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ESMAP

Energy Sector Management Assistance Programme

Rwanda

Commercialization of Improved Charcoal Stoves and Carbonization Techniques Mid-Term Progress Report

Report No. 141/91

JOINT UNDP/WORLD BANK

ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

PURPOSE

The Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP) was launched in 1983 to complement the Energy Assessment Programme, established three years earlier. ESMAP's original purpose was to implement key recommendations of the Energy Assessment reports and ensure that proposed investments in the energy sector represented the most efficient use of scarce domestic and external resources. In 1990, an international Commission addressed ESMAP's role for the 1990s and, noting the vital role of adequate and affordable energy in economic growth, concluded that the Programme should intensify its efforts to assist developing countries to manage their energy sectors more effectively. The Commission also recommended that ESMAP concentrate on making long-term efforts in a smaller number of countries. The Commission's report was endorsed at ESMAP's November 1990 Annual Meeting and prompted an extensive reorganization and reorientation of the Programme. Today, ESMAP is conducting energy assessments, performing preinvestment and prefeasibility work, and providing institutional and policy advice in selected developing countries. Through these efforts, ESMAP aims to assist governments, donors and potential investors in identifying, funding, and implementing economically and environmentally sound energy strategies.

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RWANDA

COMMERCIALIZATION OF IMPROVED CHARCOAL STOVES AND CARBONIZATION TECHNIQUES

Mid-Term Progress Report

December 1991

ACRONYMS, ABBREVIATIONS

BIT =(ILO)	International Labour Organization
BNS	Bureau National des Statistiques
CARE INTERNATIONAL	US Relief Organization
CCCE	Caisse Centrale de Coopération Economique Française
EEC	European Economic Community
EBF	Energie Bois de Feu
DGE	Direction Générale de l'Energie
DGF	Direction Générale des Forêts
KORA	Association of Metal Workers in Kigali
MINAGRI	Ministère de l'Agriculture, de l'Elevage et des Forêts
MININTER	Ministère de l'Intérieur et du Développement Communal
MINIPLAN	Ministère du Plan
MINITRAPE	Ministère des Travaux Publics, de l'Energie et de l'Eau
SNV	Stichting Nederlandse Vrijwilligers, Dutch Volunteers
UNDP	United Nations Development Programme

CURRENCY EQUIVALENTS

Rwandan Franc (FRw) = US$0.013 (March 1990)
FRw 75 = US$ 1

MEASUREMENTS, ENERGY CONVERSIONS

1 kWh	kilowatt hours	3.6 MJ = 3600 kJ
1 MJ	mega Joule	10^{-3}GJ = 10^{3}kJ
TOE	tons of oil equivalent	42.5 GJ = 10.2 million kcal = 40.5 million BTU
MT	Metric Ton	1000 kg
stère	eucalyptus wood	480 kg
stère	pine wood	300 kg
1m^3	solid eucalyptus wood	900 kg
1m^3	solid pine wood	750 kg
1 kg	of wood	16 MJ (at 15% mcwb, moisture content wet base)
1 kg	of charcoal	31 MJ
1 liter	of kerosene	35 MJ
1 bag	of charcoal	weighs 33 kg

This report is based on the work undertaken in Rwanda during the period of October '87 - December '90 and was written by: Mr. Robert van der Plas (ESMAP Task Manager); Mr. Evode Safali (Carbonization) and Mrs. Perpétue Muramutse Nsabimana (Stoves), Rwandan Project Coordinators. Mr. Peter Bocock edited the report. Consultants to the project were: Piet Visser (stove specialist); Michel Matly (economist); Bernard Cassagne (carbonization/forestry specialist); Mike Bess (commercialization specialist); Matthew Milukas (socio-economist); Pierre Munyankwaya (quality control); Alphonse Munyaneza, Bonaventure Muligande (Publicity).

ABSTRACT

This report is a mid-term progress report of the "RWANDA - Improved Kilns and Charcoal Stoves" Project, which was funded by the Dutch Government and UNDP (Kigali), and executed by the World Bank through the Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP). The field work was carried out by two Rwandan teams between October 1987 and March 1990, assisted by short-term consultants for specific technical interventions. This report consists of a concise description of the energy sector in Rwanda and the project's stove and kiln activities, as well as its achievements and impact on the Rwandan economy and the household sector.

The Improved Charcoal Stoves component of the project developed a private sector stove production, marketing and retail activity which has expanded rapidly during 1990 to a point where current monthly stove sales amount to 1500 -2000. An estimated 20,000 improved stoves have been sold, or 20% - 25% of the total market in Kigali. Household charcoal consumption has been reduced by 35% on average.

The Kilns component of the project has identified socio-economic and technical aspects of improving traditional charcoaling methods. Approximately 260 traditional charcoalers were trained, 60% of which adopted the improvements. The improved charcoaling techniques doubled the productivity under actual field conditions from one bag of charcoal to two or more bags per stere of wood. A wood pricing policy was identified and proposed to the Government.

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Background

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Energy Sector

2. The household sector is Rwanda's single largest energy user, accounting for 88.5% of total consumption (Chapter II, Table 2.2). By source, firewood, charcoal, and agricultural residues, mainly used for cooking, meet more than 90% energy demand (Chapter II, Table 2.1) and will continue to do so for the foreseeable future. Rapid population growth (3.9% p.a.) and high average population density (240 persons/km^2) are likely to increase the rate of urbanization, and the ensuing substitution of charcoal (the preferred energy source for urban households) for firewood (mainly used by rural households) would accelerate demand for woodfuels, because of the larger amounts of wood consumed in carbonization and charcoal use than in direct use of firewood as fuel (Chapter II, Table 2.3). The substitution by other fuels such as kerosene, LPG and electricity is not likely to occur on a large scale in the near future since they are about three times more expensive than woodfuels (Chapter II, Table 2.4). Therefore, Rwanda needs to ensure that the supply and use of woodfuels are as efficient as possible.

3. As much as 14% of total wood consumption is destined for charcoal production, even though charcoal accounts for only 2.7% of total woodfuel use in terms of end-use energy. This is explained by the fact that the present charcoal making process is extremely inefficient. The inefficiency of production is not reflected in the price of charcoal: on an energy basis, the retail price of charcoal is not much higher than that of firewood. In essence, the markets for firewood and 'wood for charcoal production' are not the same: the first consists mainly of plantations in the proximity of Kigali, where the price of wood reflects its economic value, whereas the latter consists of wood resources at the far end of the country where the price of wood does not reflect its economic value: both charcoalers and wood owners are subsidizing urban charcoal users.

Objectives

4. According to the Energy Assessment Report by ESMAP in 1989, the sustainable supply of woodfuels was shown to be 16% below the demand in 1987, requiring corrective measures to be taken. The present project has been designed to assist the correction process by reducing woodfuel demand (and hence deforestation) through the development of fuel saving charcoal stoves and more efficient charcoal producing methods. The project was also designed to disseminate the

benefits of these developments by establishing a commercial production and sales system for improved charcoal stoves in Kigali, and a self-sustaining program for grassroots implementation of more efficient charcoaling methods in Rwanda.

Components of the Project

5. In line with the above objectives, project implementation has consisted of two major components both related to demand management: (i) promoting the commercial production and use of charcoal saving stoves, and (ii) reducing the amount of wood required for the production of charcoal through popularization of improved carbonization methods.

6. The Project's Improved Charcoal Stove activities comprised selection of the most appropriate improved stove by households; training of stove producing artisans in producing the selected improved stove; identification of all aspects of the selected improved stove model necessary for a marketing and commercialization campaign; and launching this campaign to boost improved stove sales and use. All of these activities were accomplished in conjunction with the administration of a series of surveys.

7. The Project's Improved Carbonization activities comprised identification of all actors and practices in the charcoaling cycle; preparation of a sensitization program to promote wood planting and use efficient charcoaling methods; development of detailed training programs for traditional charcoalers, Forestry Department and forestry projects personnel in improved charcoaling techniques; identifying (via surveys), the measures needed to ensure that charcoalers continue to use improved methods; determining a new pricing policy for wood; and establishing a charcoal taxation policy.

Results

8. The Charcoal Stoves component developed a private sector stove production, marketing and retail activity which has accelerated substantially since project launch. During the start-up period of the project (October 1987 - March 1990) when the structure for sustainably producing and marketing improved stoves was being put in place, relatively few stoves were sold: the maximum number per month sold did not exceed 400, except during one month when a stand was organized at a national exposition and sales were about 800 stoves. As of December 1990, monthly private stove sales amount to 1500 - 2000, and overall, an estimated 20,000 improved stoves have been sold so far, comprising 20% - 25% of the total market in Kigali.

9. The stove model selected by households as the most appropriate to Rwandan conditions has provided benefits for all involved in its production, selling, and use. Payback times for households who purchased improved stoves were on the order of less than a month, even though their incremental capital investments were more than 100%. The profits for stove producing artisans, valued in terms of margin per stove produced, were higher for improved stoves than for traditional ones. Improved stoves have become a valued article which could be sold in department stores, whereas traditional stoves are usually sold through neighborhood markets. Surveys showed

that average household charcoal consumption was reduced by 35% for users of improved stoves, 510 gr/person/day for traditional stoves compared to 330 gr/person/day for improved stoves. These figures were identified through laboratory and household tests, and verified by perception surveys.

10. Accumulated charcoal savings were 2335 tonnes from October 1987 to March 1990, but have increased rapidly thereafter: during 1990, total charcoal savings were 4422 tonnes, while 7392 tonnes are projected for 1991. Financial savings in 1990 alone amounted to US$ 0.9 million, compared to the total costs for this component of about US$ 322,000 over 2.5 years. Since charcoal savings ultimately translate into wood savings -- the objective of the project --, these were estimated on the basis of pre-project production methods [1/] at 26,493 tonnes of wood saved up to March 1990. As noted above, however, sales of improved stoves have risen dramatically since that date. As a result, wood savings have increased rapidly and an estimated 55,276 tonnes were saved in 1990 alone. These annual savings are projected to increase by a minimum of 20,000 tonnes for upto the next five years [2/].

11. The Improved Carbonization component of the project has identified socio-economic and technical aspects of improving traditional charcoaling. Approximately 260 traditional charcoalers were trained between August 1987 and March 1990; 60% have continued to use the improved methods in which they were trained. In addition to specific training in the efficient production of charcoal, the maintenance and regeneration of existing woodlots and wood plantations were proposed. A wood pricing policy was identified and proposed to the Government, which included it in the new Forestry Law of 1989. The new pricing policy is based on the principle that the value of wood depends on the nature of the end product, the type of tree, and the distance from the place of production and the largest market for the particular end product.

12. For the same reasons, a charcoal taxation policy was proposed which would facilitate the use of more efficient charcoaling techniques. This proposition recommended two approaches: (i) a high tax (+ 25% of the sales price in the forest, or 60 FRw) to be levied on a bag of charcoal and paid by the transporter at the time he buys it from the traditional charcoaler (of the 60 FRw, 15 FRw stays in the village where the wood was grown and 45 FRw is for the National Forestry Funds); and (ii) a low tax (+12%, or 30 FRw) when it is bought from an improved charcoaler (of the 30 FRw, 25 FRw stays in the village and 5 FRw goes to the National Forestry Funds). In this way, incentives are given to transporters to locate improved charcoalers (MINAGRI know their locations), and to villages to have charcoalers use the improved techniques. Even the surcharge of 25% need not have large implications for the wholesale and retail price of charcoal in Kigali: while it reflects an increase of 11% in the wholesale price level, this could easily be offset by using improved stoves.

1/ i.e. on the basis of traditional charcoaling methods, a methology justified by the fact that in March 1990, only about 5% of the total volume of charcoal was produced with improved techniques.

2/ Additional savings of 20,000 tonnes of wood per year is equivalent to selling 300 improved stoves per month.

13. Measurements showed that improved charcoaling techniques could more than double charcoalers' productivity under actual field conditions, from one bag of charcoal (33 kg) to 2 or more bags per stere of wood (480 kg). In addition, the process of carbonization was shown to be at least 20% faster with the improved techniques, and the quality of charcoal was of higher perceived quality. Finally, use of the improved techniques could enhance the professional/social status of charcoalers.

14. During the period October 1987-March 1990, an estimated 2.5% of total charcoal output was produced with improved techniques, saving an initial 53,490 tonnes of wood. These savings are expected to accelerate rapidly: in 1990 alone, savings were estimated at 27,324 tonnes and are projected to rise by a minimum of 17,500 tonnes per year. The 1990 savings alone and the 1988 through 1990 savings are valued at approximately US$ 207,700 and US$ 406,524 respectively, which compares favorably with total project costs for this component of US$ 322,000.

Follow-up Action and Recommendations and Implications for the Project and Policies

15. On the stoves side, it was decided to transfer responsibilities for production, distribution, sale, etc. to the private sector as quickly as possible. Hence, the project ended its direct involvement in production by mid-1989, and put in place a quality control system to permit easy verification of the quality of the improved stoves produced. Eventually, this responsibility will be transferred to users, who should be the final judges on the quality of the stoves they buy.

16. The quality control system is planned to remain in place for a further transitional period of about one year, (i.e., until May 1991) so as to ensure that the majority of artisans engaged in improved stove production respect the norms originally set by the project. Another follow-up activity to be carried out in the near future is the training of artisans in other cities. This has to be done carefully, as to not induce a massive incremental switch from wood to charcoal, but to make existing usage more efficient.

17. On the carbonization side, now that the technological aspects of improving the charcoaling cycle are clear, a self-sustaining program needs to be put in place. This requires mainly additional assistance in creating associations of professional charcoalers, with access to local credit schemes, as well as directing charcoal production more and more towards the large-scale governmental (pine) plantations in the western parts of the country. Supporting activities will also be undertaken, such as conducting an awareness campaign, implementing a stumpage and/or wood/charcoal taxation policy, and researching carbonization techniques for pinewood and large-scale plantations. Most of these activities will become self-sustaining by the end of the follow-up project in 1992, and any that have not reached that point will be taken over by Ministry of Agriculture.

I. INTRODUCTION

1.1 Rwanda is a small, low income, densely-populated, landlocked country [3/], and its principal energy problems are related to these characteristics. The country is dependent on overland transport routes crossing other countries for almost all of its imports, including petroleum products, resulting in high costs and insecure supply. Its low income forces the country to continue to rely on biomass fuels and reduce energy imports where possible. High population density and rapid population growth are making biomass fuels increasingly scarce, however, and are requiring reforestation efforts to compete for land needed for agricultural production.

1.2 Rwanda depends on three main sources of energy: woodfuels (firewood and charcoal), agricultural by-products, and imported petroleum products (see Table 1.1). Firewood and charcoal combined meet more than 80% of the country's energy needs and the two other energy sources (agricultural residues and petroleum products), close to 9% each. Hydropower, which dominates the public energy sector investment program, makes up the remainder and less than 1% of total energy requirements. Final energy consumption, totalling some 1.1 million TOE (tons of oil equivalent) or approximately 170 kgoe per capita is low, as is commercial energy consumption at 16 kgoe per capita. This can be explained by low per capita income, high petroleum prices and electricity connection costs, the dominance of subsistence agriculture and the small size of the industrial sector. The household sector is by far the single largest energy consumer in the country.

Table 1.1

Total Energy Demand (1987)

	Thousand TOE	Percent
Fuelwood	874.0	78.6
Agricultural by-products	100.0	9.0
Charcoal	30.4	2.7
Peat	0.5	0.0
Petroleum products	97.4	8.8
Electricity	8.9	0.8
Total	1,111.2	100.0

Source: Energy Assessment Report (1990)

1.3 Rwanda has a limited endowment of energy resources (primarily biomass, hydropower, and methane gas). The combination of current demand characteristics, population density and growth rate and the country's landlocked position and topography means that these energy resources are either on the verge of potential depletion or are relatively costly to produce and supply. In the face of these constraints, the Government's declared energy policy places emphasis on: (i) energy self-sufficiency; (ii) regeneration and expansion of the potential for woodfuel production; (iii) improved efficiency in the production of charcoal and the use of woodfuels; (iv) identification of alternative competitive sources of energy such as peat, biogas, etc.; and (v) extension of electricity supplies to rural areas and to cottage industries, and implementing a policy of affordable tariffs. Appropriate energy pricing, reflecting the economic cost of supply and constituting the most important policy instrument to bring about effective demand management, has so far played a modest role in Rwanda.

3/ Area: 26,300 km^2; Gross National Product (1988): $285/capita);
Population (1987): 6.6 million, growth rate: 3.9%
Density: 240 people/km^2.

II. THE ENERGY SECTOR IN RWANDA

Natural Resources

2.1 Rwanda has a total of 436,200 ha of natural forest located in and around three National Parks. In addition, there are 35,200 ha of forestry domains, 44,600 ha of village forests, 149,000 ha of private forests and an approximate total of 655,000 ha of "arborization" [4/]. This is the equivalent of 25% of the country's total land area. As recently as five years ago, arborization as part of a deliberate attempt to improve fuelwood supply was virtually non-existent. Due to initiatives taken by the Direction Générale des Forêts (DGF), and followed up by farmers, arborization is now one of the prime instruments in the efforts to increase wood production. To support the high rate of replanting, Rwanda has a relatively high density of nurseries: approximately one for every 5,000 people.

2.2 Woodfuel (1988) is produced in all prefectures, with quantities varying from a low of 171,000 tons/year, in Kibuye, to a high of 317,000 tons/year, in Kigali. Arborization alone represents 56% of the total national sustainable supply. In essence, this means that Rwandan households get most of their wood from the fields of farmers. The second major source of woodfuels are plantations, which contribute a third of the sustainable supply. This proportion reaches a high of nearly 45% in Ruhengeri, where large plantation efforts have been made during the past 10 years, and is as low as 11% in Kibungo. In absolute terms, the major contribution from plantations stems from the Gitarama prefecture. (Most of) the remainder of the sustainable supply (9%) comes from natural forests, where it is illegal to collect wood.

Current Pattern and Level of Household Energy Consumption

2.3 In primary energy terms, overall household energy consumption is around 983.8 thousand TOE/year (see Tables 2.1 and 2.2), which is 88.5% of the total energy use (See Table 1.1). Of total household energy demand, the share of "modern" fuels, such as kerosene, liquified petroleum gas (LPG), and electricity, is minimal (less than 2%). Electric power obtained from the grid is manly available in urban areas; in rural areas most electricity consumption is based on dry-cell batteries for torches and radios.

2.4 Household energy demand is dominated by cooking. Household energy is also consumed to a limited extent (estimated at under 10% for ironing, lighting, refrigeration, and for use of various appliances (radios, tape recorders, etc.). As in most African countries, the final fuel used for cooking is largely determined by the user's location, with a predominance of charcoal consumption in urban areas and of fuelwood consumption in rural areas. In some of the cooler (mountainous) regions of Rwanda, wood also plays a significant role in home heating.

4/ Defined as the planting of single trees by households on farm lands, homesteads, etc.

Table 2.1

Rwanda 1987 Energy Consumption by Sector (in kTOE)

	Industries		Transport		Services		Households		Total	
Wood	24	2.2%		0.0%	7	0.6%	843	75.9%	874	78.7%
Agresidues							100	9.0%	100	9.0%
Charcoal							30.4	2.7%	30.4	2.7%
Peat	0.4	0.0%					0.1	0.0%	0.5	0.0%
Gasoline			39.1	3.5%		0.0%			39.1	3.5%
Kerosene	0.3	0.0%	0.1	0.0%	0.4	0.0%	8	0.7%	8.8	0.8%
Diesel	0.8	0.1%	35.1	3.2%	1	0.1%	0.1	0.0%	37	3.3%
Fuel oil	11.3	1.0%							11.3	1.0%
LPG							0.2	0.0%	0.2	0.0%
Methane gas	1	0.1%							1	0.1%
Electricity	3.1	0.3%			3.8	0.3%	2	0.2%	8.9	0.8%
Total	40.9	3.7%	74.3	6.7%	12.2	1.1%	983.8	88.5%	1111.2	100.0%

Percentages of total consumption
Source: Draft Energy Assessment Update (1990)

Table 2.2

Household Energy Consumption (1987) - End-Use

	Electricity	Kerosene	LPG	Agri by-products	Wood	Charcoal	Peat	Total
Unit	MWh	'000s tons						
Urban	23,773	8.1	0.2			40.0	0.5	
Rural	48	0.1		300	2,213			
TOTAL	23,821	8.2	0.2	300	2,213	40.0	0.5	
Unit	'000s GJ							
Urban	86	339	11	0	0	1,200	6	1,642
Rural	0	3	0	4,200	35,408	0	0	39,611
Total	86	342	11	4,200	35,408	1,200	6	41,253
Total (kTOE)	2.0	8.0	0.2	100	843	30.4	0.1	983.8
Percentage	0.2	0.8	0.0	10.2	85.8	2.9	0.0	100.0

2.5 Table 2.1 shows the energy consumption in Rwanda by sector, while Table 2.2 displays energy end-use data for the household sector only. Data are based on available statistical information, best estimates, and discussions with GOR officials. Fuelwood (76% of primary energy consumption), agricultural residues (9%), and charcoal (14%, but only 3% measured in end-use),

are the major sources of household usage. Although charcoal consumption accounts for only a small percentage of national energy end-use, its production has detrimental effects on the environment for two reasons: charcoal production efficiency is low, and highly commercialized (see Annex III for more details).

Woodfuel Balance

2.6 According to the estimated balance between demand and sustainable supply of woodfuel, nonsustainable national consumption amounted to roughly 500,000 tons or 16% of total demand. Four out of the 10 prefectures recorded a net deficit, the largest in absolute terms being Kigali with 239,000 tons and the largest in relative terms being Ruhengeri (with almost 50% of the demand not being satisfied from resources within that prefecture). Thus, consumption is creating net depletion of tree resources, indicating that corrective action is required.

2.7 The situation threatens to deteriorate in the future. Even at the ambitious pace of reforestation depicted in the Government's "Plan Forestier National", it appears that the gap between demand and sustainable supply will continue to grow. Thus, on the optimistic assumptions of the plan, only 3 out of the 9 prefectures would experience a deficit in year 2002, but the total deficit would be much larger than in 1987 (more than 1 million tons vs 500,000 tons) which would have serious financial/economic and environmental consequences. As an illustration of these consequences, rough calculation shows that the plantation area would have to be increased by 70,000 ha over the period up to the year 2002 (with a productivity of 15 t/ha/year) to make it possible to supply woodfuel on a sustainable basis: this objective is clearly beyond reach under current circumstances. Corrective actions such as demand management, supply enhancement and supply efficiency improvement, etc. should therefore be taken urgently and simultaneously.

Inefficiency of Woodfuel Utilization

2.8 As mentioned earlier, charcoal is the fuel of preference for the urban population. It is slightly more expensive on a useful energy basis (FRw 0.49/MJ_{eff} compared to FRw 0.42/MJ_{eff} for wood), but it offers many advantages: it is a clean fuel, without smoke and stench, which burns without constant supervision; it is less bulky than wood and can more easily be transported and stored; it can be purchased everywhere, and in small quantities; and last but not least, it is considered to be a modern fuel, as compared to wood which is a poor man's fuel.

2.9 The stoves currently used by Rwandan households are inefficient. Woodstoves made of clay or three stones are commonly used in rural areas, are subject to a range of problems of their own, but are not covered by the project (wood stoves are also generally constructed by the user without material costs, and wood fuel is often gathered without direct costs). Charcoal stoves are used in the larger urban areas [5/], are made of recycled metal by specialized artisans, and have a short life time of approximately six months to one year. Because households use two stoves

5/ Approximately 10% of the population.