalyptus* charcoal.

Until now most charcoal still comes from these southern regions and also from the Ruhengeri-Gisenyi area. An exhaustive survey on the supply zones was done in early 2000 by Christopherson and Butare. The surveys carried out in 2008 showed that the general patterns are still valid.

It is estimated that biomass constituted in 2007 about 84-85% of the national energy balance (gross supply). This is down from 90-95% in the mid-80s. Table 2 and Figure 2 show the estimated 2007 Energy Balance.

**Table 2: 2007 Energy Balance (TOE)**

| [TOE] 2007 | wood | agric Res | wood for charcoal | peat | gasoline | diesel | fueloil | kerosene | lpg | methane | electricity | total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gross Supply** | | | | | | | | | | | | | |
| domestic production | 850,936 | 99,878 | 420,542 | 301 | - | | | | | | 47,073 | 1,418,729 | |
| imports | | | | | 53,499 | 88,682 | 14,802 | 20,715 | 202 | | 15,308 | 193,208 | |
| *total* | *850,936* | *99,878* | *420,542* | *301* | *53,499* | *88,682* | *14,802* | *20,715* | *202* | - | *62,381* | *1,611,938* | *100%* |
| | 53% | 6% | 26% | 0% | 3% | 6% | 1% | 1% | 0% | 0% | 4% | 100% | |
| **Conversion & losses** | | | | | | | | | | | | | |
| electricity conversion | | | | | | 42,364 | | | | | | *42,364* | |
| elec T&D | | | | | | | | | | | 17,810 | *17,810* | |
| charcoal conversion | | | 317,802 | | | | | | | | | *317,802* | |
| *total* | - | - | *317,802* | - | - | *42,364* | - | - | - | - | *17,810* | *377,976* | *23%* |
| | **wood** | **agric Res** | **charcoal** | **peat** | **gasoline** | **diesel** | **fueloil** | **kerosene** | **lpg** | **methane** | **electricity** | **total** | |
| **Net supply** | 850,936 | 99,878 | 102,740 | 301 | 53,499 | 46,318 | 14,802 | 20,715 | 202 | - | 44,571 | *1,233,962* | 77% |
| | 69% | 8% | 8% | 0% | 4% | 4% | 1% | 2% | 0% | 0% | 4% | 100% | |
| **Exports** | - | - | - | - | - | - | - | - | - | - | - | - | |
| **Demand** | | | | | | | | | | | | | |
| households | 765,842 | 79,903 | 97,603 | | | | | 20,715 | 202 | | 33,428 | 997,693 | 81% |
| industries | 85,094 | 19,976 | 5,137 | 301 | | | 14,802 | | | | 8,914 | 134,223 | 11% |
| services | | | | | | | | | | | 2,229 | 2,229 | 0% |
| transport | | | | | 53,499 | 46,318 | | | | | - | 99,817 | 8% |
| *total* | *850,936* | *99,878* | *102,740* | *301* | *53,499* | *46,318* | *14,802* | *20,715* | *202* | - | *44,571* | *1,233,962* | *100%* |
| | 69% | 8% | 8% | 0% | 4% | 4% | 1% | 2% | 0% | 0% | 4% | 100% | |

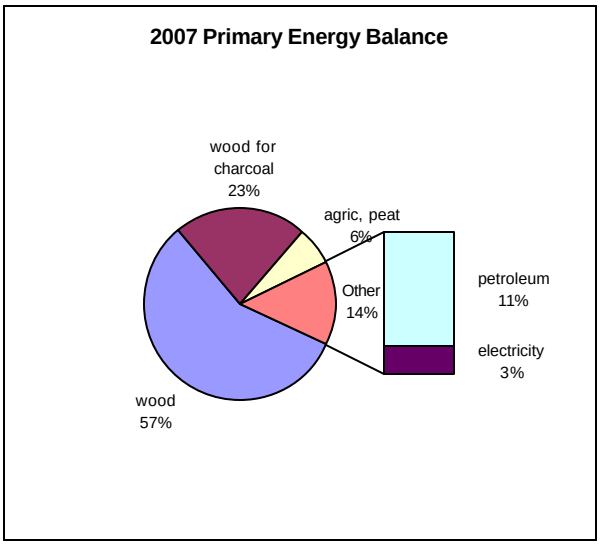
**Source**: Mission Estimates, MININFRA, Electrogaz

In terms of primary energy, biomass is by far the largest source with firewood and wood for charcoal making constituting almost 80% of the energy used in Rwanda, and agricultural residues and peat accounting for another 6%. The remaining forms of energy are petroleum fuels (11%, including diesel needed for power generation) and hydro electricity (4%). About 22% of the primary energy is lost in charcoal making, diesel power generation, and electricity transmission and distribution losses (See section on conversion losses in Table 2). The charcoal conversion losses amount to one-third of the total volume of wood used[5].

[4] Use of primary fuel is every day; secondary fuel is used as a complement; such as charcoal used for cooking (primary use) but LPG is occasionally used for making tea (secondary use).

[5] The charcoal conversion rate taken is 1.3 bag per stere of wood ; it ranges from 1 bag to 1.4 bag per stere, with the higher efficiency in the largest production zones.

**Figure 2: 2007 Primary Energy balance**




**Source**: Mission Estimates, MININFRA

## 3.2 **Energy Resources and Supply**

### 3.2.1 Biomass energy

#### 3.2.1.1 *Natural Forests*

According to the National Agricultural Research Institute (ISAR[6]), the Rwandan forests[7] cover currently less than 450,000 hectares, i.e. 17% of the country, comprising of 206,523 ha of natural forests and 240,707 ha public and private plantations.

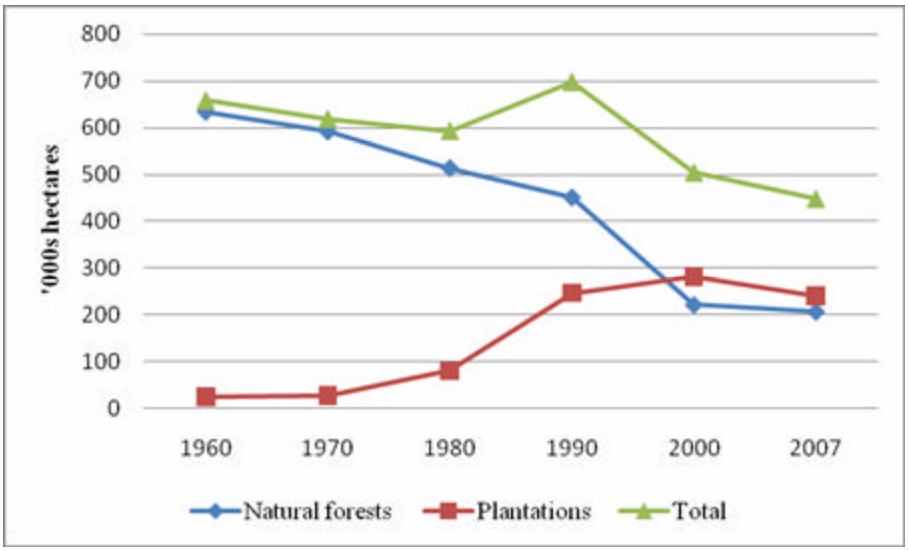
The natural forests are mainly protected areas, either national parks (Akagera, Nyungwe, Volcanoes) or forest reserves (Gishwati, Mukura). They constitute above all the hydrographical base of the country that captures rain water and slowly releases this over the year. Natural forests include various ecosystems providing a habitat for a rich biodiversity, of which rare endemic species appreciated in traditional medicine. Natural forests in Rwanda comprise of mountain, savannah and gallery forest areas, and swamps.

However, the natural forest areas are shrinking rapidly for years, as shown in Figure 3, leaving the place to ecosystems modified mainly by human action. According to available data, two third of their areas were cleared over the last 40 years (from more than 600,000 to 200,000 hectares).

[6] *Institut des Sciences Agronomiques du Rwanda*

[7] By definition, the forest is an ecosystem dominated by trees whose height exceeds 7 meters at maturity and whose crowns cover at least 10% of the projected area on the ground. According to FAO, the total area of this ecosystem must be at least ½ ha.

**Figure 3: Evolution of Forest Areas in Rwanda (> 0.5 ha)**




**Sources**: MINAGRI for 1960 to 2000, ISAR for 2007

The management of national parks comes under the Rwanda Office of Tourism and National Parks (ORTPN[8]), which is a public institution with administrative and financial autonomy, placed under administrative supervision of the Ministry of Trade and Industry (MINICOM). The management of natural forests falls under the responsibility of MINIRENA.

3.2.1.2 *State and District Plantations*

According to the first national inventory carried out by ISAR in 2007, State and District owned plantations total 65% of planted areas (see Table 3) not included plantations of less than 0.5 hectare and isolated trees in or on the side of fields.

**Table 3: Distribution of plantation according to ownership (2007)**

| | Areas (ha) | (%) | | Standing stock[c] (tons) |
|---|---|---|---|---|
| **2007 ISAR Forest Inventory** | | | | |
| State and District ownership | 156,460 | 65% | | 13,427,398 |
| Institution ownership | 22,867 | 9% | | 1,962,466 |
| Private ownership > 0,5 ha | 61,380 | 25% | | 5,267,672 |
| All plantations > 0,5ha | 240,708 | 100% | | 14,460,275 |
| **Production plantation estimates** | | | | |
| State and District, excluding protection[a] | 104,307 | 54% | | 8,951,599 |
| Institution ownership | 22,867 | 12% | *26%* | 1,962,466 |
| Private ownership > 0,5 ha | 61,380 | 32% | *69%* | 5,267,672 |
| Private ownership < 0,5 ha[b] | 5,337 | 3% | *6%* | 458,058 |
| *Sub-total institution and private* | *89,585* | *46%* | *100%* | *7,688,196* |
| **Total production plantations** | **193,892** | **100%** | | **16,639,795** |

[a]) Protection plantation estimated covering 1/3 of total area
[b]) 9% of private-owned plantation areas, according to 2008 BEST survey
[c]) Based on an average of 122.6 $m^3$/ha and 0.7 ton/$m^3$
**Sources**: 2007 ISAR Forest Inventory, 2008 BEST survey

[8] *Office Rwandais du Tourisme et des Parcs Nationaux*

Most of the plantations were created during the mid-seventies and at an increasingly fast rate during the eighties (see Figure 3) of the previous century. The main reason for creating these plantations was to increase the number of wooded areas, mainly on bare hills for soil protection, improve water catchment areas, and to provide energy to the population. A significant proportion was planted as protection plantations to prevent soil erosion. *Eucalyptus* is the dominant specie, occupying 64% of total plantation areas, except in the Nyamagabe region where there are large plantations of *Pinus*.

Numerous public plantations were planted to respond to a necessity felt by most decision makers, but without clear objectives regarding their management and utilization. That has led to lack of monitoring and silvicultural treatments (maintenance cuts, pruning, enrichment, rejuvenation, etc.), resulting in progressive degradation and decreasing natural yield due to ageing process. It is known that a poorly managed plantation develops into a source of environmental problems: soil erosion, bushfires, phytosanitary issues, etc.

According to 2007 ISAR Inventory, more than three quarters of inventoried State/District owned stands show signs of uncontrolled human activity. Despite orders to not to allow exploitation of public plantations, they are being harvested after all, albeit illegally. Tree felling is the most frequent sign, occurring in practically 80% of cases. The other main signs observed included charcoal making (4%) tracks and paths (4%). Illegal intrusion is an indication of the real needs of the surrounding population. Organized management and exploitation of plantations can generate employment and income for the local administration and local people. In the absence of direct benefits for the local population, it is tempting for them to illegally collect wood products in the closest plantation. The local administration loses out, as the plantations degrade and there is no income derived from the harvesting of wood products, but the population wins as they gain access to free wood products.

It is noteworthy that illegal tree felling is less frequent in *Pinus* plantations; *Eucalyptus* stands showed the greatest number of intrusion signs. That gives a clear indication of its importance in rural area: *Eucalyptus* is not only used as construction wood (poles, timber, stakes, handles, etc.), but also for firewood and charcoal making, which are the greatest needs of the rural population. That *Eucalyptus* is valued more than *Pinus* by the local population can also be seen at tree nurseries, where the demand for *Eucalyptus* seeds are high and for pine seeds much less.

Another sign of insufficient silvicultural management is the number of stems per hectare which ranks from 215 to 1950 stems, with an average of 654 according to ISAR data. The number of stems per hectare normally varies species and by age of plantation. The production objective determines what the planting density should be: for example, tree stands must be more densely populated for poles or stakes but less densely populated for carpenter wood. The standing tree density is also determined by the quality of maintenance operations and appropriate enrichment activities aiming at increasing the survival rate after planting and preventing illegal felling. The number of stems per ha reduces generally with age. Typically the number of stems per hectare decreases over time from 1600 at planting time to 900 after some 3 to 4 years, then to 500 due to voluntary pruning and cutting executed at different periods. However, since *Eucalyptus* coppices easily, the number of stems per hectare can increase with age: each cutting acts as a multiplier that produces several offshoots. This is another reason why farmers like *Eucalyptus*: once planted, they can use the tree for many decades. [9]

[9] Around Antananarivo farmers exploit trees that are sometimes older than 100 year to satisfy the demand for charcoal and construction wood of the Malagasy capital.

3.2.1.3 *Private Plantations*

The private plantations[10] cover 35% of planted areas of more than 0.5 ha, i.e. around 84,200 ha. They include stands owned by farmers and land owners (25%), and by institutions (9%) such as private companies, cooperatives, and religious and educative institutions, investment funds, NGOs, etc. According to 2008 BEST survey, traded wood comes mostly from plantations of less than 2 ha: 89% of the sample of plantation owners had a plantation of less than 2 ha covering 54% of planted areas.

This poses a problem for identifying whether or not the entire wood fuel supply is or is not sustainable, since a very large number of family farms cover currently less than half hectare. These family farms contribute substantially towards the supply of energy, but there is no statistical evidence about quantities of supply or even acreage under plantation trees. For long, small Rwandan farmers have traditionally kept a few trees in or on the side of their fields and/or round their homesteads. The wood products from these trees are to satisfy their own needs for poles, stakes and firewood, but can also serve as a source of income in case of unforeseen events or when a relatively large sum of money is required at once, such as payment of school fees or health expenses.

According to 2008 BEST survey, 8% of private plantations contributing to wood-energy supply channels are of less than 0.5 ha, i.e a total of about 5,300 ha on the basis of ISAR inventory results. However, the latter is an estimate and must be interpreted carefully: a specific inventory should be undertaken to get accurate and reliable data; this is being undertaken by MINIRENA and will be available late in 2009. As an example of the uncertainty and importance involved, consider an optimistic scenario whereby 75% of all rural households dispose of patches of trees of between 0.10 and 0.25 ha on their land and around their rugo[11]. The combined total of these trees would cover a planted area of around 90,000 and 225,000 ha. This compares to an acreage of 240,000 ha of all known plantations in the country. Thus, the contribution from rural farms could be substantial but is unknown; it is clear that as a priority the real contribution from small farmers to the woodfuel supply should be identified. As found during the 2009 survey, plantations below 0.5 ha comprise of the equivalent of about 38 thousand ha, see Volume 3, giving a total of about 100k ha of private plantations and 104k ha public plantations available for harvesting. Table 4 below gives a summary of the estimated land area under plantations.

**Table 4: total estimated land under wood plantations (ha)**

| | **Low estimate** | **Estimate based on 2009 rural survey** | **High estimate** |
|---|---|---|---|
| Plantations > 0.5 ha | 240,708 | 240,708 | 240,708 |
| Plantations < 0.5 ha | 5,300 | 37,650 | 190,000 |
| Total | 250,008 | 278,358 | 430,708 |

**Source:** BEST estimates

All private plantations are almost exclusively made up of *Eucalyptus*. The species *Eucalyptus Maïdeni* is in great demand by the population but has been banned from the official list of species that can be sold. The alleged water needs of this type of tree are higher than for other trees and it is feared that large-scale coverage of this tree species would draw down the water

[10] Public plantations are at least 0.5 ha, have trees of > 5 m of height, and the tree density is at least 10%.

[11] Homestead.

table too much. This however, is not based on facts and is in fact well published by ISAR[12]. In summary, for areas with rainfall over 1200 mm per year, *Eucalyptus* trees have no influence on the crops that may be planted between the trees; for rainfall between 400 and 1200 mm/yr, it is a matter of management and the number of trees per ha should be coordinated with the agricultural crops on the same land so that the water can be evenly distributed; below 400 mm/yr, it is not recommended to have agricultural crops and *Eucalyptus* trees on the same plots. In addition, the same article states that *Eucalyptus* trees are *more efficient* in water use than many other crops: *Eucalyptus* use 510 liter of water to produce 1 kg of biomass, whereas rice uses 600 liter, banana, cotton and coffee use 800 liter and *Cypress* and *Pinus* 1000 liter. In addition, it is stated that *Eucalyptus* trees have in fact a lower demand for nutrients than other trees of only 0.5% - 1% of the soil nutrients of most agricultural crops.

Since *Eucalyptus Maïdeni* seeds are no longer disseminated through official channels but are highly preferred by farmers, private nurseries have developed a seed supply while some farmers also produce their own seeds. This could lead to a progressive degeneration of the species as used in Rwanda.

According to the 2008 BEST survey, most private stands have been planted by their owners (61%), some were inherited (19%) or purchased (18%). Whatever their profile, plantation owners invest very little in their existing plantations. *Eucalyptus* trees coppice easily so why plant new trees? The only exception are tea factories whose pursuit of their main activity depends on a steady and low-cost energy supply: it has become more difficult to procure wood from third-party sources (farmers, etc), and instead some now manage their own plantations and engage in afforestation projects. SORWATHE is a good example, whereby the owner bought out thousands of plantations from farmers who were no longer interested in maintaining their *Eucalyptus* plantations. Through better management techniques, SORAWTHE showed that the production of these plantations could be drastically increased.

When the situation is critical, rural people are often responding to a shortage of woody biomass by increasing the use of crop residues, twigs and small diameter wood and taking measures to conserve energy. Farmers are also responding by planting more trees on their farms and around their homesteads. Apparently, such a phenomenon of afforestation has occurred in the Bugasera area where savannah forests were almost entirely depleted for charcoal production but where *Eucalyptus* trees are now a common sight.

#### 3.2.1.4 *Woodfuel Supply*

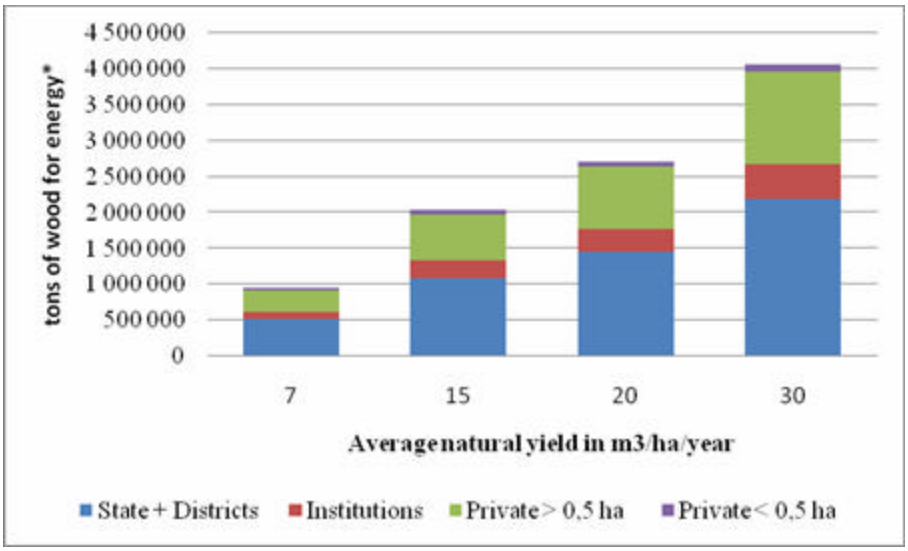
The assessment of the annual natural yield requires a complete history of the plantations evolvement. In the absence of such history for most public plantations, ISAR has proposed estimates for the stands for which the planting period was known. That gives an average yield of 6.8 cubic-meters per hectare and per year for *Eucalyptus*. According to Rwandan senior foresters, this figure is very low: they consider that 20 to 30 $m^3$/ha/year can be easily reached on condition that proper silvicultural and management techniques are applied. The low yield could in part be explained by several reasons: *Eucalyptus* plantations could be old coppices that have lost their vigour, soil and nutrient depletion, lack of management, or lack of water. Rwandan forestry experts confirm that such yields can be obtained, but it will depend on many factors: rain fall pattern, soil conditions, management of the trees. As a matter of

[12] *Eucalyptus* in Rwanda: Are the blames true or false? Review. ISAR Published in the Proceedings of National Conference on Agricultural Research Outputs, March 2007, Serena Hotel, Kigali. See also: Les *Eucalyptus* au Rwanda: analyse de 60 ans de l'expérience avec référence particulière a l'arboretum de Ruhande; C. Burren, 1995.

baseline, 20 $m^3$/ha/yr should be possible in most regions in Rwanda and 30 $m^3$/ha/yr is feasible favourable conditions that prevail in quite a few regions.

Figure 4 below gives theoretical estimates for the woodfuel supply based on average yield rates seen around the world. The column on the left shows the current natural production based on the recent inventory of probably lower than 1 million tons per year, i.e. far below the estimated demand of at least 2 million t per year (see below). However, the natural production could be easily double or even quadruple if comprehensive management plans and adequate techniques are efficiently implemented. The column on the right shows the maximum productivity possible of about 30 $m^3$/ha per year under ideal growing conditions[13] [14].

**Figure 4: Woodfuel Supply, 2008**




*) based on 0.7 ton/$m^3$, and 78% of production usable as woodfuel according to FAO

**Source**: 2007 ISAR Forest Inventory and MARGE estimates

### 3.2.1.5 *Peat*

With an identified volume of 155 million dry ton, Rwanda is relatively well endowed with peat resources. EKONO-BRGM developed the "Final Master Plan Feasibility for the Development of Peat Deposits" with financial support from African Development Bank (AfDB, 1992). The report is available in both French and English and contains: 1. General

[13] Under the conditions proposed under the strategy, the average productivity of plantations in Rwanda will increase from 6.8 m3/ha/yr to about 12.8 m3/ha/yr, or about a doubling of the productivity.

[14] Literature states that under adapted climatic conditions, a ten-year old Eucalyptus plantation could in practice easily have a woody biomass stand of 200 t – the equivalent of 30 m3 per year; Pysiological regulation of productivity and water use in Eucalyptus, David Whitehall and Chris L.Beadle, EucProd 2002; Productivity, nutrient cycling, and succession in single- and mixed-species plantations of Casuarina equisetifolia, Eucalyptus robusta, and Leucaena leucocephala in Puerto Rico John A. Parrotta; USDA Forest Service, International Institute of Tropical Forestry, P.O. Box 25000, Rio Piedras, PR 00928-5000, USA; assessing nutritional and climate limitations to the productivity of eucalyptus plantations at larger spatial and temporal scales using a simple paired-plot design coupled to traditional inventory network José Luiz Stape1, Jacyr Mesquita Alvez, Ernesto Takahashi, Walmir Franciscate and Walter Jacob, 1Department of Forest Sciences, University of Sao Paulo C.P.9, Piracicaba, SP 13418-970, Brazil

presentation of findings; 2. Peat reserves and peat inventory; 3. Hydrological effects of peat production; 4. Environmental effects of peat production and use; 5. Market potential of peat products; and 6. Peat production and feasibility report.

A summary of the most important details of the identified peat resources are presented in Table 5 below. Not included are the recent environmental restrictions imposed by REMA on the use of marsh lands.

**Table 5: Peat Resources**

| Sites | Area (ha) | Depth (m) | Ash% | Reserves (Mio m3 | Dry reserves 10^6 Tons) | Observations |
|---|---|---|---|---|---|---|
| Nyabarongo | 26740 | 2-4 | 9-20 | 800 | 40 | High ash content |
| Akanyaru North | 460 | 2-6 | 7-14 | 20 | 1 | Not drainable |
| Akanyaru North (others) | 5120 | 2-6 | 10-20 | 200 | 10 | High ash content |
| Busoro (Akanyaru South) | 800 | 1-5 | 6-15 | 32 | 1 | Presently exploited and not drainable |
| Rwamiko (Akanyaru South) | 130 | 1-20 | 6-8 | 14 | 0.675 | Not drainable |
| Akanyaru South (others) | 7070 | 2*20 | 6-15 | 920 | 69 | Not drainable |
| Cyabararika | 22.5 | 1-5 | 5-17 | 0.35 | 0.15 | Formerly exploited |
| Kiguhu (North) | 49 | 1-4 | 8-14 | 1.8 | 0.24 | Exploited |
| Rugezi (North) | 6500 | 1-11 | 2-15 | 650 | 32 | Not exploitable and water cycle regulator |
| Gishoma (South West) | 410 | 1-5 | 6-13 | 7.85 | 0.463 | Drainable and easily exploitable |
| Gihitasi (West) | 8 | 1-2 | 14 | 0.62 | 0.04 | Drainable |
| Mashya | 30 | 1-5 | 3 | 0.79 | 0.06 | Drainable |
| Kamiranzovu | 830 | 1 | 6 | 8.2 | 0.5 | Within Nyungwe natural reserve |
| Total | 48200 | - | - | 2650 | 155 | - |

**Source: EKONO**

3.2.1.6 *Papyrus and Typha*

*Papyrus* plants grow up to 4-5 meter and reach maturity in about 50 days; the plant has a 150-day life cycle and thus two "crops" per year are possible under natural circumstances. Yields per hectare are as high as 32 tons which yields up to 15 t of dry biomass. A 12-hectare river valley some 40 km away from the capital was harvested at one point in time (early 90s) to produce briquettes in an extruder press. Biannual cuttings of 25 t/ha/yr were employed using the less-than-maximum harvest to ensure that the plant community was not environmentally harmed[15]. *Typha* is a plant quite similar to papyrus and is present in Rwanda too; it recently received a lot of attention in West Africa where it has invading most wetlands due to changed hydrological conditions. *Typha* propagates more aggressively than *Papyrus*. Charcoal made from *Typha* is available on the market in parts of Mali.

The estimated *Papyrus* coverage is 20 - 25,000 ha of which much in the vicinity of Kigali. Using sustainable harvesting techniques, a theoretical maximum of about 280,000 t (dry) of *Papyrus* could be obtained. Environmental restrictions and conflicting land-use may further reduce this potential. The actual surface under *Papyrus* is unknown but a comprehensive inventory of marshlands[16] using GIS and ground truthing is underway and includes the total land covered by *Papyrus*, *Typha*[17], etc. It is not sufficient to know the total land under *Papyrus*, but one should also know how much of the raw material can be harvested given that *Papyrus* (and *Typha*) have a filtering effect on run-off water into the lakes and rivers. This will have to be analyzed before a decision can be taken as to what extent *Papyrus* and *Typha* could be developed as an energy source in Rwanda.

Under the Irish development corporation *Papyrus* briquettes were made in the early 90s, using a piston press. Complaints from users of the briquettes show that the sulphur content of the fuel is relatively high, producing sulphuric acid with the result that pots deteriorate quickly. In addition, the briquettes produced were of poor quality and fell apart easily and produced heavy smoke, particularly at start-up. It would be possible to produce better quality briquettes with screw press technology and a pre-feasibility study for the commercial production of briquettes as a fuel for Kigali was carried out in 1991.

*Typha* briquettes are produced in Mali and sold as a charcoal substitute; this appears to function well and household readily accepted the substitute as an acceptable fuel; it should be tested in Rwanda as well.

3.2.1.7 *Coffee Husks*

Rwanda is known for its high quality *Arabica* mountain coffee and the total production was 14.7 thousand t in 2007 and estimated at 25 thousand in 2008. At the moment OCIR estimated that there are some 80 million productive coffee plants in Rwanda and a similar quantity have been or will be planted to become productive around 2011. The largest processing plants are RWANDEX[18], RWACOOF, Agrocoffee, CBC, and Caferwa. Smaller facilities are ENAS, COOPAC, Rwashosuo – Maraba, and Kivu Arabica Company. In addition, some small cooperatives operate as well.

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[15] Quote from Dr. Michael Jones, professor of plant physiology in Dublin's Trinity College, 1981 in an SAUDI ARAMCO World publication (1986)

[16] Realized by SHER for REMA, July 2008

[17] *Papyrus* and *Typha* are very similar reeds with similar growing characteristics.

[18] Bankrupt in Feb 08; taken over by other factories.

For each 100 kg of green coffee, some 25 kg of coffee husks are obtained which means that in 2008, some 5-6 thousand t of husks are available. At the moment all are used, mainly for brick and tile making, and in 2011 another 5-6 thousand t are likely available for which no use has been indicated yet.

3.2.1.8 *Rice Husks*

Irrigated rice cultivation expanded from 3,549 ha in 2003 to some 13,000 ha in 2007; a total of some 66,000 ha is demarcated for rice production. The average productivity is about 4-5 t/ha, falling short of the government's expected target of 7 t/ha/yr. This low productivity is mainly due to poor agriculture practices, lack of pest and disease resistant seeds, inadequate irrigation systems, and fragmented rice plantations. To boost the production of rice in 2008, at least 7,000 hectares of marshlands will be reclaimed. Irrigation systems will be improved and seeds, fertilisers, pesticides, and equipment will be made available through the government.

Expected output according to PASR is about 70,000 t of rice in 2008 taking into account two production seasons. By weight, since paddy consists of 20% husks and 80% rice and using the above estimates, some 20,000 t of rice husks would be available in 2008.

3.2.2 Non-biomass energy

Non biomass energy consists essentially of petroleum products, kerosene for lighting and a minor part cooking, LPG that is used by the richest households for cooking, and electricity. As can be seen from the Energy Balance, the current contribution from these non-biomass sources is small.

3.2.2.1 *Petroleum products*

All petroleum products are imported from Kenya (from depots at Nakuru, Eldoret/Kisumu, Nairobi, or Mombassa) or Tanzania (Dar es Salam). The political problems at the beginning of the year in Kenya resulted in higher fuel prices in Rwanda. Although different price structures exist for kerosene for each supply route, an average uniform price is applied to even out cost differences. Liquid fuels are not heavily taxed: the total combined tax and duty levied on diesel (import duty, user energy charge, VAT) amounts to about 18% of the retail price. For LPG this is slightly different and the total tax and duty combined amounts to just over 22% of the retail price.

The total volume of oil imports into Rwanda increased from 102,308 t in 2003 to about 69,700 during the first half of 2006. Kerosene consumption increased from 13.5 thousand t in 2003 to 20.5 thousand t in 2007 and is mainly used for lighting in rural areas.

LPG imports are negligible compared to total petroleum fuel imports; they increased from 237 t/yr in 2003 to 323 t/yr in 2005 and 190 t/yr in 2007. The high price may explain why consumption dropped recently. The total CIF value of LPG was 176 million FRw, or $320 thousand in 2005. The two reasons why LPG is so expensive are the small quantity used in the country and the taxes levied. LPG retail prices are subject to a strong scale-economy effect resulting in high unit prices for small quantities: LPG bottles are now filled in Kenya but they could be filled at a filling station in Rwanda if the total volume sold per year were larger[19]. The second reason is the relatively high tax content of LPG prices. The likely result of price drop of 30% would be quite a few households starting to use LPG as a secondary fuel and this increased demand would further reduce the unit costs.

[19] KOBIL is awaiting environmental clearance from REMA for the construction of a bottling plant.

3.2.2.2 *Electricity*

Power generation capacity in Rwanda is about 73 MW peak in 2007 and is expected to reach 75 MW peak in 2008. The total demand in 2008 is expected to reach 412 GWh and the total production 282 GWh, or a short fall of about 130 GWh. There are four hydroelectric plants with a total of about 28.6 MW available, of which the largest two (combined capacity of about 24 MW) are based on interconnected lakes whose levels have drawn down to dangerous levels. An older 4.7 MW diesel backup plant was put back in service in 2004 and 7.8 MW additional diesel as well; an additional 15 MW of rented diesel capacity is in service to mitigate power shortages. In addition, Electrogaz purchases power from the Rusizi I plant (total capacity 39.6 MW) of SNEL of DRC, and Rusizi II (total capacity 44 MW), owned by Sinelac, with equal joint participation of Rwanda, DRC, and Burundi.

It is expected that by 2012 some additional 50 MW will be online, with from 2009 onwards, Rukarara (9.5 MW) and Nyabarongo (27.5 MW) hydro, while the rented 15 MW diesel will be phased out as soon as a 20 MW HFO plant becomes online. In addition, two 4.5 and 3.5 MW pilot plants are expected to start generating electricity using methane gas from Lake Kivu in 2008. The total new hydro potential is about 51 MW of which micro hydro can contribute more than 10 MW.

3.2.2.3 *Other forms of energy*

The most significant source of energy is methane gas from Lake Kivu, which has a potential of 750 $MW_e$ in total[20], of which the Rwandan share will be 350 $MW_e$ (50%, the other half will be for Congo). Not all of this will be used for power generation; other plans include 250 $MW_e$ for power generation, 50 $MW_e$ for gas to liquid fuels[21] and possibly fertilizer production. Particularly fertilizer production would be very important for both increasing agricultural productivity and the productivity of small wood plantations and this may have a high positive impact on the woodfuel supply.

A pilot plant is expected to generate electricity starting this year. It is not expected that methane gas will contribute much to the supply of energy other than in the form of electricity. Methane has a low energy density, unlike propane or butane, and cannot easily be stored in bottles similar to LPG as the pressure needs to be very high. Although some people hope that a pipeline system is built to supply gas to Kigali, this is likely to be discarded as wishful thinking: in Kigali gas would mainly be used for cooking and possibly some industries. Assume that the entire charcoal market is replaced by gas, a total value of only $60 million will be replaced per year. This is very low compared to the cost for the 120 km pipeline plus the cost for the distribution network in Kigali. However, there are no reliable estimates available for the cost of building such a pipeline. Data are available on the Alaskan Natural Gas pipeline[22], which reached an estimated cost of Can$ 26 billion (in 2007), for a length of 2250 miles; this is the equivalent of about US$7 million per km. Just the transport of gas from Gisenyi to Kigali, using these data, would cost about $800 million, excluding the distribution network in town and not accounting for the fact that the region is very hilly and densely populated (expropriation, relocation costs), which are expected to increase the unit costs. An in-depth study will have to determine whether or not a pipeline can be viable; for

[20] The equivalent generation capacity of 750 MW electricity

[21] This would produce about 1000 barrels per day, although there is some thought that 2000 barrels/d are needed for a viable operation.

[22] http://www.gov.state.ak.us/agia/

the purpose of the biomass energy strategy, it is considered that Kivu gas can only be converted into electricity.

The second largest potential source of energy is geothermal, which was estimated at 200 MW. The energy could be used in the form of electricity that would be available through the Electrogaz network. Some initial exploration work is ongoing.

Finally, solar energy with a potential of 4.5 kWh per $m^2$ per day should also be mentioned, although it is not likely that this will be used to replace cooking energy. At a price of $6-10 per watt and a power of an ordinary Imbabura around 1 kW, it is clear that this will be prohibitively expensive. Solar thermal energy could more likely be used for cooking, and a few solar cookers are present in Rwanda. However, the use of solar cookers does require substantial changes to the prevailing cooking practices in Rwanda, and it is not certain that this technology can be adopted on a large scale. In addition, the climate is such that another stove needs to be at hand at most times to cook when there is no sun.

Solar thermal energy could also be used for water heating thereby replacing electric energy.

## 3.3 **Energy Demand**

### 3.3.1 Biomass energy

According to the Government's Vision 2020 report, biomass energy demand is expected to decrease from about 90% in 2000 to about 50% in 2020. This would require Rwandans to gradually start using modern fuels such as LPG and electricity, although some 7 years later households appear slow in catching up. One reason is that modern fuels are expensive to cook with and another reason is that they are in short supply. Charcoal is the main source of energy in urban areas, particularly in Kigali, and this is expected to remain so in the foreseeable future. Therefore, the BEST is expected to be a useful tool dealing with the realities of biomass use and supply.

There have been numerous studies on the use of biomass, the first dating back to the early 80s and the latest in 2007. Trends are clear: urban households prefer charcoal and it has reached a point that the Kigali market is almost saturated. For the purpose of the BEST it is therefore less relevant to know if the consumption of Kigali is 100,000 t/yr or 120,000 t/yr. However, it is relevant to know how the consumption and the production can be influenced, whether it continues to increase with population growth, etc.

Since there is greater lack of data on the woodfuels supply chain, BEST focussed more on the supply side and less so on the demand side. Having said this, charcoal prices recently increased from about 5500 FRw/bag to over 7500 FRw/bag in a matter of a few weeks. This unprecedented increase must have an impact on consumption: some households are likely no longer able to cook all their meals with charcoal and either change their diet or find alternative and lower-grade fuels. The high price subsisted for a few weeks, after which it returned to its "normal" position of around 5500 – 6000 per bag. A clear explanation has not been found: it could be speculation, from producers or transporters to let charcoal prices better follow petroleum fuel price trends; it could be the fact that the legislation had changed (restrictions in the production, removal of forestry police control around Kigali); or simply the effect of the rainy season. An analysis of price charcoal trends over 10 years did not show similar behaviour; the average monthly price is not subject to large variations.

Table 6 below shows the main biomass energy trends as observed through large surveys ten years apart: charcoal use increases while fuelwood use decreases; agricultural residues remain approximately the same.

**Table 6: Biomass energy trends**

| | ESMAP (1989) | 1999 (Christopherson, Butare) |
|---|---|---|
| Fuelwood | 75.9 % | 69.9% |
| Charcoal | 2.7% | 15.1% |
| Agricultural residues | 9.0% | 8.3% |

**Source**: ESMAP, Christopherson

In addition, as reported by Christopherson and Butare in 1999, the average consumption of woodfuels is higher today than it was 10 years ago: the fuelwood equivalent consumption of fuelwood and charcoal is 1.45 + 0.48 kg = 1.93 kg per individual per day, and this is substantially higher than the level documented in 1991 by ESMAP: 1.33 kg per person per day. This may both reflect a higher relative consumption of charcoal as well as higher unit consumption as a result of higher disposable incomes.

**Table 7: Fuel Use Distribution**

| | Percent in Terms of FW Equivalent | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Biomass Energy | | | | Commercial Energy | | | |
| Prefectures | Fuelwood | Charcoal | Ag. Residues | Other | Kerosene | LPG | Electricity | Total |
| Kigali Urban | 19% | 70% | 3% | 0% | 2% | 0% | 6% | 100% |
| Kigali Rural | 72% | 11% | 14% | 0% | 2% | 0% | 1% | 100% |
| Gitarama | 76% | 22% | 0% | 0% | 1% | 0% | 1% | 100% |
| Butare | 60% | 23% | 16% | 0% | 0% | 0% | 2% | 100% |
| Ruhengeri | 71% | 12% | 16% | 0% | 0% | 0% | 0% | 100% |
| Gisenyi | 70% | 20% | 4% | 1% | 5% | 0% | 0% | 100% |
| Average | 61.2% | 26.3% | 8.8% | 0.1% | 1.8% | 0.2% | 1.5% | 100% |

**Source:** World Bank, 2000

### 3.3.1.1 *Firewood*

Firewood is used in rural areas and secondary towns for cooking; urban households buy it from the market or from the road side, a few sticks at a time or by the stere (stacked $m^3$). In rural areas, households will first collect as much twigs, sticks leaves, dead wood as possible before buying firewood. For the purpose of estimating the consumption of wood taken from the growing stock of trees, it was assumed that households use between 1 and 1.3 kg per day per person using this fuel This is likely to be a high estimate, as dead wood and other forms of woody-biomass, etc. are not included in this number.

Firewood is used in a number of stoves; the simplest is the 3 stone open fire, which can be built just about anywhere at no cost. Many Districts have improved stove programs in place and some even claim that they are reaching close to 100% coverage rate. The type of improved stove is a rectangular mud stove with 2 or 3 pot openings, not unlike the Lorena type. While it may be true that households are equipped with such stoves, there is no independent evaluation to demonstrate the level of savings or indeed if these stoves are used at all. This is not irrelevant, as a recent evaluation in Uganda showed that savings compared to the 3 stone open fire were negative, i.e., the improved stoves consumed more firewood

than the 3 stone open fire[23]. Thus, one needs to be careful assessing the fuel consumption levels applied. The TOR for the current evaluation did not include rural household use and an average annual consumption of 1640 kg of wood per household for a traditional stove and 1260 kg for an improved stove was assumed.

3.3.1.2 *Charcoal*

Charcoal is the fuel of preference by most Kigali households and quite a few households in other towns. Charcoal is embedded in the culture and therefore difficult to stop using. Even if rich households have LPG cookers, the domestic worker often prefers to use charcoal for cooking and simply ignores the instruction to use LPG. Charcoal is available everywhere from dedicated selling spots and there even is a delivery service travelling door by door to sell charcoal.

For the users, charcoal has many benefits compared to firewood: the energy content is higher so only small quantities per day are used; they can buy it in small quantities or in bags that last 2 weeks; most volatiles have been removed during the carbonization process, so the burn is relatively clean; charcoal doesn't deteriorate over time or attract insects; and charcoal is affordable for most households.

*Charcoal Stoves*

Rwanda is one of a few countries in Africa where improved charcoal stoves have penetrated far. Recent surveys suggest that penetration rates of 50% or higher have been attained and that improved stoves have spread to other cities as well. This is remarkable, as the last specific project to promote improved stoves dates back to the late '80s. At the moment, 4 different improved stove models are on the market[24], one all metal stove (DUB 10, which originally comes from Burundi) and 3 mixed ceramic-metal stoves. Of the latter, one is the improved KCJ, the Kenya Ceramic Jiko, one is similar in size but without the bell-bottom form, and the third one is an evolved model of the Rondereza: whereas the Rondereza was an all-metal stove, the current model uses a ceramic fire basket the same size as with the improved KCJ. Unfortunately, the USAID stove study only tested the KCJ and discarded all other improved stove models. Based on the existing data, in the BEST analysis an annual consumption of 700 kg[25] of charcoal per household for the traditional stove and 540 kg for the improved stove was taken.

*Price Structure*

The price structure of a bag of charcoal is presented in Figure 5 below.

The cost of wood per bag is about FRw 1031, which is the equivalent of about US$ 8.2 per t. This is for a tree still standing in the plantation. This cost contributes for 17% to the consumer price.

The cost of charcoaling of FRw 1836 includes cutting the tree, drying to wood (if any), transport to the kiln, making the kiln, carbonizing the wood, and transport to the nearest road where transporters can pick it up. A safekeeping cost and the cost of a bag are included as well. The roadside price is FRw 3120, or US$ 5.8 per bag. Included is FRw 253 in terms of

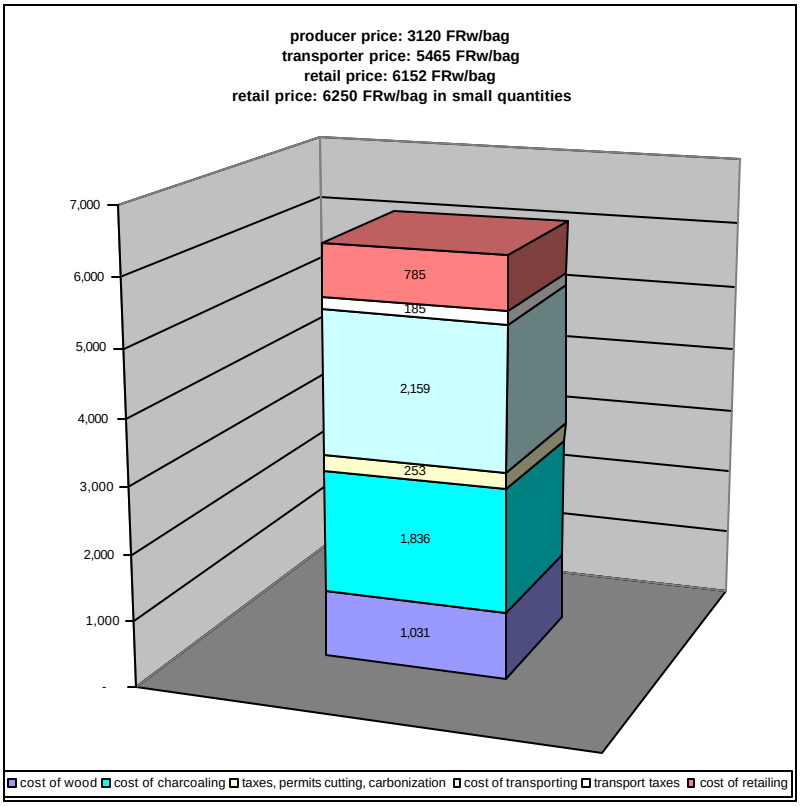
[23] Fuel Efficient Stove Programs In IDP Settings – Summary Evaluation Report, Uganda, September 2007, USAID

[24] Implementation Plan For Increasing The Adoption And Use Of Efficient Charcoal Cookstoves In Urban And Peri-Urban Kigali, May 2007, USAID

[25] Or about one bag per 2 weeks.

permits and taxes: contribution to the National Forestry Fund, cutting permit, included cost of travel and other costs for obtaining the required permit.

**Figure 5: Price Structure of Charcoal**




**Source**: BEST survey data

Transport adds FRw 2159, or $4 per bag. Included is FRw 185 for transportation taxes, and any charges needed to obtain the permit. Wholesale distribution adds FRw 681 per bag and retailing FRw 98 per bag. This gives a retail price for purchase in bags of FRW 6152 or FRw 6250 for purchase in small quantities, or US$ 11.4 – 11.6 per bag.

The total amount of taxes is FRw 438 or 7% of the end-user price.

In total, some 49% of the retail value in Kigali stays in the rural areas and 51% is used to transport and distribute charcoal in town. This is much higher than what was observed in the late '80s and explains probably why charcoalers today are quite satisfied with their jobs, which they were absolutely not back then. Firewood is subject to a similar price structure, whereby the cost of transport is higher but the cost of transforming lower than with charcoal making.

**Table 8: Price Structure of Charcoal**

| | FRw/bag (33 kg) | |
|---|---|---|
| cost of wood (standing tree) | 1,031 | 17% |
| cost of charcoaling | 1,836 | 29% |
| taxes, permits cutting, carbonization | 253 | 4% |
| cost of transporting | 2,159 | 35% |
| transport taxes | 185 | 3% |
| cost of retailing | 785 | 13% |
| retail price | 6,250 | |

**Source**: BEST survey data

### 3.3.1.3 *Agricultural residues*

Rural households will use agricultural residues if and when these are available; immediately after harvesting season, maize and millet residues are used in large quantities by farmers for their energy needs. It was estimated that some 115,000 t of maize residues are produced annually, 13,000 t of rice husks, 5,500 t of coffee husks. The latter two are in high demand by small-scale industries, such as brick and tile producers. Since they cannot use wood anymore they switched en masse to using rice and coffee husks, to the detriment of poor households that earlier used these residues.

Agricultural residues are sometimes for sale in larger towns, albeit not on a large scale. There is no specific stove for agricultural resides, and the traditional rural wood stove is normally used.

### 3.3.1.4. *Dung*

Population pressure is the reason that animals are increasingly kept in a pen or shed much of the time. Goats, cows, and to a lesser extent pigs used to be walked around by the children but this is less the case nowadays. Generally dung is not used for energy purposes; however, if it is used, it is used in a traditional wood stove.

Under GTZ's EnDev program MININFRA implements an activity that intends to install at least 15,000 individual fixed-dome biogas systems[26] over the next years till end 2011 through assisted market development; this is done with the support of SNV in the form of technical assistance for developing the domestic biogas sector. The most popular size digester is 6 $m^3$ and uses about 40 kg of dung per day that requires the output of 2-4 cows; it is expected that farmers will take a loan to finance their systems. A few demonstration units made from fibreglass have been imported from China for field testing; these units are expected to be easier to construct (only need to dig the hole, no need to build the brick dome) possibly leading to lower prices. The gas is used for cooking and possibly lighting, and the resulting slurry can be used as an organic fertilizer. Unit costs are around $1100 for the complete 6 $m^3$ system including stove etc., and the program provides a Government subsidy of $350. Larger biogas units are currently in use in some public buildings, such as prisons, hospitals, and schools; it was found that the construction costs of a digester system are about equal to the costs of constructing latrines, but with much lower operational costs for the digester.

[26] Chinese design.

3.3.1.5 *Briquettes*

Several producers of briquettes have been active during the past few years (EWB, ENEDOM, SAM) although for now only one is still operational: COOPCEN. They mainly use urban residues as their main feedstock for producing briquettes, sometimes mixed in with other residues or woody biomass; the feedstock or the briquettes are not carbonized. Based on combustion characteristics, this type of briquette normally replaces firewood and not charcoal. ENEDOM first used coffee husks and residues from woodworking industries but found it increasingly difficult to locate sufficient quantities of raw material. ENEDOM and SAM are currently relocating their plants as these are no longer allowed to operate at their original site due to recently strengthened environmental rules for economic activities in proximity of marsh lands.

The main raw source of materials for the production of briquettes is likely to be municipal solid waste, MSW. Although quantities of some agricultural residues are of the same order of magnitude or larger, they are scattered over large areas and logistical collection problems are likely to prevail, making it expensive to use these residues. Quantities of agro-industrial residues are not as large but are available in concentrated areas, which make it commercially attractive to convert; however, most agro-industrial residues are already fully utilized.

MSW is regularly collected for transport to dump sites and it is relatively easy to sift out the usable parts for briquette making. Kigali's volume of MSW was estimated at about 73,000 t per year; USAID found that of this total, 28% is theoretically available for briquetting (dry), or 45 t per day. If carbonized to make a fuel for substituting charcoal, about 1,400 t/yr of carbonized briquettes would be obtained compared to 100,000 t of charcoal. From this analysis it is clear that briquettes from MSW do not carry much commercial weight as quantities are necessarily too small to make a profitable business. If briquettes would replace firewood, they would need to compete in price with firewood and this does not leave much room for earning money from the production: the price applied for briquettes (SAM, COOPCEN) was 70 – 80 FRw/kg in 2007, whereas firewood was sold for about 60 FRw/kg. An explanation could be that briquettes burn longer or cleaner, but this cannot be substantiated as it has not been tested. Nevertheless, some industries expressed an interest in briquettes to replace petroleum fuels, particularly UTEXRWA that claims it could use 12 t of briquettes per day and OCIR 4 t per day.

Another raw material is available for briquetting with a higher commercial potential than MSW: charcoal dust. At the moment, this dust is discarded, taken away by the urban cleaning brigades. Some 5% of the charcoal is converted in dust and remains in bags or at retail sites. For a charcoal market of 100,000 t/yr, in theory some 5,000 t of briquettes could be produced if one were successful in collecting dust from retail sites.

Special stoves for briquettes are available, in large versions for institutional use and in small versions for household use.

3.3.1.6 *Agroindustrial residues*

Since the Government prohibited the use of firewood for brick and tile making in 2004, many factories switched to coffee and rice husks, etc. For household use, these fuels are now difficult to obtain and are fully used by the cottage industries that are no longer allowed to use wood. Poor households preferred to use these fuels because of the lower costs than firewood or briquettes and will now have to look for alternatives.

Bagasse production was estimated at 72,000 t per year. The sugar factory recently upgraded its boilers and is now able to use bagasse. Previously it only used firewood and at one point

explored the use of peat as an alternative for cost-reasons. With the new boiler, it now has excess bagasse available with which it could produce electricity to sell to Electrogaz.

Although there are papyrus plants in large quantities, its use may be difficult as it was reported to have a high sulphur content, which may cause metal and aluminium pans to deteriorate quickly. Apart from the earlier failed piston-press briquetting operation, papyrus was used in the past to make roofing tiles. At the moment there is renewed interest in papyrus as an alternative fuel.

3.3.1.7 *Peat*

The Gishoma highland peat deposits in the South West have earlier been exploited until the '60s for supply to the Cement Factory of Katana in DRC. Presently peat is manually exploited in Kiguhu in the Northern area (Ruhengeri) and used as direct fuel for pyrethrum processing, and in Rwabusoro marshland semi-automatically by a private company[27] and used as domestic fuel on small scale in some institutions. By 2009 CIMERWA intends to use peat for its operations as well as for the generation of electricity for sale to Electrogaz. With some 14 MJ/kg, the energy value of peat is lower than wood. Since it has a lower density too, its use is most efficient when transport is minimized and the points of use and exploitation are in close vicinity.

Although not presented in Table 5, for certain peat deposits Sulphur content is high and this has implications for its use. Some observations of high deterioration of pots and pans have been reported. The high ash content of peat makes it also less interesting for households and other small users. Larger users are more easily able to realize investments in a dedicated boiler, furnace or stove to overcome these practical problems than small users - if and when justified from a commercial point of view. Peat does not burn well in available traditional (or improved) stoves and specific peat stoves for household use are not available at present.

Carbonization is often mentioned as a solution to transform peat into a cleaner fuel, however, this may not be the case: raw dry peat already contains 20% ashes, carbonized peat will therefore contain double that volume. This results in waste disposal problems that households normally do not appreciate particularly since the fuel they used before, firewood or charcoal, do not have such problems. In Burundi ONATOUR tried to develop markets for peat and carbonized peat for over 25 years but it was never able to obtain other clients than the army that was mandated to use peat.

The most likely use of peat is for institutions or small-scale industries using specialized boilers or furnaces. Another possibility is the generation of electricity. Now potential customers are in a flux as it is not clear what they can or cannot do with peat while they are made responsible for carrying out an (expensive) Environmental Impact Assessment for every site that they want to develop. It might be better if the Government reviews the environmental impact of harvesting peat in the country and issues guidelines where and how peat can or cannot be used.

3.3.2 Non-biomass energy

3.3.2.1 *LPG*

As can be seen in Table 10, the costs of using LPG for cooking are almost 3 times higher compared to charcoal; LPG is so expensive that it is therefore hardly used. At $4,500 per t, it is more expensive than elsewhere; in Kenya LPG retails for about $2,500 per t. The

[27] Rwanda Auto Service (RAS)

difference of $2,000 per t are explained by taxes and import duties that make up about $1,000 per t, and a higher transport and distribution costs due to the small size of the market. The political disturbances in Kenya early 2008 probably also contributed to an increase in the price.

Households that rely on gas most likely have 2 or more containers given the prevailing supply shortages. LPG stoves can be bought in upscale stores. In other countries, LPG consumption for cooking "took off" when it became available in 3 and 6 kg containers. Many households are likely to accept the higher cost of energy for convenience reasons. Since they will use it only for specific tasks (such as coffee or tea in the morning), incremental costs are manageable. They will continue to use charcoal and may reduce their consumption slightly. At the moment, 6 kg containers are available in limited quantities and most of the stock of containers is in the form of 12 and 20 kg bottles.

**Table 9: LPG Price Structure**

| Cost structure LPG (2008) | US$/t |
|---|---|
| FOB Kenya | 1,329 |
| Costs | 503 |
| Total | 1,832 |
| import tax 30% | 550 |
| Subtotal landed border costs | 2,382 |
| VAT 18% | 429 |
| costs CIF | 2,811 |
| distribution costs + margin | 1,730 |
| retail (FRw 2,470/kg) | 4,541 |

**Source**: KOBIL

Some 46,500 t of LPG would be needed to fully replace 150,000 t of charcoal, or more than 200 times the current LPG consumption. This would cost roughly US$ 110 million per year.

3.3.2.2 *Kerosene*

Kerosene is used by households mainly for lighting. If kerosene is more expensive than diesel, some households will switch to diesel. Kerosene and diesel prices are regulated by the Government; sudden price changes and price increases are avoided in this way. Kerosene is subsidized by the Government by some 47-90 FRw per liter in 2007 (7-12%) but it is not entirely clear where the subsidy comes from; diesel was subsidized by roughly the same amount making it slightly higher in percentage points.

Some cooking with kerosene takes place and low-cost, poor quality Chinese and Indian wick stoves are available on Kigali markets. The total consumption of kerosene is small and the equivalent of about 3 litres per person per year, mainly for lighting in rural areas. It is expected that with better stoves, particularly pressurized ones, more kerosene will be used for cooking similar to what happened in Kenya (notably Mombassa) and Djibouti.

If all of 2007 charcoal use were replaced by kerosene, an additional 53,000 t of kerosene would be needed; this would increase the imports of oil products by about 50%.

3.3.2.3 *Electricity*

Between 1998 and 2004 peak demand and distributed energy have been constrained by available supplies and network reliability. Since then rented diesel became available and as tariffs were increased accordingly, the supply situation improved considerably and a large-scale roll-out of new clients can now be expected soon to reach a total of 350,000 clients by the year 2012. However, promotion of electricity for cooking is out of the question for the

time being as this will be reserved for the richest parts of the population only. Electrogaz currently has some 97,000 connections, most of which in Kigali and in other towns; some 80% of all consumers have prepayment meters.

MININFRA recently commissioned an electricity demand study that will shed more light on the prospects for using electricity on a large scale with a targets of more than 200,000 additional clients in the next 3 years. However, it is unlikely that in the future electricity is used for cooking by a large share of the population due to its high costs. In addition, capacity constraints make it difficult too, as can be demonstrated by the following example. Imagine all households in Rwanda to use an electric cooker of just 500 W, a peak capacity of 600 MW would be needed, which is 10 times the currently installed capacity. This is potentially a sensitive issue, as the Government wants to have electricity available to all Rwandans at the lowest possible tariff, but if the tariff is too low the consumption of electricity will skyrocket.

Electric ranges and appliances are available in upscale shops; low-cost electric water heaters and rice cookers are available too as well as low-cost electric hot plates.

### 3.4 **Energy Prices and Costs of Cooking**

Energy prices escalated in March 2008 but have since then partially come down to more normal levels. Particularly charcoal prices rose dramatically from about 5500 to over 8000 FRw/bag and LPG also soared by more than 10,000 FRw per 20 kg bottle in less than 2 months, See Figure 6 below. Kerosene prices also increased to around FRW 900 per liter but are now at a level of FRw 810, mainly following global petroleum price trends. General high inflation is blamed, but other aspects play a role too: farmers and charcoalers are fed up with lengthy approval procedures and started to buy their way out while the security situation in Kenya also impacted petroleum prices in Rwanda.

Table 10 below gives an overview of the different cooking options and their costs, based on current prices. Included are potential options that are presently not available: briquettes made from charcoal dust or papyrus charcoal[28]. Although firewood remains the cheapest option, this is no longer practiced by the majority of Kigali households, which have moved up to charcoal. An improved charcoal stove is clearly a good option, as already discovered by many households: an incremental investment of around 6000 FRw yields an annual saving of about 38,000 FRw.

**box 2**

In South Africa the Government intervened in the kerosene stove business and set minimum standards, mainly because for safety reasons as many homes are burn every year because of leaking stoves. The industries were given 2 years to develop better models and were told that the sale of non-approved models would then no longer be allowed. As a result, a few different kerosene stove models are now available, in a price range from cheap to expensive. The most interesting reaction from households was that they didn't go for the cheapest model, but for one that was more modern looking and moderately priced.

Cooking with kerosene is only slightly more expensive than cooking with a traditional charcoal stove. Yet, there are very few households that actually cook with kerosene; the most likely reason is the absence of acceptable stove models. The cost of cooking with electricity is about double that of cooking with an improved charcoal stove or 50% more expensive than with a traditional charcoal stove.

Since electricity is a cleaner and more convenient energy source than charcoal, this difference in cost is quite reasonable. However, if the electricity tariff is reduced in the future, as is on

[28] Production costs have been estimated; this needs to be analyzed in greater detail.

the Government's medium-term planning, a large surge in electricity consumption for cooking can be expected and it is not clear that the production capacity will be able to cover the early evening – cooking time peak

Cooking costs with briquettes from MSW are lower than from charcoal but more expensive than firewood. This shows that MSW briquettes are priced to replace charcoal for the less wealthy households, even though the comfort level is lower than charcoal. For households hard pressed to buy charcoal, such briquettes may be a solution.

**Figure 6: Charcoal price evolution in constant FRw (2003)**

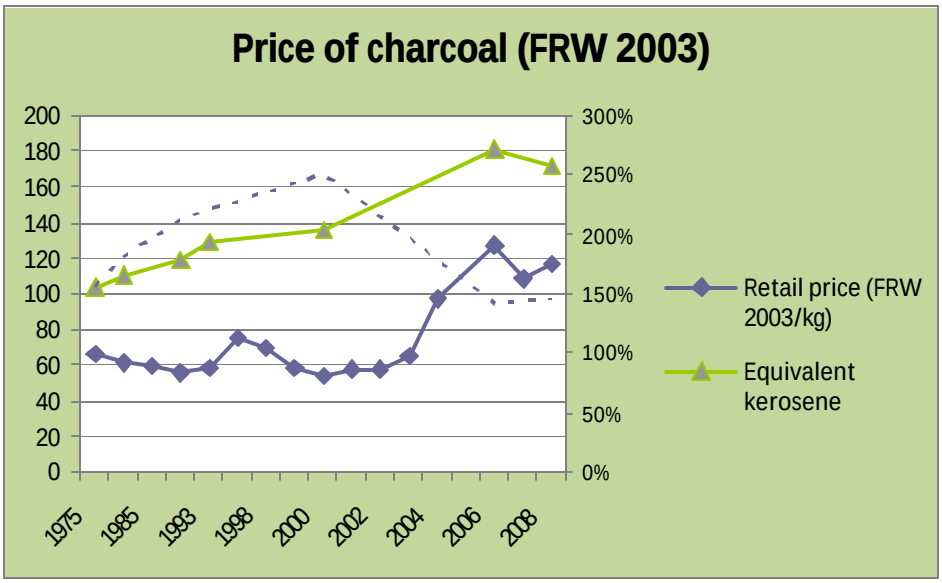



Figure 6 shows the price of charcoal in constant terms (FRw 2003); it is shown that the price from 1975 to 2003 remained roughly constant and doubled between 2003 and 2008, with a sharp increase in 2004 that was never recovered. There are two possible explanations: during the first period, the production of charcoal resulted in deforestation and the cost of the wood resource was not internalized. Since 2004, a sharp deforestation occurred which resulted in higher energy prices; from then onwards, all production of charcoal and firewood comes from plantations, with a large part from farmers who are simply recovering their costs. They are no philanthropists and need to have their investments recovered.

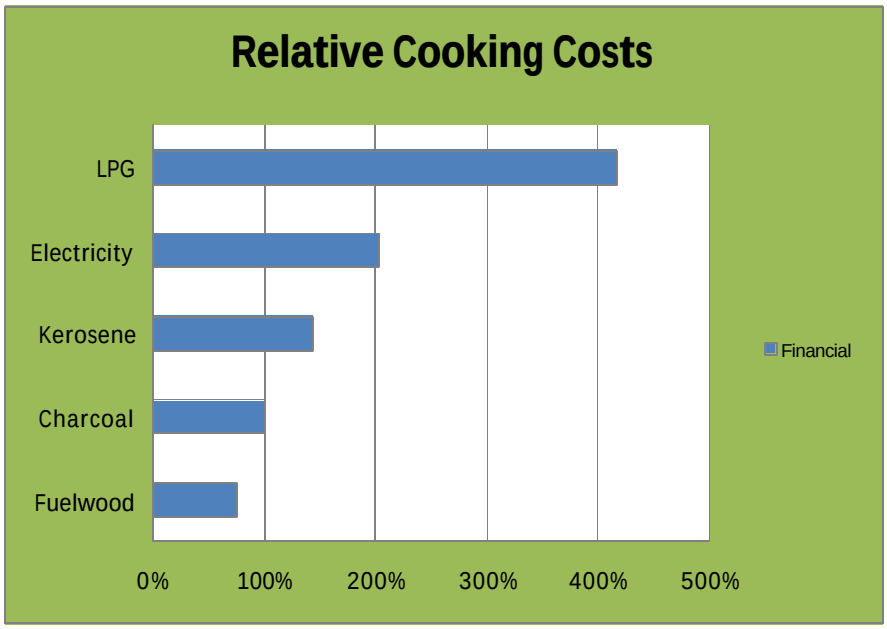
**Table 10: Actual Cooking Costs for different fuels**

| Type of fuel | Price<br>FRW/unit | Price<br>FRW/MJU | Budget<br>FRW/HH/year | Cost compared to charcoal<br>% |
|---|---|---|---|---|
| Fuelwood (trad) | 57 | 21.0 | 93,589 | 57% |
| Fuelwood (improved) | 57 | 16.1 | 71,992 | 44% |
| MSW briquettes | 70 | 25.0 | 111,650 | 68% |
| Charcoal (trad) | 233 | 36.5 | 163,100 | 100% |
| Charcoal (improved) | 233 | 28.1 | 125,462 | 77% |
| LPG | 2470 | 116.0 | 518,253 | 318% |
| Papyrus charcoaled briquettes | 150 - 174 | 32.5 - 32.7 | 145,000- 168,355 | 89% - 103% |
| Charcoal dust briquettes | 160 - 180 | 29.1 - 32.7 | 129,900 - 146,160 | 80% - 90% |
| Kerosene (per liter) | 623 | 40.1 | 179,214 | 110% |
| Electricity (per kWh) | 132 | 56.5 | 252,234 | 155% |

**Source** mission, April 2008

It must be born in mind that data from table 10 only presents a snapshot of the current situation; prices evolve all the time and so do cooking costs. However, the general trend that with rising incomes households prefer more convenient cooking solutions is not observed in Rwanda, and high prices are likely to blame for this. The cost of cooking with petroleum fuels and electricity is much higher than with charcoal, and in particular with an improved stove. See also Figure 7 for the cost of cooking with different sources of energy compared to a traditional charcoal stove.

**Figure 7: Relative cooking costs**



### 3.5 Organization of the sector

3.5.1 Wood supply

The total demand for commercial firewood was estimated at 696 thousand t in 2007. This demand is spread out over the country, with most use in smaller towns. The distribution system for firewood is similar to that for charcoal, with trucks that collect wood from the plantation site or small-scale transporters who collect wood and bring to a collection point. Trucks bring firewood to the retail site in towns and villages. Since the focus of this report is on charcoal, not more is said here.

3.5.2 Charcoal supply

The supply chain has improved over the decades. Whereas prices were set entirely by transporters even 15 years ago, today charcoalers have a much larger say in the matter. It is even mentioned that the widespread use of mobile phones can also be indicated as a reason for the increase, as charcoalers now immediately know when prices in town have increased and can negotiate a better price for themselves. Kigali businessmen are presently looking for ways to get more involved in the rural business in order to be able to get a larger share of the revenue.

The sector has become more professional and more efficient: the performance of 100s of kilns was measured in the late 80s, early 90s and the average transformation efficiency was calculated to be around 1 bag per stere of 35 kg[29], or a transformation efficiency of 10%. The 2008 survey found that the conversion rate had increased on average to 1.4 bag per stere or an efficiency of 13% while in the largest production zone 1.5 was obtained (14%). This represents a performance increase of 40-50%, bringing Rwandese charcoalers in the same efficiency range as most other countries. The survey found that the output ranges between 27 and 30 bag per kiln in the most productive zones[30], and between 8.4 and 11.7 in lesser productive zones[31]. More than 50 bags were weighed in Kigali and found to have an average weight of 33 kg[32], which means that it has not change much over 20 years.

Charcoalers mostly apply the traditional mound kiln or a "rectangular hill-side kiln", which is a mound-type kiln whereby a platform is dug out in the hill side on which wood is stacked and covered first with leaves and then with earth/dirt. Charcoalers now remain on-site with their kiln when the carbonization takes place, something they did not practice before and which certainly contributes to the observed higher efficiency. They also know about better kilns, notably the "Casamance kiln", but they claim that required investments are too high, particularly for the chimney[33]. In one District charcoalers stick one or more wood poles into the kiln, creating a simulated chimney; they claim that this improves the conversion rate. On average, before carbonization they let their wood dry for 9 days in the dry season and 13 days in the rainy season and they claim that they would prefer to apply longer drying times but that they don't have the financing to realize this.

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[29] A stacked $m^3$, or stere, of air dry *Eucalyptus* wood weighs about 350 kg, giving a conversion rate of 1:10; the weight of a bag was 35 kg, which nowadays is 33 kg.

[30] Nyamagabe, Nyaruguru, Cigumbi

[31] Rusizi, Ngororero

[32] Standard Deviation: 3 kg

[33] The purchase and welding together of 3 oil barrels reportedly costs 100,000 FRw.

There are three types of charcoalers: Charcoal Master (*Patron charbonnier*); Foreman (*Contremaître charbonnier*); and labourer (*Ouvrier charbonnier*). The Charcoal master typically can invest in the purchase of trees, he actively searches for wood to be carbonized and makes dealwith wood owners, and sometimes he transports the end product to Kigali; he also makes arranges necessary permits with the local authorities. Business men from Kigali are increasingly trying to operate like this, buying up old plantations and *defacto* becoming wood producers too. The Foreman works for a Charcoal Master or for a wood owner and manages the workmen team; he doesn't have the financing to buy the trees up front, but can make a deal about sharing the output or paying for a salary. The labourer carries out the work and is either paid a salary or shares in the output: the Charcoal Master often applies this latter system if he is not the wood owner himself and when he doesn't personally follow the carbonization, in which case he offers between 30 and 50% of the bags produced to the team; Charcoal Masters observed that the output increases when shared.

In general, bags are brought to the road side closest to the kiln, where a guardian remains with the bags until a transporter comes along to buy them. Some charcoalers complain that it is difficult to find a transporter and in general there does not seem to be a system in place whereby a transporter always deals with the same charcoaler. However, this is changing as the trade is more and more perceived illegal. Bags are now stored out of sight of the road and transporters are developing more links with specific charcoal transporters.

Most of the charcoal is made from *Eucalyptus* wood, although in Nyamagabe sometimes pine charcoal is produced. Prices are different to reflect the difference in quality: pine charcoal is light, it easily ignites and burns fast, whereas *Eucalyptus* charcoal is more difficult to light and burns longer. Savannah charcoal is heavier than *Eucalyptus* and burns the longest,. For which reason it is normally more preferred than *Eucalyptus* charcoal. In February 2008, a bag of pine charcoal sold for 1200 – 1700 FRw and a bag of *Eucalyptus* charcoal for 1800 – 2800 FRw. The farther away charcoal is produced from the main road, the lower price the charcoal can obtain for his bags.

Charcoalers dispose of a revolving fund to pay for their operational costs; the average found in the survey was about 450,000 FRw per charcoaler, whereas in Districts where the most professional behaviour is found (e.g. Nyamagabe) these funds may exceed 1 million FRW. Bank loans, if obtained, rarely exceed 50,000 FRw. Some 65% of charcoalers stated that lack of funds prevents them from enlarging their operations, and 55% states that they have difficulties obtaining bank loans.

Although 45% of the 375 interviewed charcoalers state that they have difficulties finding trees to make charcoal, 47% find it difficult to locate a buyer for their charcoal, 74% think that charcoal making is complicated, and 84% find that it is nearly impossible to obtain permits, 94% also states that it is profitable to make charcoal. This is a clear improvement over the situation some 10 to 15 years ago, when charcoalers found it very difficult to earn a living.

### 3.5.3 Transport

Some transporters specialize in the transport of charcoal and their main type of vehicle used is the pick-up truck or a light truck; many others don't specialize in the transport of charcoal but transport just 2 bags in their vehicle most of the time as this is likely within the allowable limits of "personal use". As mentioned before, charcoal has entered a phase whereby it is not entirely clear that it was produced legally or illegally, and downstream actors make use of this incertitude by applying "personal taxes". Transporters cannot always show that the

charcoal was produced legally, in which case the official stopping the car can insist on receiving payment for letting transporters continue their journey.

Charcoal is collected for 55% along the roads, for 16% via intermediaries, and sometimes through a prearranged deal whereby transporters advance money to finance the cutting and carbonization. Table 11 below gives more details for the different charcoal markets.

**Table 11: Charcoal procurement**

| Destination | Main method for obtaining charcoal | Percentage (of transporters interviewed) |
|---|---|---|
| Cyangugu | Charcoalers depot | 86% |
| Gisenyi | Along the road side, and looking for wood owners with charcoal | 38% each |
| Butare | From wood owners (at random) and along the roadside | 50 % et 44% |
| Kigali via Nyacyonga | Along the road side | 74% |
| Kigali via Giticyoni | Along the road side | 61% |
| Moyenne nationale | Along the road side | 55% |

**Source**: mission

### 3.5.4 Urban distribution

Arrived in town, transporters have 3 mechanisms to sell their charcoal: (i) at the city entrance some sell to intermediaries who have come to collect charcoal for redistribution in town; (ii) at an urban market site with a section for charcoal, where some sell to their regular customers and distributors; or (iii) in residential areas, where some realize door to door sales. The average retail price ranged from 6152 FRw/bag for sale per bag and 6250 FRw/bag for sale in small quantity.

### 3.5.5 Regulatory Environment

Since the decentralization started to get hold, Districts increasingly intervene in the charcoal supply chain. Several Districts prohibit the production of charcoal during part of the year (Rusizi: June – September; Gicumbi: June – August and December – March; Ngororero 4 months; Nyamagabe: severe restrictions, none specified) or is prohibited from cut trees at all (Nyaruguru). Carbonization is most efficient during the dry season; dry wood is easier to obtain during the dry season and kilns made with dry wood give a higher per unit charcoal output. The reason mentioned by Districts to halt charcoal making during the dry season is fire prevention, but it appears over-regulation because charcoalers are fairly consistent in preventing forest fires: this destroys their future income. It would be better to prohibit charcoal making during the rainy season, for silvicultural reasons (trees coppice more difficult during the rainy season, and chances increase that a poorly cut stump will rot and eventually die).

Country-wide, cutting of young trees is not allowed and a permit is needed for cutting a mature tree. For surfaces less than a hectare the permit can be obtained at the Sector level, but for larger parcels it needs to be obtained from the District. An inspection will take place to decide if the trees can be cut, and delays in getting the permit may be as long as 4 months or more. Please note that if one wants to cut as little as 30 trees, a permit is needed. Only for own use is a permit not necessary. There are many complaints about these procedures, and also uncertainties: for good plantation management, (young) trees need to be cut from time to time; does one need a permit for this? It is unclear, and the fact that one needs several months to obtain a permit including travel to the district offices several times, setting up an appointment for visiting the trees to be cut, and realizing the visit. Even when the permit is

obtained, it is not always clear for how long it is valid: just for cutting the trees, or also for carbonizing them? The limits vary per district, in some it is just one week, others have 3 weeks or a month. But, once the permit is obtained, the wood owner needs to quickly organize a team of wood cutters and charcoalers, or he can't complete the tasks within the legal limit.

A wood transport permit is needed from District authorities to bring products to the market. For charcoal the permit is limited to a particular Sector where the bags can be collected and also limited in time: 1 day in Ruzizi, up to 3 weeks in some other Districts. Both reduce limits the usefulness of the permit since most transporters are not enough organized to have a clear idea where/when to pick up their charcoal. Sometimes a tree cutting permit needs to be shown before a transport permit can be obtained. The price varies per district; in Ruzizi, it is 100 FRw per bag. The survey found that the average price paid for transporters is about FRw 185 per bag.

Check points around Kigali until March 2008 used to stop all transporters between 5-6 am and 6 pm to verify transport permit compliance. Since this check was eliminated, much of the charcoal transport now takes place at night. It is not clear why this happens, although transporters say that they want to arrive early to easier sell all their wares (56%), to avoid difficulties with the police and "Local Defense" (27%), and to maximize the use of the permit validity. Transporters reported that when they ply along the main roads they are increasingly stopped at random by uniformed persons in an attempt to extract some money.

As a conclusion, one can state that the regulatory environment needs simplification. While it is necessary that harvesting and management of village and state plantations is well regulated, this is not necessary for the plantations of private farmers. They should receive advise when to cut, how to cut, what to plant, etc., but they should not need to demand an authorization for cutting trees that they have planted in the first place. For farmers, trees are just another perennial crop, contributing to their income, just like maize and other annual crops. The regulatory system should take this in consideration, particularly if the sustainable supply from private farms is expected to increase.

### 3.6 Sectoral contribution to the economy at national and local levels

The contribution from charcoal to the rural economy is large; with a total market for charcoal of about 150,000 t per year, the total value is about US$ 50-60 million; this is the equivalent of more than 2% of GDP. This is also on the same order of magnitude as the market for electricity (estimated at $55 million) or larger than the export value of coffee ($38 million). Total maize production was about 115,000 t in 2004, with a market value of $30 million. This shows that business generated by the essentially informal charcoal sector is actually quite substantial.

About 50% of the retail price remains in rural areas, for the purchase of trees and for the value added by charcoalers. The estimated total value that remains in rural areas is $26.3 million. In addition, transporters have a market of $19.7 million for the transport of charcoal to towns, and retailers earn a total of $6.6 million for selling charcoal to end-users.

#### 3.6.1 Maize versus charcoal

One of the main crops in Rwanda is maize (maize) and most farmers have planted at least some; according to the FAO, in total about 115,000 ha were planted in 2004 and the total output was about 90,000 t. This represents a value of about US$30 million at 2008 prices. Charcoal production was roughly 150,000 t with a value of some $60 million produced from a total of 240,000 ha of plantations.

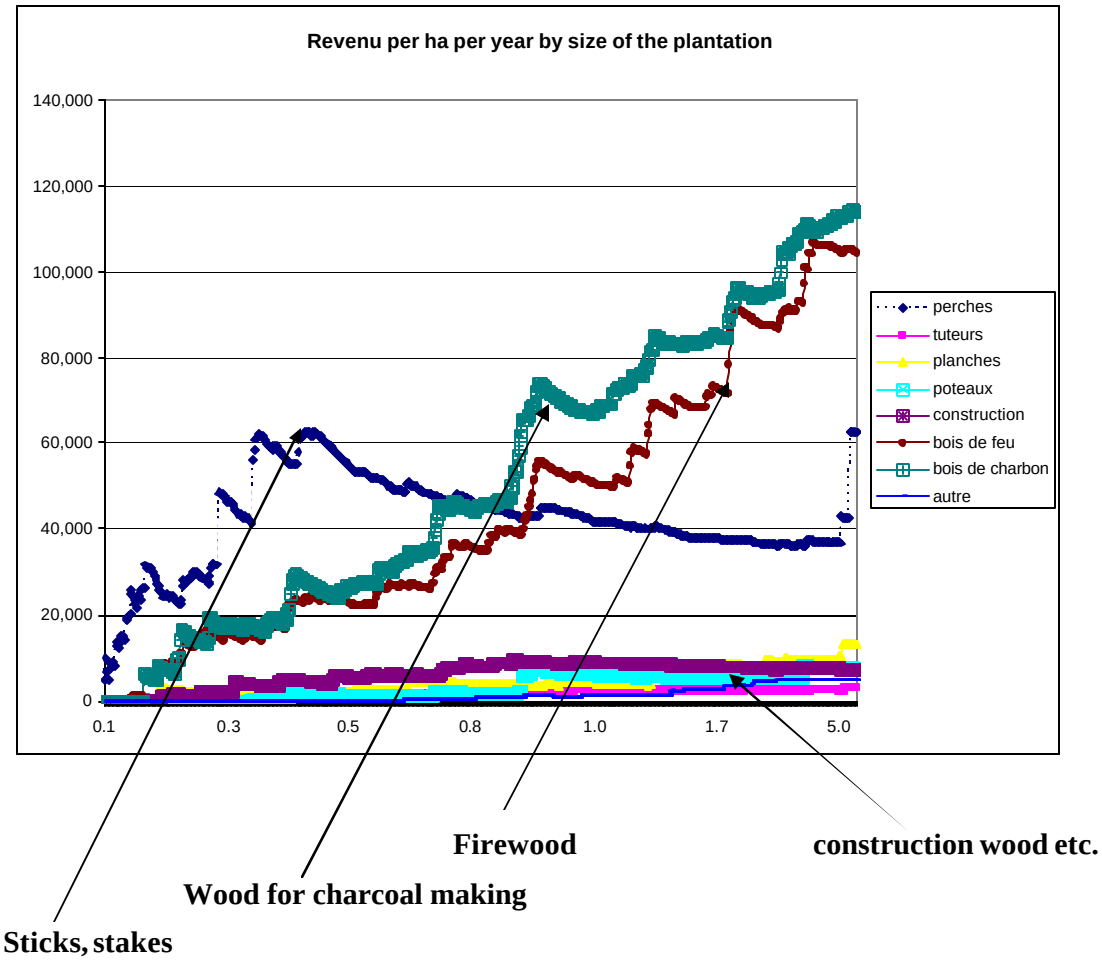
**box 1**

Farmers in the Gikongoro region were asked by authorities to clear buffer plantations around the Nyungwe Forest and plant tea instead. They refused, saying that they preferred to plant *Eucalyptus* Maïdenii – this would, according to them, provide a higher income. In another region, farmers preferred to plant trees instead of potatoes or maize, also quoting higher revenues. Although there have not been systematic evaluations of these phenomena, the observations should be taken seriously as normally farmers do know what is best for them!

If farmers plant maize, they'll be able to harvest in about six months time and he can harvest twice per year. His outputs are 1500 kg of maize per hectare, with a value of FRw 270,000 and a total estimated cost for seeds, and labour of FRw 191,000[34]. This leaves the farmer with a benefit of about FRw 53/kg of maize and FRw 79,000 per hectare per year. Would the farmer apply fertilizers, he could possibly triple his output to 4500 kg per hectare and obtain a benefit of FRw 69 per kg of maize and FRw 313,000 per hectare. Intensification of the crop production pays of handsomely, but is hardly used by farmers in Rwanda for lack of funds to invest in fertilizers.

For revenue from trees, see figure 8 below. It is difficult to give average values, as the production depends on many aspects, such as the size of the plantation and the type of product.

**Figure 8: Revenue from tree plantations by type of product**




[34] IFDC, International Center for Soil Fertility and Agricultural Development; personal communications, 2008

However, a few trends are clear: all farmers, irrespective of the size of their wood lot or plantation, sell poles, construction wood, planks, etc, but to a very limited extent; the maturity time is between 10 and 15 years and they only have a few trees available every year that they can sell; markets are also expected to be limited for this type of product. Depending on the tree size, trees are sold for FRw 3000 – 10,000 each. Sticks form the major source of income for the smallest size woodlots; average revenue over the whole sample was about FRw 37,000 per ha and selling prices were about FRw 500 per stick. The market for this type of wood must be enormous and farmers will have no problem selling what they produce.

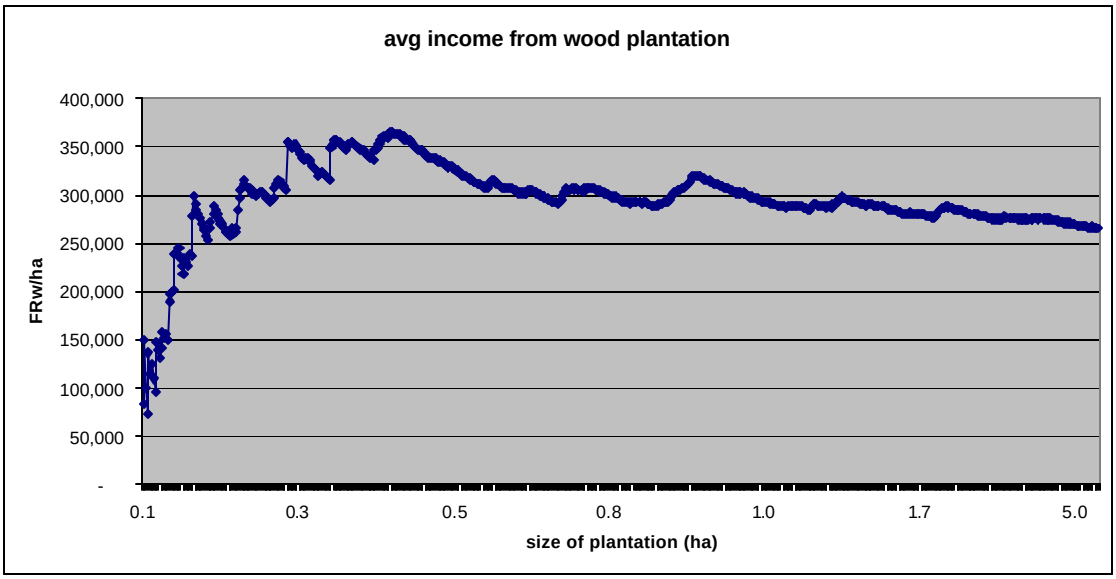
Wood for charcoal and firewood sales increase with the size of the woodlot; the average revenue per ha is about FRw 115,000 for charcoal wood and FRw 105,000 for firewood. Prices per stere ranged from 2000 to 3000 FRw.

Farmers are able to benefit year-round from products that they can sell from their tree plantations, although it takes a few years before the trees can yield a sustainable benefit, with comparable benefits to maize. However, maize requires a lot of attention during preparation of the fields and until the plant is mature. Trees, once well established, do not require a lot of attention and this is reflected in the income derived from the plantations. Figure 9 shows an average revenue per ha of about 270,000 FRw[35]; this must be interpreted with much care. It does not mean that every farmer earns this amount per hectare and per year as it depends on what products he sells, and when: stakes can be sold annually, firewood too, but charcoal wood once every few years and poles can be sold only after 10 to 12 years. Thus, if we assume an average rotation of 7 years, the obtained revenue per year should be divided by 7 too[36], and the resulting average revenue of some 38,000 is about half of what farmers obtain from maize.

[35] The farmer was asked if he was willing to share information about his earnings for different plantation products. This was added per plantation and calculated on a per hectare basis. However, he was not asked how often he obtained such revenues and therefore the information is only roughly indicative. A more elaborate survey is needed to determine the exact benefits from plantations.

[36] This is an estimation; the data do not include the timing, i.e., every how often they sell their products; it does give just the products and amount they sold. More data collection and analysis is needed to give a more definite answer. However, it is clear that farmers earn a substantial amount of money from their trees.

**Figure 9: Average Total Income from Wood Plantations**




**Source: BEST survey**

The earnings are the smallest for the smallest plantation and this is understandable: these plantations are too small to get regular revenues, and possibly some of the output is for own use. There appears to be a peak in income for 0.4 ha, and it may well be that farmers with this size plantation prefer to sell high value products (for which the market is smaller) rather than firewood and charcoal, whereas farmers with larger plantations sell more of the latter as the market for these products is very large but of a lower unit value than say poles or timber.

## 4. Policy, Institutional, Legal and Regulatory Context of the Sector

### 4.1 National Energy Policy

As in many other low-income countries, the energy sector in Rwanda is characterized by a split between 'modern energy' (petroleum, gas and electricity) and 'traditional energy' (biomass) sub-sectors. Most of the energy policy attention until recently has been on on increasing access to grid electricity, increasing power supplies, and reducing Rwanda's dependence on imports for energy. Traditional energy is in fact a misnomer, at a time that individuals and firms in the USA and Europe start to use biomass as an alternative to expensive and scarce petroleum fuels, one can hardly say that biomass belongs to the past. As being a renewable source of energy, locally produced, and not dependent on outside influences such as OPEC or foreign exchange, it is worth to revalue the importance of biomass.

Petroleum fuels and electricity will remain more expensive energy sources than biomass, and as such only the richer households will have a choice to use more convenient and more expensive fuels. For middle and lower class households the prices will be out of bounds and they will continue to depend on lower-cost biomass fuels. It is therefore important that these remain available until no longer required, and this implies that the supply of the biomass fuels will have to be sustainable.

Adding additional generation capacity will increase access to electricity, which is excellent and highly justified, but it will not reduce the cost of production of electricity. The tariff paid by households will depend on the generation mix and associated production costs, and the tariff is unlikely to decrease substantially in the near future despite the political will to do so. It is important that the above is understood so that no false expectations are created: electricity is not and will not be a substitute for charcoal or firewood any time soon.

Economic growth remains dependent on transporting goods, rendering the economy more dependent on oil products than the small share of oil products in the total energy balance would indicate. Alternative sources available but not used on a significant scale are solar energy, wind energy, geothermal energy, methane gas and peat. Most of these sources are either not developed or only in the pilot phases of development. Use of these alternative sources would also address global environmental concerns about the use of fossil fuels.

A new electricity law and a new gas law have passed both Chambers of Parliament. A law addressing biomass energy is not planned but this decision should be reconsidered. The national energy policy is being updated and is expected to become finalized before the end of 2008.

### 4.2 National Forest Policy

Until 1990, there was no official forest policy in Rwanda. The first attempt in developing a national forest policy dates back to 1993, more than a decade after the creation of the Directorate General of Forests (DGF) and several years after the development of a ten years Forestry Plan (1987-1997). Forestry related activities were therefore implemented without much focus on broad goals or principles, such as currently guiding the forestry sector in all its activities.

Vision 2020 recognizes that the forest sector development is a national priority and to that end, the Government intends to expand forest areas up to 30% of the national territory in 2020, and the target is that agro-forestry systems will cover 85% of cultivated areas.

Given the importance of agriculture to the economy, the PRSP adopted in 2001 retained rural development and agricultural transformation as the first broad priority area. EDPRS adopted

in 2007 assigns a great importance to conservation and sustainable rehabilitation of forest and agro-forestry resources, income generation from forest and agro-forestry products, and to efficient policy and regulation that strengthen appropriate forest protection and use.

The national forest policy elaborated in 2002 and adopted in 2004 aims to put PRSP priorities into practices. Its development objective is to transform the forestry sector into an important pillar of the national economy and environment. Its specific objectives are to: (i) increase and diversify national forest resources; (ii) improve forest resource management; (iii) improve forestry animation and education; (iv) valorize wood and non-woody forestry products; (v) develop forestry and agro-forestry research; (vi) reduce the consumption of wood; (vii) improve the capacity of public forestry institutions; (viii) assess forest sector contribution to the national economy; (ix) strengthen sub-regional and international co-operation on forestry; (x) include gender issues in forestry activities.

At the moment, the 2004 adopted forest policy is not fully enforced. Public plantations are currently not managed and harvesting is officially not allowed, even though in practice it was observed that 80% of all plantations showed signs of exploitation. However, there is currently a particular interest to return existing public plantations into production and to fully incorporate decentralization policies.

A new Forestry Act is currently under review and a draft is discussed below.

### 4.3 Decentralization

The strategic objectives of the decentralization policy are: (i) to empower and mobilize local people to participate in the formulation, implementation and monitoring of development programs; (ii) to make the local authorities directly responsible vis-à-vis their communities; (iii) to promote participatory and bottom-up approaches at central and local levels; (iv) to develop a sustainable economic planning mechanism based on efficient management of local resources.

The decentralization policy was implemented by the adoption in 2001 of laws and regulations establishing the Provinces (delegated entities), and Districts, Sectors and Cells (decentralized entities). The Districts are run by a Council and an Executive Committee elected for 5 years.

The first phase of the process revealed rather low quality and rapidity of services rendered by Districts to the population, lack of knowledge by the population on the share-out of competences among central and decentralized entities, and weak financial viability of most Districts. These shortcomings and weaknesses have partly prompted a new round of public reforms in 2006. The administrative boundaries were redrawn to reduce the number of Provinces, Districts and Sectors. The decentralized levels now have more actual power in decision making and planning, and more resources as well. The responsibilities assigned to decentralized entities authorities have also been redefined. The Districts have become the entities in charge of planning and coordination of development plans and programs and resource mobilization, while the Sectors and Cells become the executing bodies. The Districts and Sectors are staffed with qualified agents: at least 5 executives in each District and 4 in each Sector.

The Districts are responsible for promoting and developing agriculture, animal husbandry, forestry, tourism and environmental conservation, within the framework of District Community Development Plans. They manage budgets which are directly transferred from the Central Government. They are in charge for collecting some taxes. They have the possibility of signing partnership agreements with donors, and the accountability in management of project funds from bilateral and multilateral cooperation.

The decentralization of public power to the Districts has made enormous progress and as a relevant example one can now see the intervention of District officials in terms of regulation of the charcoal sector: every district has its own rules, which vary from outright, year-round prohibition to produce charcoal to a ban during several months of the year. In addition, taxation is important for Districts as in part they rely on their own capacity to generate funds, and some have discovered the charcoal sector as a means to generate public funds through taxation and permits.

However, none of the recently developed local development plans fully incorporates the forestry sector and its enormous development potential. Forests are mentioned because they are under threat of disappearing, private plantations are not incorporated, and improved stoves are sometimes mentioned as partial solution. The fact that most forests are plantations, planted and managed by private individuals has not been mentioned, nor that the production of firewood and charcoal greatly contribute to the development in the Districts.

### 4.4 Other policies

Several other policies are in force, notably the one on privatization of essential public services, the promotion of private sector development in general, and the use of public Private Partnerships. The latter have recently become more important and the development of the Lake Kivu gas resources and six micro-hydro plants can be mentioned as an example of this policy.

Rwanda is a forerunner of Environmental Policy, and the Rwanda Environmental Management Agency REMA has become an important player in the country to ensure that economic activities are sustainable and neutral to the environment. For almost any new commercial or industrial activity environmental clearance is needed and even existing activities are not excluded from environmental considerations: recently, all economic activities – old and new – close to the marshes and river valleys were obliged to relocate to higher grounds to protect the vulnerable wetlands; some industries that operated for 10 or 20 years now had to relocate. As part of environmental protection, planting of trees is promoted to conserve soils and to protect watersheds.

The habitat policy may affect energy supply as the current move into Umugudugus may relocate people farther away from their field s and their energy source.

In order to meet the Vision 2020 and PRSP objectives set out for the agricultural sector, the GoR adopted a National Agricultural Policy in 2004. This policy aims at reducing rural poverty and contributing to sustainable food security through: (i) a modernized agriculture at the household level; innovative, professional and specialized jobs to generate more rural off-farm income; and more market oriented development; (ii) a more integrated and diversified agriculture, regionally specialized to ensure food security for the population and a fair distribution of resources and income; and (iii) the preservation of the environment and natural resources.

The Strategic Program for Agriculture Transformation (SPAT) was adopted in 2005 to implement the National Agricultural Policy. It recognizes Peasant Organizations (POs) as key partners and includes support activities for strengthening their capacity, increasing their participation in the agricultural development process.

Finally, there is an active policy to promote equal rights for men and women. Gender issues are proactively addressed in all economic development sectors and are included in all policies.

## 4.4 Legal, regulatory and financial instruments

### 4.4.1 Forestry, legal and regulatory instruments

The forest policy adopted in 2004 has not yet resulted in a new comprehensive legal and regulatory framework, including a decentralization operation. The regulations in force are defined by the Law No. 47/1988 of December 5, 1988. This Law makes provision for the following elements: National Forestry Plan, District Forestry Plans, Forest Service, Forest Commission, National Forestry Fund, State/District/Private-owned forestry land, forest conservation and forestry, forest management contracts, arboriculture, forestry police and penal provisions. However, the related implementing measures were not promulgated, notably regarding the organization and responsibilities of the Forestry Service, and forest management contracts. In addition, the Law No. 47/1988 is not consistent with new laws and the 2004 forest policy, and may generate conflicts of some roles and responsibilities.

In order to face this unfavorable situation, a new Forest Act is currently under review by the GoR. The draft Act reaffirms some fundamental principles:

- The national forest policy elaborated by MINIRENA[37] defines the general directions for implementation and are translated into a National Forestry Plan.
- Each District elaborates a forest management plan for its territory in order to take into account local particularities, and implements upon approval by MINIRENA. The District involves relevant public and private stakeholders.
- Forest management and protection rely on the following principles: (i) to minimize the negative impact on tree plantations, by means of appropriate choice and diversification of species; (ii) to give priority to private forestry and agro-forestry development; (iii) to pay special attention to the ecologically-vulnerable areas; (iv) to involve all stakeholders in the decision making process; (v) to rigorously plan necessary forestry activities; (vi) to base forest management practices on the results of research; (vii) to transfer management of public plantations progressively to private operators; (viii) to consider all public and private forests of general interest; and (ix) to protect endangered local flora species.

The institutional framework defined by the draft Act includes the creation of the National Forest Authority (NAFA, see next Chapter) and two financing mechanisms: the National Forestry Fund (NFF), already mentioned in the former 1988 law (No. 47/1988), and the creation of District Forestry Funds (DFF) in each District.

### *4.4.2 Financial instruments*

Taxes play a role in the formal energy sector, such as electricity and petroleum products, but not in the traditional energy sector that provides about 85% of the country's energy. Applied taxes and duties are (i) VAT, Value Added Tax [38]; (ii) import duties, which in principle are 30% of the CIF value for diesel, petrol, and LPG and 5% for kerosene[39]; and (iii) in addition, there is a Consumer Tax on petroleum fuels of 37% of the CIF Custom's Reference Value and a contribution to the National Road Fund..

[37] Previously MINITERRE

[38] 18%

[39] However, in practice a much lower tariff is applied by taking a CIF Custom's Reference Value rather than the straight CIF value; the reference value varies by supply route and is much lower than the real CIF.

Currently, taxes on traditional fuels are set by the Districts that have chosen their own levels; some are levied in the form of a permit rather than a tax per se. The total value, including additional costs for obtaining the permits[40] was calculated to be about 7%, based on the survey of wood owners, charcoalers and transporters. VAT is not applied.

The draft Forestry Act under review makes provision for various taxes (concession charge in case of forest concessions, harvesting tax, export tax and/or deforestation tax). Their rates would be set out by a ministerial decree. Concession charges and tax products would fund the NFF, and then be split between the NFF and DFF of Districts of origin.

[40] Travel time to the District office to register the application; sometimes contribution to travel cost of the District official so that he can visit the plantation; additional travel to verify that the permit is issued; sometimes one need to pay local official a small fee for expediting the process, etc.

## 5. Stakeholder Analysis

### 5.1 Institutions and their responsibilities

5.1.1 Current institutions of biomass energy administration and roles

The following institutions play a role in the biomass energy sector: MININFRA, MINIRENA, MINAGRI, MINILOC, and MINECOFIN.

MININFRA deals with the user aspects of biomass energy, including the rational use of energy. As such, it is interested in promoting energy efficient equipment as well as to promote the use of alternative fuels.

The responsibility to manage public forests and plantations was transferred from MINAGRI to the Ministry of Natural Resources (MINIRENA) in 2003. The mission statement of the Ministry of Lands, Human Resettlement and Environmental Protection (MINIRENA) consists of realizing rational management of lands, favoring the development of viable human settlement and assuring conservation and protection of the environment in view of sustainable human development. So, MINIRENA provides its services to the population, the public and private sector, and to the different development partners. MINIRENA deals notably with land ownership issues and with public forestry resources including parks and plantations. The majority of private land owners have their own private plantations on their land, and although MINTERE has no direct involvement, it tries to assist wherever it can to increase the productivity. It also intervenes through regulation, such as it mandated that trees, including trees planted by individuals on their own land, can only be cut if they are mature.

MINIRENA is also the parent institution for REMA and for NAFA. Rwanda Environmental Management Agency's (REMA) attributions include implementing the Government's environmental policy, advising the Government on legislative and other measures for the management of the environment, and verifying the environmental compliance and/or sustainability for most economic activities, including monitoring of performance.

The National Forestry Agency (NAFA) is in charge of implementing the Government's forestry policy (i.e. management, conservation and monitoring of forests, and forestry police), advising the Government on legislative and other measures for the management of forests, public plantations.

MINAGRI, the Ministry of Agriculture and Animal Resources, is in charge of agricultural and livestock development and as such is interested in increasing the productivity of smallholder plantations as well as developing off-farm activities as a means to complement agriculture income.

MINILOC is the representative of the District authorities, which are increasingly aware of the markets for woodfuels and how this can contribute to local development. Or, it also happens that some district officials are not aware of this, and e.g. in the most densely planted district charcoal production has been banned completely. Not that this makes a difference in practice, the survey found that a large percent of the total charcoal flux still comes from this District.

MINECOFIN, the Ministry of Finance and Economic Planning is in principle in charge of taxation.

5.1.2 Capacity, strengths, weaknesses

The main observation is that responsibility for managing woodfuels falls between the institutional cracks. MININFRA is interested in the user-aspects of woodfuels, but not so much in its production. MINIRENA and MINAGRI are in interested in the production but

their hands are tied as more than 80% of the supply comes from private lands and private plantations. The demand and supply are much more closely interlinked than is the case with petroleum fuels of electricity. It would be good if one institution were in charge of both supply and demand management of woodfuels.

REMA has been active and prohibited the use of wooden scaffolding in construction businesses, the use of wood for thermal energy needs in several industries, particularly brick & tile and cement industries. In addition, the Government announced that trees need to be mature before they can be cut.

The main strength of the woodfuel sector is that it has been able to steadily supply fuels at reasonable costs; there are no regular shortages and that is quite an achievement for a sector where several thousands of people work independently. However, recently price increases were observed and quite a few households now complain that they cannot afford charcoal any more. To cope with that, they either start using other, lower-cost, fuels as well, cook less, and change their diets (e.g., more pasta instead of beans). An impact study has not been carried out.

The main weakness is that it appears that the sector operates more and more in a non transparent manner; it isn't really prohibited or illegal, although some individuals try to behave like it is illegal. Responsibilities rest now more and more with decentralized authorities that do not have a unified approach. It would be good if the Government could make a strong statement conveying the message that woodfuels are the backbone of the energy supply in the country for the foreseeable future, and that a strong performance of the sector benefits the whole population.

Forest management has faced significant shortages for many years, mainly due to an inadequate and weak institutional capacity. There is insufficient forestry staff at all levels and funding remains low. For example, in 1999 the country as a whole had only 46 forest officials out of a total needed of 146. Recently, the DGF had only 3 forest engineers to ensure planning and monitoring of forestry activities at national level.

The provincial level also has a lack of professionals in charge of forests. The District has only one single officer in charge of environment and natural resources, who can be a geographer, an agronomist, a forester or an ecologist by training. He is in charge of coordinating the forestry activities which are implemented by the Sectors as executing entities.

The capacity at the Sector level is also very limited; there is only one agronomist per Sector, who is also responsible for all economic infrastructure, trade, crafts and industries. A Sector agronomist works for 4,000 to 10,000 households. He has no vehicle although he must follow-up activities in numerous Cells or villages. He has generally no educational background in forestry although he has to deal with nurseries, tree plantations and forestry regulations enforcement regarding forest extraction, transport and trading of woody and non-woody products. In addition, despite a significant number of requests for services and advice on forestry issues from the general population, there is no skilled staff permanently living among the population at Cell or village levels.

Finally, it has to be pointed out that the forest sector has been under-funded for many years, despite the fact that forest degradation has clearly been identified as a major issue in Rwanda. The funding situation has deteriorated since 1994. During the recent years, the ordinary budget allocated to forestry activities counted for less than 7% of MINAGRI's budget. Only a few donors are still supporting forest activities in the country. Since 2003, the *Projet d'Appui à l'Aménagement Forestier* (PAFOR), funded by the African Development Bank (ADB), is the only on-going forestry project covering only half of the Provinces.

## 5.2 Biomass Energy Projects and Programmes

The following substantial biomass energy related projects presented by donor are under implementation or are planned for implementation in the very near future. Together they are the building blocks up on which the Biomass Energy Strategy will be designed. All actors have been invited to participate in the Steering Committee for the Biomass Energy Strategy to ease coordination between the different activities.

### 5.2.1 UERP/World Bank

The Urgent Electricity Rehabilitation Project (UERP) financed by the World Bank includes a biomass energy component (US$0.5 million); the mid-term review of the UERP project that was undertaken in April 2008 confirmed that this component should now be implemented soon. The activities to be undertaken will be to design an urban energy efficiency program (Demand Side Management), particularly focussing on charcoal stoves. Stove producers have been particularly successful in Rwanda in promoting the use of more efficient stove models and acceptance is high already. This should now be taken at a different level, focussing on public awareness about possibilities for using energy more efficiently, capacity building of stove producers, and promotion of an energy efficiency label.

In the late 80's the World Bank through its ESMAP program also financed, together with UNDP and the Netherlands Government, the first large-scale project to address improved stoves and kilns. This particular project has been successful in the sense that it started the promotion of improved stoves in urban areas, which are still available today albeit in modified form. It also demonstrated that improved kilns could substantially improve the conversion efficiency; even though the improved kilns are not used, many charcoalers still make reference to the experience and they have adopted a few techniques that were promoted then with the result that the average efficiency improved from 1 bag per stere to 1.5 bags.

### 5.2.2 CARE/EU

CARE-Rwanda obtained EU funding (€1.2 million) from the ACP-Energy Facility to carry out an improved stoves and carbonization program in the Southern Districts of Rwanda over the next 3 years. The initial recommendations for the Biomass Energy Strategy, to professionalize the entire charcoal chain, will be tested in the Nyaruguru District. CARE engaged a team that is in place now.

### 5.2.3 Netherlands Government

The Royal Netherlands Embassy financed the Forest Inventory that was completed in 2007 and published in 2008; the final text has just been published. The focus was on plantations larger than 0.5 hectare but the findings show that there are numerous small private plantations smaller than one hectare that are perceived, and in fact could contribute significantly to the supply of wood products. The inventory was the first since more than 15 years and provided much useful information. One of its recommendations is to carry out a study on these micro-plantations to identify their contribution to the wood supply in Rwanda, and the second recommendation was to assist village and private land owners to manage and increase the productivity of their plantations. A proposal for this latter activity is being prepared (several million €) and is likely to start implementation in 2008.

### 5.2.4 FAO

FAO started a project in April 2008 to study a rationalization of the wood energy sector in Rwanda; this project had already been proposed a few years ago but was never approved for budgetary reasons. Since the TORs for the study are basically the same as for the BEST, it was agreed that FAO would use the study to complement some of the emerging conclusions

of the BEST surveys. In particular, it would try to focus on the productivity of small holder wood plantations and on the management and potential productivity of papyrus resources.

5.2.5 Belgian Government

The Belgium Government funds the Reforestation Support Program in Rwanda (PARR[41]) aiming at implementing efficiently the National Forest Policy to the benefit of all rural population brackets. The program (€ 3.125 millions) should start during the second half of 2008. It will facilitate and concretely test the setting up of the new institutional forestry framework, notably the inter-relations and co-ordination between the stakeholders at central and decentralized levels, and the operation of NAFA.

PARR specific objectives are to improve the knowledge of each Rwandan regarding the forestry regulations and standards in force, and accompany to that end the decentralization process; to stimulate investments in the forestry sector; to increase and sustainably managed the existing forest resources; to make wood jobs attractive through the setting up and support to forestry management groups; to improve knowledge regarding the choice of species; to better the information of population on the various functions of forests; to promote substitute fuels for woodfuel and energy saving techniques.

At District level, PARR will finance in 6 Districts of the East and North Provinces, based on clearly expressed demand: (i) reforestation (2,000 ha), by means of plantations or agroforestry, (ii) support to better management of forest areas (10,000 ha) by means of forestry management plans at District level, and (iii) co-financing of implementing activities that follow as well as awareness and training of Forestry Management Groups.

5.2.6 Clinton Hunter Development Initiative

The Clinton Hunter Initiative has started a $100 million program in Rwanda and Malawi to promote sustainable development. In Rwanda, the foundation assisted the Government of Rwanda with the single largest purchase of fertilizer in Rwandan history resulting in saving the Government 10-20% from previous year prices and enabling more than 4,000 farmers to increase their yields by 240% thereby providing food for 30,000 people; it partnered with 6,500 coffee farmers in Rwanda to help strengthen their production, expand their operations, increase their sales and ultimately develop their company, called Misozi Coffee Company, into a profitable enterprise. By the end of 2007, Misozi farmers had increased their production by 20% and increased their sales by over 30%. In addition, it started a plantation program for small farmers and established rainwater harvesting and latrine programs at 12 schools.

5.3 Lessons learned from past and current energy programmes

Lessons learnt from past energy programmes are multiple and important. The first lesson is that the Rwandans are determined to duly implement improvements when necessary and when profitable. The success of planting trees on all types of land are exemplary for the rest of Africa; clear land tenure rules allowing for private ownership certainly help to explain why this was possible in Rwanda and not so much in other countries.

Until recently, decision making authorities related to woodfuel issues and applied rules had been very clear, but this situation has started to degrade recently. As a result of the decentralization it is less clear now who has the authority to decide, or even when it is clear who decides, farmers and transporters more and more decided not to obey the rules because

[41] *Programme d'appui à la reforestation au Rwanda – RWA 06 04311*

they find these unduly restraining: too laborious and too cumbersome. The time that structured top-down decisions were obeyed seemed to be over, and as the decentralization and mondalization of the rural population begins to take hold, the rural population will request more say in important matters and are not afraid of taking matters in their own hands. It is reminded that in one district charcoal production is prohibited year-round, but the BEST surveys showed that a large percentage (30% or more) nevertheless comes from this District. Under these conditions, other conditions than prohibition needs to be realized to reflect reality and make use of the existing opportunities.

Improved stoves were introduced in the mid-80's and today they are still around. The private sector took improved stoves up as a regular product and such stoves are now available throughout the country. User rates are fairly high and it is common knowledge that such stoves consume less fuel than traditional stoves.

The same occurred with improved carbonization methods that were also introduced in the mid-80s. Charcoalers still know about these methods and have adapted these in their own way; rather than use chimneys that are expensive, they have invented an alternative that apparently also works. At the same time, they've adopted the better stacking techniques and apply better supervision during the carbonization phase, something they were not willing to do in the mid-80s. As a result, the survey showed that the average carbonization efficiency increase by almost 50%, bringing it up to par with efficiencies obtained in other countries.

Finally, although not directly related to energy, it is necessary to mention land tenure laws and the impact this has on wood production. Rwanda is one of the only countries in Africa that applies private land ownership on a large-scale. It may well be the only country in Africa, as most countries apply common land policies where no-one is the explicit owner except the State. As a result of allowing private land ownership, trees can be seen everywhere. People have an incentive to plant trees when they know that the tree will still be their property when it matures, which is not the case on common lands. As was shown in the previous section, trees benefit farmer at about the same level as maize – but they do not need to provide the same labour intensity. Trees form a sort of security for farmers, that they can cash in case of need – if allowed by the rules governing their exploitation, which appears no longer to be the case.

## 6. Elements of a Biomass Energy Strategy

### 6.1 Description of building blocks

Building blocks that can be used to develop the proposed Biomass Energy Strategy are described below. In what follows, a description is given to understand what is required to make this work in practice. References will be made in the Strategy Report to the write-up in this chapter. The overall development objective of the work is to provide a sustainable supply of affordable woodfuels. The specific objectives are to (i) Increase the sustainable supply of woodfuel; (ii) Increase the energy use efficiency; (iii) increase the use and production of substitute fuels; and (iv) Create the institutional capacity to implement the Biomass Energy Strategy.

The relation between deforestation and charcoal does no longer exist in Rwanda as charcoal these days entirely comes from man-made plantations. Therefore, charcoal should be considered a normal commodity and not as the destructor of forests as it is still regarded by many. As a consequence of this important observation it is recommended that charcoal and firewood produced on private farms be subjected to limited regulation only; when produced on community or state plantations, rules should be uniform but simplified compared to the current regulation.

It is recommended that the Government takes a renewed and more serious interest in biomass: it is a local source of energy, renewable and sustainable, provides substantial rural income and a cheap source of energy for the urban population, and doesn't depend on global and geopolitical influences. Moreover, it could be a perfectly green fuel, something that is being realized in the USA and Europe now where households and businesses are switching to use biomass more and more. However, they use very modern appliances, that are not available in Rwanda – yet.

The Government should become more proactive, starting with changing the regulatory system to facilitate a modernization, and to take biomass as serious as electricity or petroleum fuels: they all have their specific role to play in the economic development of the country. While electricity is required for a modernization of the business, telecommunication, and lighting applications of the economy and petroleum for the modernization of the transport sector, a modernization of the biomass sector is now necessary to allow the domestic sector to enjoy access to affordable and acceptable cooking energy.

#### 6.1.1 Increase The Sustainable Supply Of Woodfuels

The underlying idea behind an increase in the sustainable supply of woodfuels is a professionalization of the whole supply chain, from Districts managing their plantations and farmers growing trees via charcoalers who cut trees and make charcoal to transporters who bring woodfuels to the market. In a way, this process has already started by itself and it is now time to provide guidance to maximize the benefits for all. It would be beneficial for all if procedures for obtaining permits and paying taxes are clear, simple, and as quick as possible and no longer remain the hindrance observed by all actors. In the end, charcoal is a commodity, produced on a District or private plantation or a farm, and Districts and farmers would benefit if they can maximize the returns on their investment to produce this commodity, just like farmers do for growing maize.

Managing existing stands and/or planting trees can and do provide environmental and other benefits such as slowing down the rate of wind and water erosion, reducing the evapo-transpiration rate in fields, acting as nutrient pumps, controlling the flow of water into streams and increasing biodiversity and carbon sequestration. Some of these are of national

benefit and others of global benefit. Therefore, the various tree planting and management initiatives should have national and international backing.

6.1.1.1 *Efficient planning of woodfuel supply management activities*

(i) Design and implementation the Woodfuels Supply Master Plan (WSMP) for the main Rwandan cities. The WSMP gives agreed priority guidelines for the organization, regulation (location, quotas, specifications) and monitoring of charcoal production, and the programming over next 10 years of the forest areas that should be exploited, protected and/or rejuvenated, as well as the related required investments (silvicultural activities, infrastructure, etc.). It will primarily concern the cities of Kigali, Gisenyi and Butare. The expected results are also: a reliable, accurate and updated data bank at District and Sector levels on forest resources (inventory, mapping) and demand for wood products in current and potential urban supply areas; simple and comprehensive methodologies and tools for each steps of the WSMP design, that could also be directly usable in developing the District Forestry Plans and associated management and exploitation plans; training of central and local staff to apply these methodologies and tools; a more efficient and increased involvement of District Services, conjugated with a strengthened and constructive dialogue with woodlot owners and charcoalers, in the organisation of charcoal production and supply channels.

The WSMP design includes: (a) establishing an agro-socio-economic zoning with regard to the characteristics of forest resources and exploitation; (b) assessment of accessible woodfuel resources; (c) analysis of current and future demand for the supply of cities and rural areas with woodfuels, timber and other wood products; (d) analysis of charcoal flows, (e) defining the conditions and technical specifications for sustainable charcoal production (simplified rules for plantation/woodlots management and exploitation, improved carbonisation techniques, required investments); (f) proposing recommendations on the decision making process, sharing of responsibilities and coordination between Districts, Sectors and Cells, with regard to forest and plantation management and exploitation; (g) synthesizing all information to designing the WSMP.

(ii) Design and implementation of the District Forestry Plans (DFP). The support on DFP design and implementation aims at stimulating the effective involvement of Districts and Sectors in protection and rational management of forest resources existing within their territories, in compliance with the adopted WSMP; pursuing the efforts to professionalize the charcoal chain; and promote the privatization of management the State or District owned plantations through contracts of services signed with specialised forest management groups and/or professional charcoaler groups. The expected results are: accelerating the design and implementation of DFPs and related forestry management and exploitation plans, turning the concerned Districts into so-called “green Districts”; increasing the market-supply share of charcoal made in “green Districts”; and ensuring significant and long-term tax revenue for the funding of FFN and District Forestry Funds.

The support includes: (a) development of methodological tools (management and exploitation rules, terms of reference and simplified models of contracts for DFP design, supporting measures for the Sector officials and the charcoalers); (b) setting up the supporting scheme (facilities for professional groups, information / awareness and training tools, recruitment and training of rural animators, information workshops for local Authorities and officials, support to the development of expertise in DFP

engineering for DFP); (c) field intervention in the Districts (funding and monitoring the DFP design and implementation by specialized contractors/service providers, rural animation, training workshops and support for the development of professional groups).

(iii) Modernization and strengthening of charcoal flow monitoring and control. The establishment of a modern and efficient system for monitoring and control of charcoal flows aims at enforcing the WSMP, providing in time reliable and updated information and data on the progress of charcoal production and supply, and ensuring an efficient collection of charcoal taxes to increase revenue for the FFN and District Forestry Funds. The expected results are also regulatory reforms when required, a better understanding of charcoal supply chains and price formation, and a greater motivation of staff in charge of forests at District and Sector levels.

Modernization and strengthening of monitoring and control includes the following: (a) improvement of the transport permit system for forest products (new procedure for issuing the permits coupled with the tax collection, computerised registration and control of transport permits); (b) setting up of the control system (construction of checkpoints at city "gates", recruitment and training of control officers) [42]; (c) establishment of a computerized monitoring of charcoal flows and trade, and related tax revenues, to provide in time the information and data required to verify the compliance with the DFPs, and redirect if necessary the operators.

6.1.1.2 *Rehabilitating and better management of District plantations*

(i) Rehabilitating and better management of existing public plantations. There are many existing woodlots, plantations and roadside trees that are poorly managed, if managed at all. Improving the management of existing tree formations – whether pblic or private - should be an important goal of the Government and District authorities. If farmers had been involved in their establishment, then they should be entitled to benefit from their efforts without much hindrance. These areas or roadside trees should be vested in the local communities and simple management plans drawn up so that the communities will benefit from their involvement. Once people realize the benefits flowing from management of their tree formations they will be more inclined to protect and improve existing resources and plant new trees. All Districts should undertake a survey of existing plantations and roadside trees and discuss costs and benefits with farmers. If agreements can be reached with the interested parties about managing these areas and sharing the assets, then the District with NAFA help could compile simple management plans in collaboration with the people. Binding agreements should be drawn up specifying responsibilities and sharing of costs and benefits to the contracting parties.

(ii) Reforestation. Tree planting in woodlots, along roads and streams/rivers are other ways to improve the supply of woody biomass and tree products both for rural and urban people as well as giving environmental protection. This can be done on areas where it is the most appropriate land-use or where it is needed to prevent erosion or to provide shade. The 2007 ISAR Inventory estimates that about 80,000 ha are currently available for reforestation. Tree planting should be approved by and executed with the full cooperation of farmers in the immediate surroundings. Previously, many people have been involved in such schemes

[42] For example, the forest control at main Kigali "gates" would require 4 check points and about 20 control officers.

without fully benefiting from their efforts. All new schemes should state clearly the obligations and responsibilities for all involved beneficiaries and the benefits they should receive. The full cost of a plantation or woodlot is at least $ 500 per hectare, but with participation of local people who provide some or all of their labour free in exchange for receiving material benefits from such plantations, the cost could be reduced to about US$ 200 to 250 per hectare including establishment and tending.

6.1.1.3 *Tree planting and increasing productivity of private small-holder tree farms*

(i) Agroforestry. Arable, pastoral and homestead planting is mentioned first because this is the key to improving farm productivity, provide woody biomass where it is most needed and produce tree products for home use and for sale. Farm tree management should be the responsibility of the farmers and they should be able to manage the trees in the way they think appropriate, but management advice could be provided through general training and even at the school level for the next generation of farmers. However, farmers should not have to seek permission to cut down trees on their property, as is the case now. If farmers are capable of harvesting cereals, they should be capable of harvesting trees. If they feel restricted in harvesting what belongs to them, they will certainly not plant more trees. Improving the woody biomass resource base on or near farms and assisting with agricultural productivity will also increase the supply of residues and dung. It is a win-win situation with several economic and environmental benefits.

Any major expansion of on-farm tree planting should take account of the existing systems. Tree-planting options include generally mini-woodlots round or near the homestead on variable rotation ages from 2 to 10 years or more; single or double row hedging round the fields and homestead on a four-year rotation and pollarding mature trees (10 to 15 years plus) along boundaries and in fields for fodder, poles and fuel. Promotion of tree-planting requires providing seedlings to meet the tree planting objectives. However, many trees can be seeded directly. Also, some trees, shrubs and bushes can be propagated from cuttings and cloning, and some can come from digging up 'wild' seedlings and replanting them on the farm or homestead. In addition, seed multiplication is vital to ensure that certified and superior seeds of the right species are available to farmers. More seeds may be required, particularly of agro-forestry species, fruit trees and fruit bushes, if more intensive efforts are to be made to encourage a greater number of trees on farm.

(ii) Farm tree planting initiatives. Demonstrations should be established countrywide. These demonstrations would be part of a package and include: Nitrogen fixing tree and shrub species on short rotations (1 to 3 years); shelterbelts of trees and/or shrubs at right angles to the prevailing wind; planting trees and grasses along stream and riverbanks to slow down bank erosion (may be done in combination with physical interventions such as terraces, gabions and levees); planting trees, bushes and grass along contours or terraces; planting fruit trees and fruit bushes in homestead areas; planting of fodder species in grasslands/rangelands and/or enclosing grasslands, preferably with live hedges to exclude animals and rotating animals in pastures; planting trees along field boundaries and along paths; expanding school nurseries and trees round the school and in the schoolyard.

Through meetings with farmers such initiatives could be discussed and the *modus operandi* agreed. Farmers may also propose other initiatives. Farmers will have to agree if and where such demonstrations can be sited. It is preferable to have them on farmer's fields. Therefore, guarantees will have to be given to the farmers and

compensation will have to be paid for the possible reduction of crop yields while the interventions mature and for potential failure.

6.1.1.4 *Professionalizing charcoal value chain*

(i) Creation of professional charcoal associations/private firms. The creation of professional charcoaling groups should be promoted; possible institutional arrangements include to create an association, a small private firm or another institutional entity (GIE: groupement d'intérêt économique), depending on the specific conditions. An association would be good for tax purposes, but in Rwanda there is a poor experience with associations (whereby the Chairman often runs with the money). In any case, the idea is that the group operates more formally, with a clearly defined internal structure, and is more commercially oriented, eventually gaining access to more up to date information about sources of wood available for carbonization and obtaining access to credit.

Techniques applied by professional charcoaler could in principle be more efficient than those applied by non-professionals. Charcoalers now use earth kilns and obtain transformation efficiencies of 14-15%; using simple techniques such as adding chimneys to better control the carbonization process this can be improved to about 20-22%, as was demonstrated in the late '80s. Wood savings of 30% are possible if the average efficiency increases from 14% to 20%. The maximum transformation efficiency in practice, using modern kilns, is about 25%; however, such kilns easily cost Euro 250,000 for a kiln with a production capacity of 1000 t of charcoal per year.

(ii) Creation of charcoal depots. To assist charcoalers to obtain better prices, charcoal depots could be set up, at least one in each charcoal producing District or possibly more than one in the districts that produce much charcoal. The example used as a model is the CECMA, an association of potato farmers created in 2000. Farmers bring their potatoes to centralized depots where transporters can easily charge a full truck load. Charcoalers could bring their charcoal to a similar centralized depot instead of waiting along the roadside for transporters to pass by and buy their charcoal. The depots would be staffed by people from the charcoaler associations (or whatever institutional solution has been found). Since large volumes of charcoal will be handled here, it is likely that charcoal dust accumulates: this can be transformed on site into briquettes and sold along with charcoal. Eventually, information could be available about availability of charcoal from which farmer/location; this could be the start of an MIS system linking wood owners and charcoalers. Statistics will be collected about the flow of charcoal, including its origin, its destination, and who transports it.

(iii) Regulate transport. The benefit for charcoal transporters is that they don't need to look for charcoal throughout the Sectors but simply visit the depot and instantaneously charge their truck and leave. Much time can be saved in this way, which should considerable reduce the transport costs. One could even imagine that it becomes the modus operandi that transporters only pick up charcoal at the created depots. The transport permit system can be adjusted to incorporate and facilitate the existence of the depots: transporters buy the permit on the spot, it is valid for the number of bags purchased and only for transport to the indicated destination on one day; transport permits for pick up from other spots would not be available or more expensive.

(iv) Uniform charcoal transport tax. Such a tax would simplify the current system a lot: it replaces all individual tax systems and provides funds to all involved, including the charcoal depot, Sector administration and District administration. The principle is simple; transporters pay a tax on the transport of charcoal; every bag needs to be accompanied by proof of tax payment; if they pick up charcoal from the depot, the tax payment is simple; no other payments will be required, so anyone else demanding money along the road to the market would be demanding an illegal payment, and this fact should be widely publicized. Any transported travelling with charcoal but without proof of payment can be stopped and made to pay a higher level of tax on the spot, for which he will also obtain proof of payment so that he can't be asked to pay another time. At the moment, the average level of tax and permit payment combined is about 7%, of which about half is a proper tax payment and the rest is in the form of travel to obtain a permit or tax, money to expedite or facilitate, etc. The new unique transport tax could be 10% and replace all other taxes and permits including cutting permit.

### 6.1.2 Increase The Energy Use Efficiency

The justification for energy efficient equipment is more visible when energy prices are high, but in fact it always makes sense from an economic point of view to use low-cost high efficient equipment. Improved charcoal stoves are included in such equipment and given the present very high prices, their usage rates are already fairly high. What is proposed here is not yet another improved stoves project, but developing a mechanism that promotes the use of higher efficient equipment. Very high efficient and modern looking wood stoves have recently become available and are being tested. These stoves can also burn agricultural residues without smoke and could be a good modern solution for some categories of rural households.

It is proposed to set standards for energy equipment, such as charcoal stoves and firewood stoves, and also for electric appliances such as lamps, fridges, air conditioners, etc. The equipment can be recognized by the use of a visible energy efficiency label. By setting fuel efficiency standards and promoting the use of labelled equipment that meets or exceeds the standard, consumers can be convinced to switch to better equipment. Several accompanying measures would be useful, such as an awareness campaign, assistance to manufacturers, and enforcement of the standards.

#### 6.1.2.1 *Capacity building*

It is likely needed to assist manufacturers of stoves to understand the need for such a standard, and what will be required to produce equipment conform these new norms. Although no large changes are needed, the mechanism put in place will allow also the promotion of much more efficient equipment, which is not available in Rwanda yet. This would be the next generation of improved stoves, such as a gasifier stove, a stove with a fan, etc.

#### 6.1.2.2 *Quality Label*

A label should be used to visualize energy efficient equipment; this label can be used for other equipment than biomass energy, such as low-consumption lamps. The focus of the program should thus not be on a particular stove model, but on all equipment that meets the energy efficiency standards. Manufacturers should be convinced to produce more energy efficient models for which as result of the promotional activities, a large market can be expected.

#### 6.1.2.3 *Publicity*

An awareness and publicity campaign is needed to inform end-users about the standards, the label, and the benefits from switching to using more efficient equipment. The focus is on the label, which shows that this particular type of equipment indeed meets the minimum standards and thus can be expected to be energy efficient and save the user money.

In addition to energy efficiency and fuel consumption, awareness should also be raised about the health impact of smoke, and that better stoves do not emit harmful emissions. This is more important for rural stoves than for urban stoves, although $PM_{2.5}$ emissions from using charcoal are fairly high, even for the currently used improved stoves.

6.1.2.4 *Other*

Large-scale rural wood consuming institutions & industries should be advised to invest in energy saving equipment or in a sustainable supply of wood energy. These institutions and industries in absolute terms do not use as much wood energy as all rural households combined, but due to the concentrated nature of the consumption, in relative terms it is likely to be more damaging to the environment overall. The firewood demand for a school, a hospital, a prison, etc. is most likely met through a commercial service, i.e., a firm who provides the needed firewood on a regular basis so that the institution never runs out. This commercial supply will be based on the cutting of whole trees just for the purpose of making firewood, whereas rural households normally do not cut whole trees for their firewood needs. This has an obvious impact on the environment. For institutions, the main recommendations are to use highly efficient stoves and boilers, and to use biogas based on the waste stream from the school. For rural industries, the main recommendations are to mandate either the use of sustainable wood, i.e., tea industries can create their own plantations to supply the needed wood, and can market their tea as "green", or the use of alternative fuels that do not contribute to reducing the wood resources in Rwanda.

For households and institutions alike, complementary action could be promoted to further reduce the consumption of wood fuels, whether charcoal or firewood, often based on different kitchen practices or equipment:

(i) soaking beans overnight before cooking may reduce the energy needs by over 30%;

(ii) using a lid on the pan or pot when boiling water could also reduce fuel consumption;

(iii) the use of a haybox for cooking beans or boiling rice is practiced in some West African countries with much success: after bringing the food to a boil, the pan with food is placed in a haybox, a well insulated box that can be closed off, after which the temperature will remain high for a long time so that the food cooks without using additional energy; and

(iv) the use of pressure cookers can also speed up the cooking process and reduce fuel consumption.

6.1.3 Increase the use and production of substitution fuels

The two alternative fuels of most interest in Rwanda are peat and papyrus. Both are available in large quantities and the second is even a renewable resource. For both the current status remains uncertain: should the Government allow the use of these local sources of energy? If yes, under what conditions? An environmental impact assessment is clearly needed first. It would be necessary for the Government to take a stand point on this and issue clear guidelines for the use - or prohibit the use - of these sources of energy so that potential users may know what to expect and can invest accordingly.

(i) Peat could be an option for industries and institutions located not too far from a source of peat. Specialized equipment such as stoves, boilers, furnaces will be needed, but it is likely that the benefits outweigh the costs. The main costs will be those of extraction and transport, and a feasibility study and environmental impact assessment are needed for every potential user to determine the costs of using peat compared to their current form of energy.

(ii) Papyrus [43] is a plant with a rapid growth, faster than eucalyptus, and if harvested under the right conditions would provide an interesting source of energy. The papyrus reserves are close to Kigali, making it an even more interesting alternative. It has been reported that papyrus may contain sulphur, and this will need to be investigated. If the papyrus is carbonized and densified, an additive can correct this problem. The cost of harvesting are most likely the largest cost-factor and a feasibility study is needed to determine the price level needed for a profitable supply.

(iii) LPG and kerosene are fuels that may appeal to richer households, despite their higher associated cost. As already mentioned before, better cooking equipment might accelerate the use of these fuels and decrease the consumption of charcoal. For LPG supply, measures can be taken to reduce the cost at least temporarily at relatively low economic costs to facilitate an uptake of this fuel.

### 6.1.4 Develop Institutional Capacity

There is no institution that takes the lead in addressing biomass energy issues. Whether this is monitoring of performance or developing policy solutions, the responsibilities are divided. In the process this often means that biomass is forgotten when other energy forms are discussed. It is therefore recommended that an institution or organization is identified that can assume these responsibilities. Unfortunately, the National Energy Development Agency never saw the institutional light; it would have been a good vehicle for systematically pursuing biomass energy issues.

A discussion will have to be held which other existing institution can assume the responsibilities, or if a new organization will need to be created. One thing is certain: a strong institution is needed to look after the major source of energy that is used in the country! Whether or not this institution only addressed biomass, the main source of energy for quite some time to go, or also rural electricity – the most wanted source of energy, needs to be determined. There are African countries that created an agency to deal with both electricity and biomass (Mali, Madagascar), but there are also countries that created an agency exclusively to deal with biomass (Chad) or electricity (Senegal).

[43] Papyrus is mentioned here and includes - for now – also Typha; Papyrus and Typha are very similar in terms of cultivation and potential contribution to the woodfuel supply, but the full extent of both species is unknown until the marshland inventory is completed.

**Box 3: LPG in Senegal**

*The experience of LPG introduction in Senegal serves as an example. The Government of Senegal intended in the late 1980s to increase the use of LPG to reduce pressure on the forests. It introduced a substantial subsidy on the price of LP and sustained this subsidy for an extended period. Only after small bottles (3 and 6 kg) were introduced started households using LPG for more than making tea only. In the beginning LPG use was additional to charcoal consumption, it did not reduce the use of charcoal, but over time households became more used to the benefits of LPG that when the Government withdrew the subsidy in the early 2000s, households continued to use LPG despite its costs.*

Regulation and fiscal incentives are among the tools available to manage the biomass energy sector. It is recommended that the Government strongly and explicitly states that charcoal is not an illegal commodity, that the production of charcoal is allowed, and that it wishes that the actors would become more professional. A reinforcing tool would be the unique charcoal transport tax, which is to be levied on every bag of charcoal transported. The tax would be paid at the charcoal depots, whereby the proceeds are distributed to the various actors with a right to receive funds from this tax. Transporters with bags without tax would be fined a pre-determined amount. It would be known to all involved that there is only one tax payment, so that possibilities for fraud or baksheesh are limited. The tax at the depots would be low – but 80% of the proceeds go directly to the stakeholders: plantation owners, charcoalers, sector and district administrations. Since it is levied by the stakeholders who are allowed to keep part of the proceeds, a high recovery rate is expected. In all other situations, the tax will be higher (such as double) and will go to MINIRENA and be used for further investments in the charcoal and plantation sector.

At the moment, taxes on charcoal make up about 7% of the retail price, but much of that disappears in someone's pocket and doesn't serve the community. The costs of verification and control can be finance from the proceeds of the tax at a level of about 10%, or a minor increase in price.

Fuel taxation policy is another tool that can be used to promote or discourage certain energy options. Highly prospective alternative fuels, such as peat and papyrus briquettes, are currently not available to consumers. However, they could be promoted through tax measures, e.g. producers who are exempt from paying VAT until a certain production capacity is reached or for a limited number of years.

A major objection to applying tax measures voiced typically by Ministries of Finance is that they do not want to forego possible revenue. However, if applied well, an exemption could yield more rather than less revenue. An example is the use of import duties and VAT on LPG in Rwanda as shown in Table 12.

**Table 12: LPG price and taxes**

| | current | ---------- possible future scenario ---------- | | | | |
|---|---|---|---|---|---|---|
| t/yr | 300 | 300 | 1000 | 3000 | 10000 | 20000 |
| FOB Kenya | 1,329 | 1,329 | 1,329 | 1,329 | 1,329 | 1,329 |
| costs to bring to border | 505 | 505 | 480 | 455 | 429 | 384 |
| *Border price* | *1,834* | *1,834* | *1,809* | *1,784* | *1,758* | *1,713* |
| import tax 30% | 550 | | | | | 514 |
| *subtotal (border price + duty)* | *2,384* | *1,834* | *1,809* | *1,784* | *1,758* | *2,227* |
| VAT 18% | 429 | | | *) 161 | 317 | 401 |
| *costs CIF* | *2,814* | *1,834* | *1,809* | *1,944* | *2,075* | *2,628* |
| distribution costs + margin | 1,716 | 1,119 | 995 | 972 | 934 | 1,051 |
| **retail price** | **4,530** | **2,953** | **2,804** | **2,916** | **3,009** | **3,679** |
| Minecofin | 293,835 | - | - | 481,590 | 3,165,147 | 18,294,407 |
| consumer price reduction | | 35% | 38% | 36% | 34% | 19% |

**Source**: BEST team estimates

*) 50% of VAT is applied

The current situation is presented in column 1, a sales level of 300 t/yr and a total revenue from import duty and VAT of US$ 294 thousand. Assume as a hypothetical case that both duty and VAT are temporarily exonerated. As a result, the price of LPG will be 35% lower than it is today, with the likely result that more households will start using LPG. Because of scale economies, the unit price of transport to bring LPG to the border and the unit distribution costs within Rwanda will be reduced considerably and eventually it becomes justified that a local filling station be constructed that will further reduce the cost of supply. Table 12 shows that when the sales level is 10 times the actual level and if the VAT is applied for only 50%, total tax revenue exceeds today's levels while the price to the end-user is 36% lower than today. If the sales level reaches 20 thousand t/yr (or about 70 times higher than today and a typical consumption level for a city of the size of Kigali), both VAT and import duties can be charged normally to obtain a tax revenue of more than $18 million/yr and a consumer price that is 20% lower than today's price. Thus, a temporary suspension of the duty and VAT could lead to higher use of LPG and to a substantially higher tax revenue in just a few years.

## 6.2 **Potential Benefits and costs**

### 6.2.1 Improved charcoal and firewood stoves

The main benefit at the national level is that the total demand for wood and charcoal can be reduced; however, this has a temporary effect as the population continues to increase and there is no significant switch to other fuels, the benefit obtained by improved stoves are just temporary. In addition, since a large percentage of the population – both urban and rural – already uses improved stoves, the incremental benefits of more new improved stoves are marginal. It is therefore necessary to adapt or develop new stove models, a second generation of improved stoves that are much more fuel efficient than the current models.

For firewood such stoves exist, but not for charcoal; an internationally know electronics firm recently started to sell a next generation firewood stoves. These are modern stoves with an electric fan or blower and fine power controls; it sells this stove for about Euro 30-50 in India and more recently started selling on a pilot basis in Ghana and Kenya. People seem to like

this stove and there are other firms now trying to sell similar stoves. Firewood is no longer a backward fuel, as can be observed in Europe and the USA where quite a few people have recently started to use wood for heating their homes to cope with the higher petroleum prices.

Other economic benefits are derived from lower health costs due to the fact that the combustion is cleaner and people breathe cleaner air in their kitchens. This would be more important for rural areas than for urban areas.

The costs of improved stoves to the economy are the costs of the program to realize larger private sales of improved stoves; such costs are minor compared to the total benefits.

The main costs and benefits of improved stoves are thus at the household level, inducing an investment to realize a lower consumption of fuel; in fact, the consumption is as low as possible with currently existing equipment on the market. Households may reduce their fuel bill by 20-35% - or indeed cook more with the same fuel budget as compared to a traditional stove. Although this benefit is sustainable, the effect is felt only when switching equipment, i.e. when buying a new stove and abandoning the traditional stove. The benefits at the household level are considerable and a payback time normally observed is less than one month. The costs at the household level are thus minor indeed, although the poorest households may find it difficult to pay for the incremental costs between an improved and traditional stove.

### 6.2.2 Professionalizing charcoal value chain

The main benefits are split between the national economy and plantation owners. Making better use of existing resources and increasing the productivity is far more efficient than planting new trees from a time and a financial point of view. The main alternative for the Government would be to plant more trees, but this is difficult in Rwanda due to existing land pressure and constraints at finding new lands to develop. Firewood and charcoal are just a commodity that derives from trees, or indeed from the land on which the trees have been planted. There is competition with agriculture that mainly provides annual crops, i.e., commodities planted this year and also harvested this year, whereas trees require several growing seasons before they can be harvested. The farmer will determine what's best for him and a smoothly and efficiently operating market for wood products will convince many farmers to maintain and plant trees. On the other hand, if farmers are too much constraint in developing their stand of trees into a real sustainable cash crop, they'll not pay much attention to it.

The main costs will be to implement an information and awareness campaign among farmers, charcoalers, and transporters as well as the support costs to assist farmers to increase the productivity of their lands (better seedlings, fertilizers) and to set up the regulatory measures to allow for a more professional handling of the supply chain. Much of these costs are borne by the Government; the costs of implementing specific measures to increase the productivity of land and plantations should be borne by farmers and communities, and a mechanism to assist them realize this may be needed.

### 6.2.3 Fiscal measures

Fiscal measures are a tool to manage the whole supply chain and as such they do not constitute a cost but just a fiscal transfer. Taxes should be as low as possible to provide the desired benefits to guide all stakeholders. In principle, a tax of 10% of the final retail price is acceptable to consumers and gives them an incentive to use improved stoves; the 10% is more than what is actually the case, and could provide sufficient funds to Districts, Cells to cover their operating expenses as well as to the FFN to finance the awareness programs needed.

6.2.4 Promote production of alternative fuels (briquettes, peat)

The cost to the economy are minimum as investments will be done by the private sector. The government should decide whether or not peat and papyrus can be considered a real alternative, and if the answer is yes, they should put in place the mechanisms needed to support the private production of these fuels. In principle, there is sufficient papyrus to replace Kigali's charcoal consumption, so it is assuring to know this. But as a final solution it fails, as it would put hundreds of thousands of farmers out of a source of regular income and the soil protection mechanisms will gradually fail with severe implications on the hydroelectric potential.

## 6.3 Implementation Arrangements

It is proposed that EDA, the Energy Development Authority, once created assumes the responsibility for coordinating the activities in the biomass sector. It could take the lead in addressing biomass energy issues and it should collaborate closely and thoroughly with NAFA.

## 6.4 Presentation of anticipated results of proposed interventions

Three strategies are analyzed, (i) business as usual, as if there are no changes to today's practices; (ii) intervention on the demand-side only; (iii) Vision 2020, as proposed by MINECOFIN and which is the official strategy that is in place; and (iv) a proposed realistic alternative. The fourth strategy is presented in more detail in the Volume II Report.

### 6.4.1 Business as usual

This presents the case if no intervention is undertaken and present supply and demand trends continues to evolve as before. Figures 10 and 11 present the consumption of woodfuels without any intervention to render it sustainable and the origin of wood by type of plantation: at the moment, the use of wood will continue to grow for two reasons: (i) population growth; and (ii) more households start using charcoal, as it is a more convenient fuels that is still affordable. The non-sustainable use of wood will continue to increase until there is no tree left. This will never happen in reality, but it is true that over-harvesting is damaging the wood resource base and under the baseline scenario this damage will increase rapidly as shown in figure 11.Non-sustainable use of wood means that the demand for wood products exceeds the total annual growth or increment of the entire tree stock in the country. As as result, harvesting rotations are shortened, trees are cut and not replaced fast enough, and the total stock of trees will be reduced. The demand will therefore in the future need to come from a smaller tree stock, and this future damages will be even larger. In reality however, farmers will start planting trees and households will start using lower-grade fuels, such as firewood or residues and twigs, leaves, and grasses.

**Figure 10: Consumption Woodfuels Baseline Scenario**

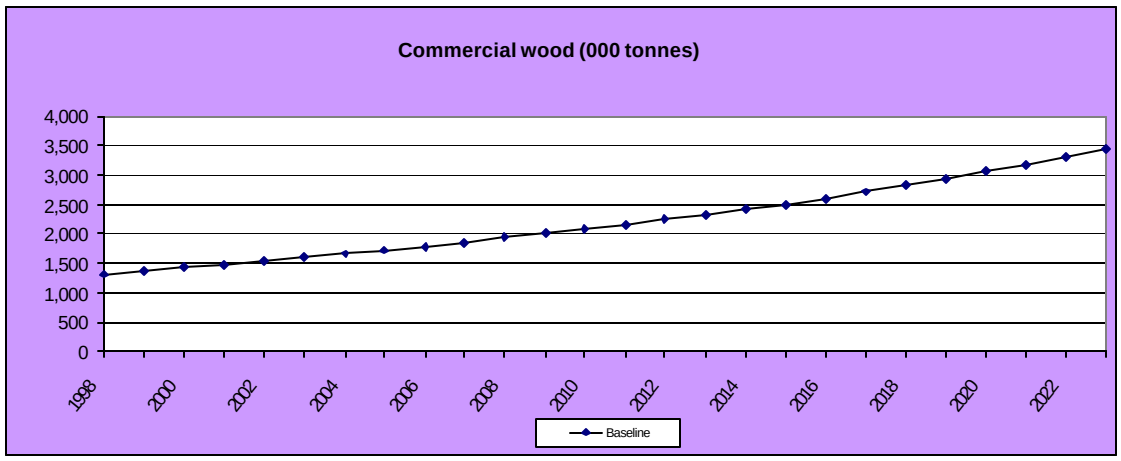
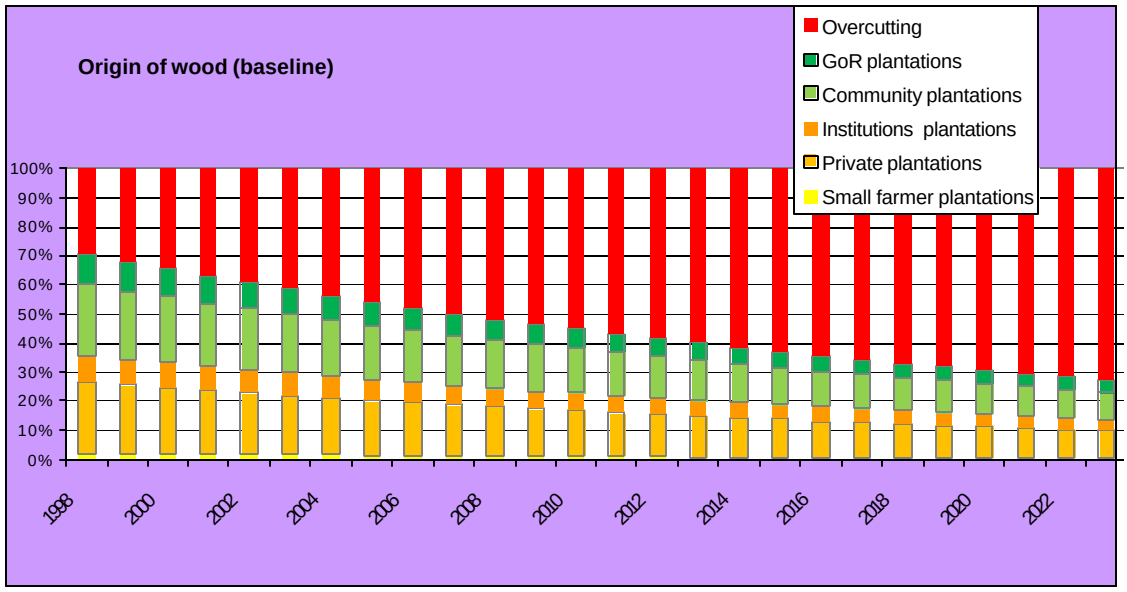



**Figure 11: Origin of Wood Baseline Scenario**




This doomsday scenario is the baseline scenario used for the analysis in this report. Eventually, when there is no more charcoal or firewood produced in Rwanda, households will either have to switch to other fuels or new fuels will need to be produced. This will cause a major inconvenience (use of low-grade fuels, such as residues, grasses, twigs, leaves, etc), or expensive (kerosene is the next best alternative, that will increase cooking costs by 50% or more and that will increase the petroleum import bill). Savings relative to this scenario are considered as the benefits in the proposed alternative development scenarios.

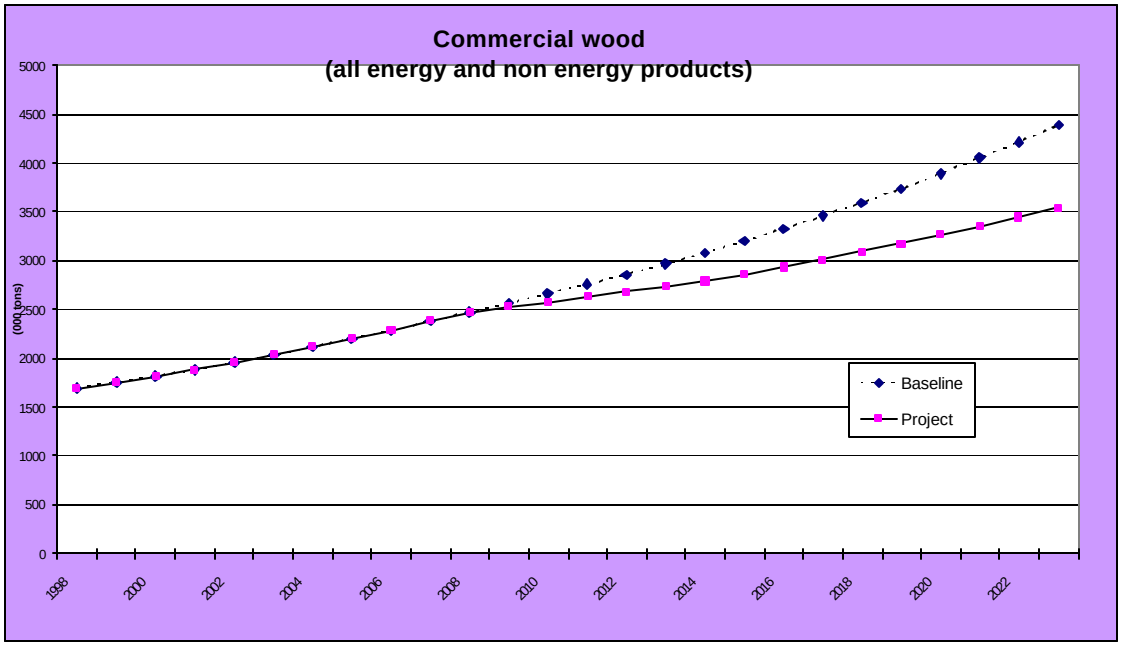
### 6.4.2 Demand-side management scenario

When conservation and progressive use of kerosene, as being the lowest-cost non-biomass alternative are pursued, it is shown in Figure 12 that despite the intervention, commercial woodfuel consumption continues to increase. In this scenario, it is projected that close to

100% of the urban households use and improved stove and kerosene is used by 20% of the households by 2023.

As a result, the increase in commercial wood consumption slows down but continues to grow at almost the same pace as before: one only buys some time. The non-sustainable part of the supply continues to grow, and the conclusion is that it is imperative to develop alternative solutions on the supply side.

**Figure 12: Wood Consumption (with and without intervention), with conservation only**




### 6.4.3 Scenario 3– Vision 2020

The next scenario represents - as far as possible - the official strategy in place. The 2020 Vision scenario aims to reduce the share of traditional fuels (wood, charcoal) in the overall energy balance from an estimated 94% in 2000 to 50% in 2020. The reduction is expected to come from:

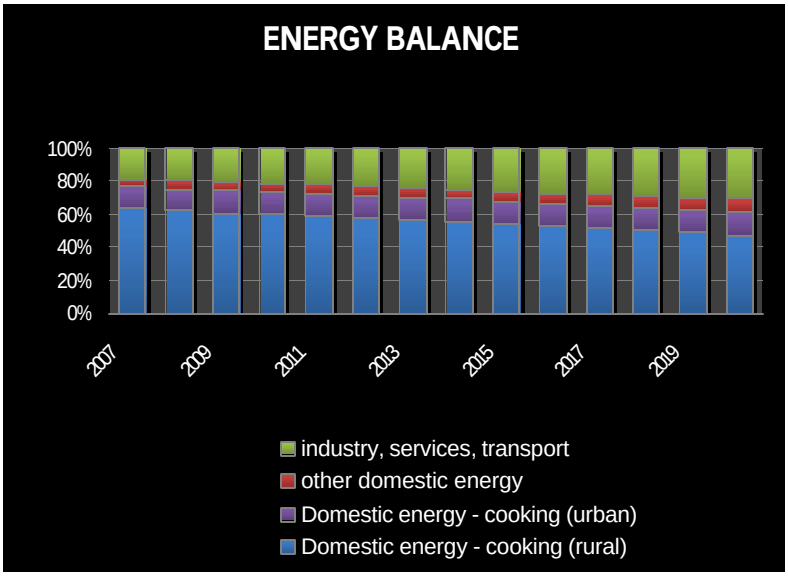
- the development of modern uses of energy (that require mostly fossil fuels and electricity), due to economic and social development, and the consequent relative decrease of the relative importance of energy for cooking, then woodfuels, in overall energy uses,
- specific actions to reduce the share of woodfuels in present and future domestic and non domestic uses, through conservation and substitution.

The evolution of the Rwanda national energy balance may be simulated linking the energy consumption with some simple parameters: differential demographic growth rates for Kigali, other urban and rural areas according to Statistical department, assumptions of the 2020 Vision regarding average GDP growth (8%) and electricity (around 12%). This gives the following evolution and results for the Vision 2020 scenario:

**Table 13: Prospective evolution of the national energy balance over 2007-2020**

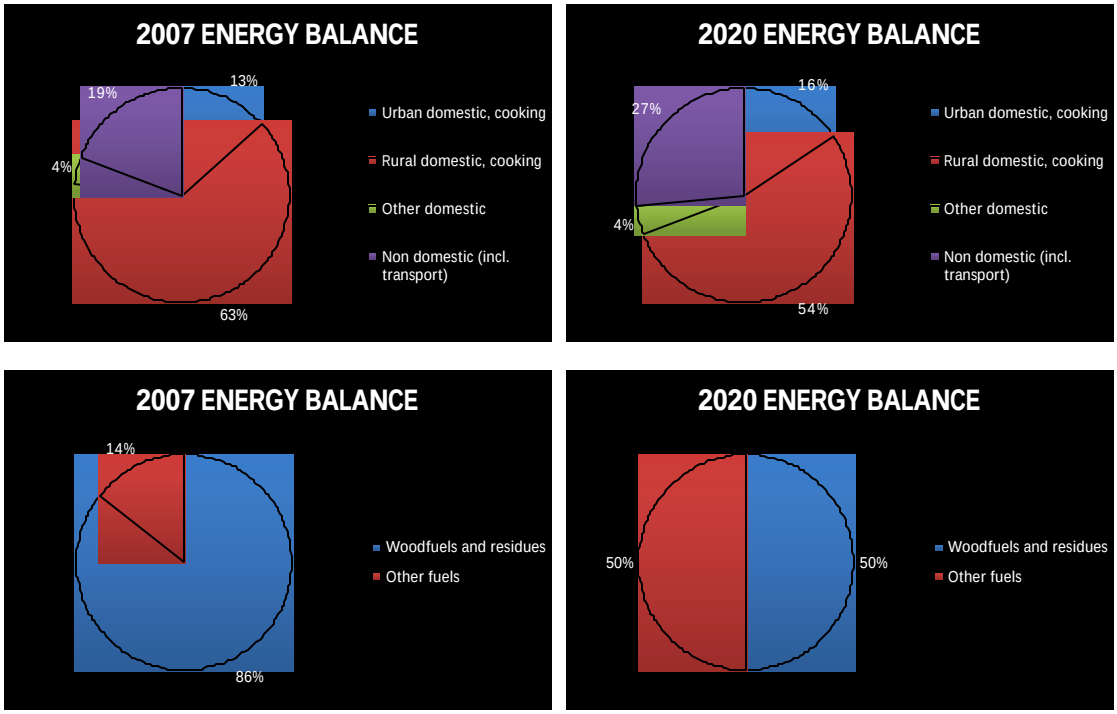
| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic energy for cooking and similar uses (urban) | 13% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% |
| Domestic energy for cooking and similar uses (rural) | 63% | 62% | 61% | 60% | 59% | 58% | 56% | 55% | 54% | 53% | 51% | 50% | 49% | 47% |
| Sub-total | 77% | 76% | 75% | 74% | 72% | 71% | 70% | 69% | 68% | 66% | 65% | 64% | 62% | 61% |
| Other domestic energy | 4% | 4% | 5% | 5% | 5% | 5% | 6% | 6% | 6% | 6% | 7% | 7% | 7% | 8% |
| Non domestic energy (industry, services, transport) | 19% | 20% | 21% | 22% | 22% | 23% | 24% | 25% | 26% | 27% | 28% | 29% | 30% | 31% |
| TOTAL | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

**Figure 13: Prospective evolution of the national energy balance over 2007-2020**




This leads to a significantly different breakdown of energy final use, by sector as well as by type of fuel:

**Figure 14: National energy balance, 2007 and 2020, 2020 Vision assumption**




Within this framework, reducing the share of biomass fuels (firewood, charcoal, etc) to 50% of the final energy demand means:

- Excluding the use of biomass from urban domestic and non-domestic energy demand, which would only be possible if Rwandans had access to convenient and above all competitive alternatives – which is not the case for now;
- A total exclusion is not possible as there are also urban households that collect their wood energy, and it will be necessary that a small part of rural domestic energy demand is substituted by alternative fuels (e.g., among the relatively small share of rural households already paying for their cooking fuels).

To give an idea of the effort to realize to reach this objective, one can take a penetration rate of alternative fuels of 90% in urban domestic and non-domestic markets, with a resulting 4% in the rural domestic market. This represents in 2020 around 650,000 households using alternative fuels (LPG, electricity, biomass briquettes...), of which 280,000 in Kigali, a 290,000 in other cities and 80,000 in rural areas.

In the case of more conservative hypothesis of economic development and of development of modern uses of energy (the 2020 Vision document fixes objectives but does not predict future usage rates), the task is made more difficult. Taking as an example an average growth of GDP of 6% and electricity around 4,5% (the last figure being used in the power sector expansion plan), the energy needs of rural households for cooking keep over 50% of the overall final energy demand. Still reaching the 50% objective will oblige to promote substitution at a higher level in rural areas (14%), which is particularly difficult due the fact that a large number of rural households does not pay for their cooking fuels. This would represent about 900,000 households using alternative fuels, of which 300,000 rural customers.

This more conservative scenario is not in itself impossible, but substitution at this level in domestic markets would be:

- very costly and difficult: locally produced alternatives to woodfuels are limited (biomass briquettes) or require substantial transformation to adapt to the domestic market (peat, methane) and this would suppose making LPG and electricity competitive with high levels of subsidy[44], representing heavy and unjustified recurrent cost for public budgets, as well as high constraints for the power sector (load factor, competition with non domestic demand).
- On a macroeconomic level, the high price of imported hydrocarbons already places a burden on the Rwandan economy today, with a cost of importing petroleum products representing more than 60% of the national trade balance; the importation costs of the substantially increased petroleum fuel consumption will be almost impossible under the projected consumption levels of this scenario; and
- Disastrous for the rural economy: the income drawn from selling woodfuels is an important source of cash for farmers and a determinant contribution to their survival.

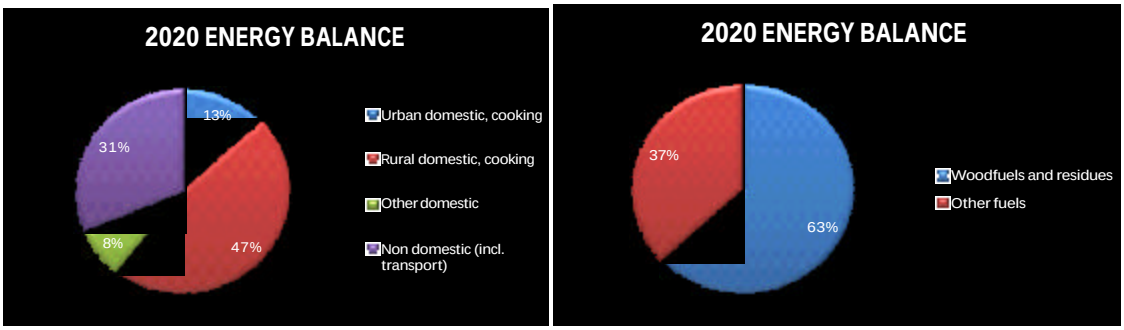
6.4.4 Scenario 4: Proposed reasonable alternative development scenario

Another scenario is proposed as a reasonable alternative; see also the report Volume 2, the Proposed Biomass Energy Strategy.

- Keeping ambitious, but realistic substitution objectives, reaching just over 20% of households in Kigali and 10% in other cities, that will use in 2020 other fuels than wood and charcoal for cooking, based on a far less costly public private partnership;
- Reinforcing the effect of substitution by a more aggressive and active policy of energy conservation; and above all,
- Ensuring that firewood an charcoal are produced in a sustainable way by an efficient and professional woodfuel sector, through rational management and harvesting of private and public plantations and more efficient charcoal-making methods.

This would lead to a similar evolution of the Rwanda energy balance in terms of final uses (due to both conservation and substitution).

**Figure 15: National energy balance, 2020, team scenario**

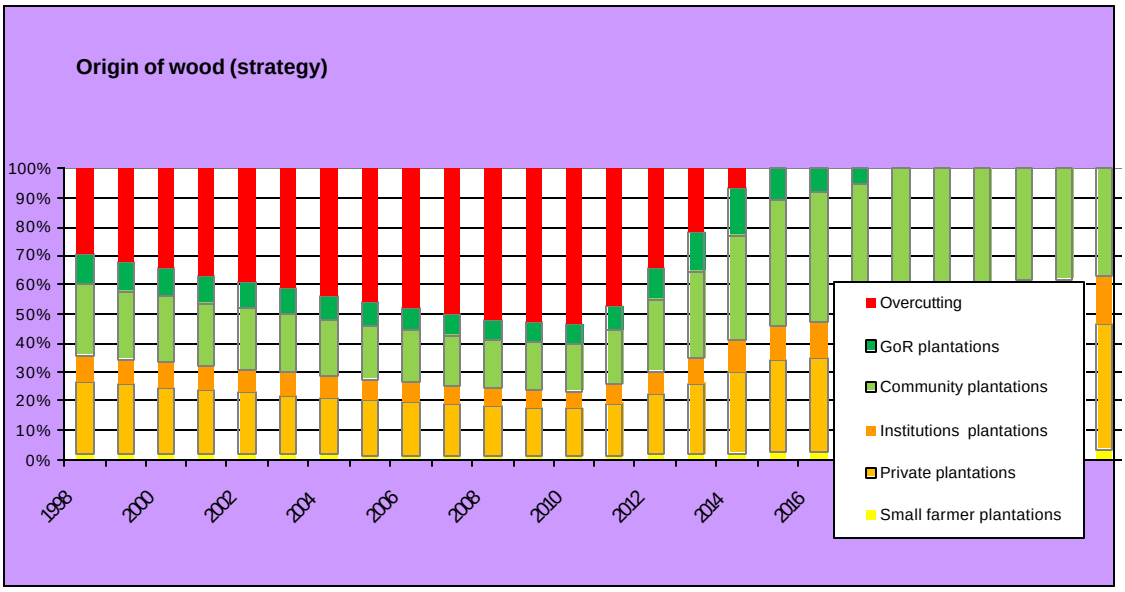



The breakdown between wood and other fuels (around 60% - 40%) is not so far from the one expected by the 2020 Vision (50% - 50%). In the proposed alternative scenario, woodfuels

44 A substitution mix (electricity, LPG, other fuel) would require as an average around $725 per ton subsidy: this would represent some $72.5 million during the 5 year 2009-2013 period, with annual subsidies reaching above $145 million /year in 2020.

are used efficiently and moreover produced sustainably and this should not appear as a problem, but on the contrary as a pillar of the national energy security and auto-sufficiency, and also of the rural economy by generating sustainable incomes to Rwandan farmers. Figure 16 shows the result on the woodfuel supply situation and shows that within 10 years the supply could become fully sustainable. Volume 3, the proposed strategy gives a better description and analysis of this scenario.

**Figure 16: Distribution of Woodfuel Supply**




## 7. Implementation and Monitoring of the Biomass Energy Strategy

### 7.1 Two year action plan and institutional responsibilities

Implementation of the action plan has started through the activities of CARE, the World Bank, the FAO, and the Netherlands Embassy; they should be reviewed in the next 36 months to learn the lessons and adjust the strategy. A more detailed action plan should be prepared once the strategy has been publicly discussed. The strategy should not be a fixed, one time plan, but should be adjusted regularly as a result of progress or unplanned intervention.

### 7.2 Monitoring and evaluation system

The following are the proposed outputs that will count towards accountability and demonstrate progress of the implementation:

- Issuance of a sectoral policy letter that fully incorporates biomass; MININFRA, MINIRENA, and MINECOFIN are responsible for this;
- Revised and enacted legislation to reflect the fact that firewood and charcoal are regular products from plantations and that they are no longer illegal;
- Revised taxation policy for charcoal, LPG and kerosene;

- Creation of an agency dealing with biomass; MININFRFA and MINECOFIN are responsible for preparing this;
- A Supervisory Board should be created to oversee the functioning of the agency with member from all relevant ministries and other stakeholders; ministries included are MININFRA, MINIRENA, MINICOM. MINILOC and MINECOFIN; representatives of the private sector should be an association of transporters, charcoalers, wood owners, sectors, etc.
- An actualized overview of the status and results per district; initially this will be a detailed overview of the regulatory aspects per district, but eventually this will include the results of any action that will be undertaken with regards to the strategy in that district; data collection to be done by sector and district officials, record keeping and cross-checks by the newly to be created agency;
- Preparation of Investment Plans per district; the Districts will be responsible for this;
- Specific monitoring tools, developed to monitor long-term progress of certain elements of the strategy, such as the flows of sustainably produced charcoal per sector and district; the receipts of charcoal taxes per sector, to be cross-checked with the physical flows; newly to be created agency will be responsible for this;
- Centralized monitoring of tax receipts; MINECOFIN, with assistance from the newly to be created agency

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