Report No. 3778-BU

3778

Burundi: Issues and Options in the Energy Sector

June 1982

Report of the Joint UNDP/World Bank Energy Sector Assessment Program

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CURRENCY CONVERSION

US$1.00 = 90.00 BuF (Burundi Franc)

ENERGY CONVERSION FACTORS

TOE = ton of oil equivalent
= 10,500,000 kcal (kilocalories)
= 3940 kWh (kilowatt-hours) electricity and hydro
= about 9.0 m3 of fuelwood
= about 1.5 tons of charcoal
= about 3.5 tons of peat at 35% moisture content
= 0.92 tons = 1240 liters gasoline
= 0.95 tons = 1210 liters kerosene
= 0.99 tons = 1150 liters gas and fuel oil

This report is based on the findings of an energy assessment mission comprising Mr. D. Hughart (Energy Economist), Ms. C. Tobias (Consultant), and Mr. C. H. A. Killoran (Senior Power Engineer), who visited Burundi in April and May, 1981. Ms. S. Baile (Researcher) assisted in the report's preparation and secretarial assistance was provided by Ms. Linne Toehl.

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BURUNDI

ISSUES AND OPTIONS IN THE ENERGY SECTOR

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I. SUMMARY AND RECOMMENDATIONS

Energy Problems

1.01 Burundi confronts a range of problems in the energy sector. The first and most important is the increasing scarcity of the fuelwood and other traditional fuels on which almost all of Burundi's population depends for cooking and other basic energy needs. The extraordinarily high cost of oil imports, now estimated at $100 per barrel, is another, as is the low reliability of supply by any means other than air freight. Together with its neighbors Zaire and Rwanda, Burundi faces the problem of assuring reliable supplies of electric power over the medium and long term, when the capacity of plants that now exist or are under construction in the inter-connected system serving the three countries is fully exploited.

Energy in the Economy

1.02 Burundi is a small, landlocked country of 27,820 km2 in central Africa. Ninety-five percent of the population of about 4.2 million lives on isolated farms in rural areas, engaged primarily in subsistence agriculture and small-scale coffee cultivation. Burundi has traditionally had adequate rainfall for crop raising, but with increases in population density have come reductions in fallow periods and an increasing use of crop residues as fuel rather than mulch, which have combined to decrease the soil quality of agricultural lands. Population density overall is about 150 inhabitants per km2, but reaches over 350 even in some primarily agricultural areas. About 140,000 people (70% of the total urban population) live in Bujumbura, the capital city, located on Lake Tanganyika.

1.03 Coffee exports comprise 90% of total merchandise exports and Burundi's external current account balance is therefore heavily influenced by fluctuations in coffee prices and volume. In 1976 and 1977, it registered a surplus, but between 1978 and 1980 the deficit has increased each year due in part to falling coffee prices but also to increasing imports. In 1980, the external current account deficit was equivalent to about 10% of GDP, and it is expected to increase during the next few years. Petroleum product imports have accounted for about 16% of total merchandise imports (c.i.f. basis) in recent years, which is about three times the 1975 proportion but still much below their share in many other developing countries.

1.04 Nearly all of the energy consumed in Burundi is in the form of woodfuels or agricultural residues. Most of these fuels are gathered rather than sold, and although consumption data are not yet available, annual consumption per capita is at least 0.5 m3 fuel wood equivalent, and traditional fuel consumption accounts for at least 90% and perhaps over 95% of the total energy consumed. 1/

1.05 Table 1.1 shows the estimated commercial energy balances for the years 1973-1980. The table shows that 75% of Burundi's commercial energy needs are met by petroleum products, while electricity accounts for about 23% and peat about 2%. The overall growth in apparent commercial energy consumption during the 1973-1980 period was about 9.0% p.a. The growth rate appears to have accelerated from 4.8% p.a. in 1973-77 to 14.9% p.a. in 1977-80, but part of this increase is probably accounted for by petroleum inventory changes. The acceleration in electricity consumption (from 5.6% p.a. to 10.6% p.a. in the same two periods) was also pronounced, however. Economic growth as measured by GDP slowed in the meanwhile from about 4.7% p.a. in 1973-77 to 4.2% p.a. in 1977-80.

1.06 Reliable data on energy consumption and output by economic sector are not available and therefore neither an analysis of the very high 1977-80 growth rates nor of whether they are likely to continue can be made.

1.07 Commercial energy consumption per capita and per unit GNP is lower in Burundi than in almost any other country, and, as Table 1.2 shows, is only about one-third the average for other contries similar in size and income level. This is owing partly to the relatively high cost of fuel imports imposed by the country's geographic position and partly to the low energy intensity of its productive sectors.

1.08 As illustrated in Figure 1.1, there are very strong associations between specific sources of energy and specific categories of energy demand in Burundi's economy, and weak links among the sources or among the users. Most of the population uses firewood, charcoal and agricultural residues for cooking and other household energy needs and, conversely, the bulk of traditional fuels consumption is accounted for by rural households. Oil imports are similarly associated with transportation and construction, while electricity is obtained virtually entirely from imports and used predominately in urban areas for lighting and operating electrical machinery. While a limited amount of interfuel substitution is possible, energy issues in Burundi must really be treated in parallel sub-sectors rather than as an integrated whole. The

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1/ A conservative consumption estimate of .5 m3/person/year gives an annual consumption of about 525,000 TOE for those fuels, or 92% of total energy consumption in 1980. If the amount consumed were 1 m^3/person/year, the total would be 1,050,000 TOE or 96% of total energy consumption in 1980.

Table 1.1

BURUNDI - COMMERCIAL ENERGY BALANCE, 1973-80

(tons oil equivalent)

	1973	1974	1975	1976	1977	1978	1979	1980
PRIMARY PRODUCTION								
Hydro	-	-	-	-	-	-	-	1080
Peat	-	-	-	-	10	510	680	1020
Total					10	510	680	2100
IMPORTS								
Gasoline	9800	13500	10100	12700	12890	15270	13700	18050
Kerosene	3200	2500	1700	1700	1040	1310	1070	910
Diesel & Fuel Oil	6500	9900	7000	9100	9210	12290	11750	16300
(Subtotal)	(19500)	(25900)	(18800)	(23500)	(23140)	(28870)	(26520)	(35260)
Electricity	5990	6170	6330	6720	7540	8630	9100	10200
	25490	32070	25130	30220	30680	37500	35620	45460
TRANSFORMATION								
Petroleum Products	-370	-370	-340	-340	-340	-400	-400	-470
Electricity	260	260	240	240	240	280	280	330
FINAL CONSUMPTION								
Petroleum Products	19130	25530	18460	23160	22800	28470	26120	34790
Electricity	6250	6430	6570	6960	7780	8910	9380	11610
Peat	-	-	-	-	10	510	680	1020
Total	25380	31960	25030	29120	30590	37890	36180	47420

Sources: Ministry of Commerce and Industry.
Banque de la Republique du Burundi
Bank, IMF, and USAID estimates.

Notes: Ton of oil equivalent taken as 10.5 million kcal.
Electricity converted at 2666 kcal/kWh.
Thermal generation assumed to require 3800 kcal/kWh.
Stock changes included in consumption.
Traditional fuels excluded since only very rough estimates based on presumed annual population could be provided.

Table 1.2

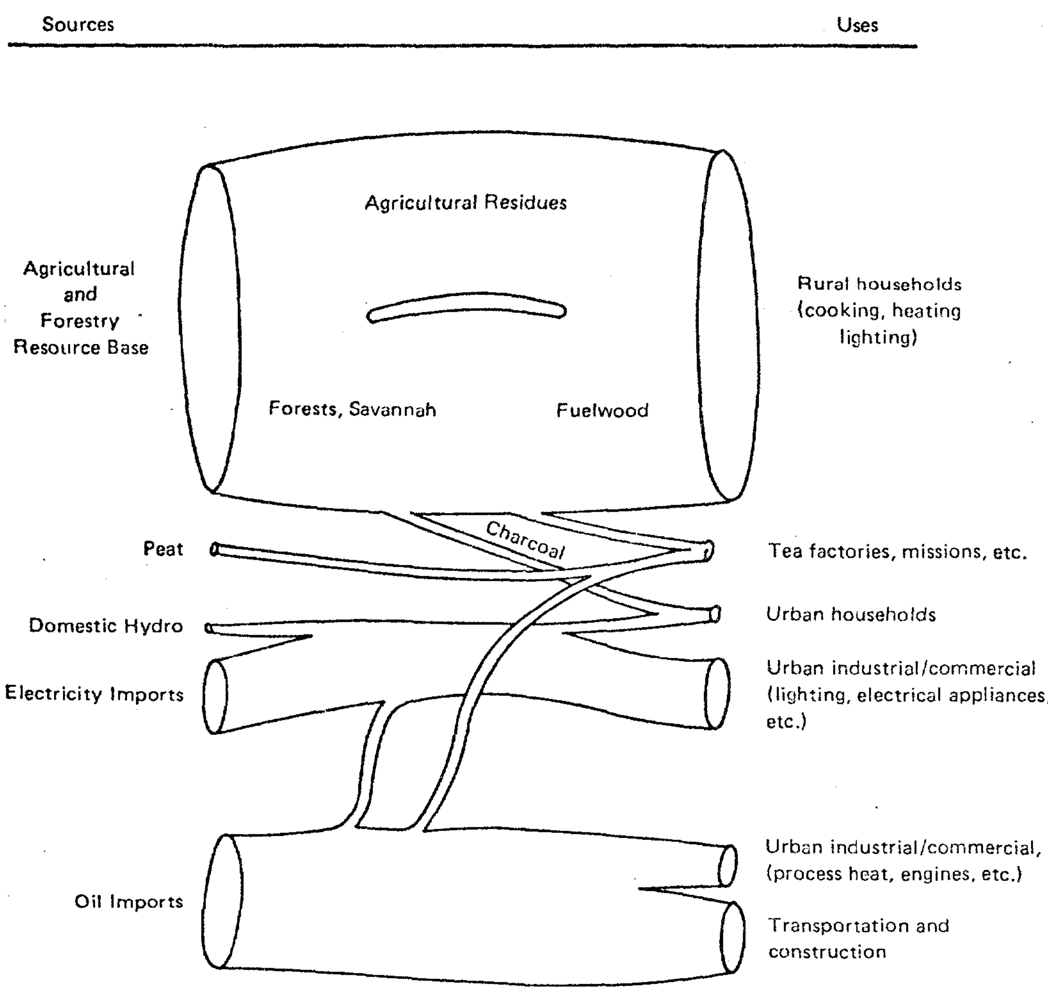
(BURUNDI) INTERNATIONAL COMPARISONS OF COMMERCIAL ENERGY CONSUMPTION, 1978

	Population (millions)	GNP/Capita ($)	Energy Consumption (mn, kg, o.e.)	(kg, o.e./cap.)	kg, o.e./$GNP	(% Petroleum)
BURUNDI	3.9	160	38	10	0.06	(77)
Chad	4.3	150	64	15	0.10	(100)
Upper Volta	5.6	160	106	19	0.12	(100)
Malawi	5.7	180	239	42	0.23	(49)
Rwanda	4.5	190	57	13	0.07	(73)
Benin	3.3	230	137	42	0.19	(88)
Sierra Leone	3.3	230	259	78	0.35	(100)
(unweighted avg.)	(4.5)	(190)	(144)	(34)	(18)	(85)

Note: Burundi's GNP per capita in 1980 is estimated at $200. Comparators are countries whose populations and per capita GNPs are between 67% and 150% of Burundi's.
kg, o.e. = kg oil equivalent = 10,500 kcal.

Source: Table 1.1, World Bank Atlas and Data Files.

**Figure 1.1: Energy Flows in Burundi
(not to scale)**



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structure of this report follows this approach, with separate chapters covering the sources and uses of firewood and peat, oil products and electricity. Moreover, efforts to strengthen Burundi's energy planning capability must also be concentrated at the sub-sector level rather than by establishing an overall energy planning unit.

1.09 It is worth emphasizing that while it is more convenient to label the energy sub-sectors according to form of energy involved or the source of supply than by the set of energy demands with which they are associated, this does not imply that energy supply policy issues are more important than those related to energy demand. In the fuelwood and peat (or "rural household cooking, heating, and lighting") sub-sector in particular, efforts to improve the efficiency with which energy is used may prove to have a higher and faster return than efforts to increase supply.

Woodfuels

1.10 The principal issue in the fuelwood sector is how to deal with the rapidly dwindling supply. Current or planned reforestation projects, overseen by the Director of Waters and Forests in the Ministry of Agriculture, appear to be doing as much tree planting as is possible with the available financial and manpower resources. Therefore, the mission recommends that attention be given to other issues, namely the shortage of trained Burundi foresters, the weaknesses of the forestry extension program, the lack of data on rural household cooking fuel consumption and the need to introduce conservation methods. Since Burundi currently has only one trained local forester, several students should be sent abroad for university level forestry training. A current project already provides for the training of technicians to assist the foresters. A countrywide survey of the household use of firewood and agricultural wastes is in progress. It should provide important data to allow the identification of those areas of the country where forest resources are in shortest supply, to permit the best allocation of the sub-sector's resources. Current forestry extension programs have suffered from a lack of funds which has led to poorly trained and poorly supervised extension workers. Efforts have been made to develop an audio-visual program on tree care for rural farmers which is a good beginning. Well-trained extension workers are needed to teach not only tree care and woodlot management, but also fuel conservation methods. Relatively little has been done thus far to develop and introduce better charcoal production methods or fuel conserving cookstoves. Charcoal producer licensing fee arrangements should be changed to encourage wood conservation, and improved kiln designs should be introduced. Improved cookstoves for firewood and charcoal should be developed and extension workers should assist the local population with their construction and use.

Peat

1.11 Burundi's peat resources are a potential substitute for fuelwood, for small industries and for rural institutions, and perhaps eventually for urban households. ONATOUR, a parastatal under the

Ministry of Mines and Energy, oversees peat development. Over the past two years the assessment and development of Burundi's peat reserves has become much more systematized. A current USAID project is developing production and markets for highland bog peat. The IDA-financed Musongati nickel study will test various techniques for the extraction and processing of peat from the flooded Akanyaru Basin. The principal issue in the peat sector is the uncertainty about the extent of exploitable peat reserves. If peat from the Basin can be economically extracted without causing serious environmental problems, Burundi's exploitable peat reserves will increase from hundreds of thousands to millions of dry tons. A recently discovered bog, Nyamuswaga, might contain up to four million dry tons of peat which could possibly be extracted more easily than that in the Akanyaru bogs. This amount is four times the total content of all the highland bogs combined. Pilot production is to begin in 1982. Additional studies are needed of the potential industrial market and of means of reducing transportation costs.

Petroleum Products

1.12 Burundi has no domestic oil production or refining activities. Geological assessments offer only limited encouragement to further exploration for oil, and limited consumption levels make a refinery inadvisable. The Ministry of Commerce and Transportation supervises petroleum imports. Almost all petroleum products are currently imported into Burundi by truck from Nairobi. A supply interruption occurred during the Uganda war, and a principal issue in this sector is the availability and appropriate scale of strategic petroleum reserves. Another issue is how to deal with the very high cost of imported oil, now about $100 per barrel, including freight but exclusive of taxes, twice what most other countries must pay. Over a third of the cost of Burundi's oil imports is attributable to the differences between (a) the cost of the pipeline-truck transportation route via Nairobi that is now used for most imports and rail-lake transport from Dar es Salaam and (b) Kenya's export price and prices in the open market.

1.13 SEP (Societe' d' Entreposage de Petrole), which is owned jointly by five foreign oil companies, operates petroleum storage facilities near the port at Bujumbura. The Government is constructing an additional storage capacity near Gitega. These tanks will bring Burundi's storage capacity to the equivalent of over eight months of consumption, without counting stocks held by retailers and consumers. Filling this capacity may not be economically justified at this time unless oil is obtainable on concessionary terms or the likelihood of a cutoff in supplies is thought to be high. Moreover, little information is available on the needs of priority sectors, and an allocation system for occasions when there is a supply cutoff has yet to be designed. Priority should be given to developing a suitable plan for stockpiling of products. The costs of building and maintaining reserves should be passed on to the consumers who will benefit from them.

1.14 Burundi is at a disadvantage in bargaining over petroleum prices given the limited number of suppliers and the high cost of transport.

Kenya charges a premium price for exported oil products. However, gasoline and diesel fuel purchased at spot market prices in the Persian/Arab Gulf and shipped to Mombasa would cost about $14 per barrel less than the Kenyan export price. Another alternative might be for Burundi to purchase oil in international markets, especially in the Middle East, and bring it across Tanzania.

Electricity

1.15 Currently, 95% of the electrical power consumed in Burundi is imported from Rusizi I in Zaire to Bujumbura. Burundi has substantial hydropower potential which it would like to develop to decrease its dependence on foreign sources. Two 2 MW units of an 8 MW Chinese-financed hydroelectric plant were completed in January, 1982. Several smaller plants are also under construction, and the Government has arranged funding for an 18 MW plant at Rwegura. In addition, the Government has decided to participate in the Rusizi II project jointly with Rwanda and Zaire.

1.16 The principal issue in this sector is the appropriate development in indigenous power resources in view of possible investments elsewhere in the region. Electricity produced at Rwegura would cost about BuF 17 per kWh (in 1982 prices) which is on the high side. REGIDESO, under the Ministry of Mines and Energy, has primary responsibility for the power sector, and the mission recommends that a strong planning unit be established within REGIDESO to draw up and implement an overall power sector development plan, to set priorities and to determine when and how the available sites should be developed. In addition, the regional organization, EGL, needs assistance in formulating regional strategies and ensuring that member countries are not put in vulnerable positions.

Other Energy Sources

1.17 With the possibly significant exceptions of solar water heating for the brewery and textile mill, other energy sources such as solar, biogas and wind seem to offer no substantial, practical substitute for current energy sources at the present time. The mission therefore considers that major investment in alternative energy resources, primarily solar, biogas and wind, should not be considered until there is an analysis of these industrial applications and other potential markets. Limited experimentation with solar and biogas should, however, continue and may provide energy for some rural institutions. Producer gas might be able to substitute for some liquid fuels if a suitable raw material other than wood can be found. If the Nyamuswaga bog can be economically exploited, that peat could perhaps be used in gasifiers.

1.18 CRUEA (Centre de Recherche des Utilisation des Energies Alternatives) was organized at the Science Faculty at the University of Burundi to develop alternative energy resources. It has only a small regular budget supplemented by donations from outside. So far its work has concentrated on hardware development with inadequate attention given to the socio-economic characteristics of the potential market. The mission recommends that CRUEA's work focus on areas which are likely to provide practical solutions to the country's energy problems.

II. WOODFUELS

Supply and Demand

2.01 Burundi's already scarce forest resources are dwindling rapidly. One estimate 1/ is that even with all of the current reforestation work, tree cover could be reduced to 40% of present levels by 1990 and wood production could decline to only 124,000 m^3/year, which would be far too low to meet the expected demand.

2.02 Natural forests comprise the remnants of dense montane tropical forest along the Zaire/Nile crestline in the northwest (about 40,000 ha), small areas of savannah woodland (15,000-20,000 ha) in the south, and forest galleries along water courses and in steep gorges. These forests have not been managed for maximum yields, due in part to the absence of trained local foresters, and their increment is low, about 1 m^3/ha/year. In addition, it is estimated that there are 25,000 ha of forest plantations, mainly Eucalyptus, as well as roadside trees and small woodlots. The average annual increment of plantations is about 10 m3/ha. The total annual forest increment is about 310,000 m3, including both natural and planted forests. Wood supply from roadside trees and small woodlots is not known precisely. Total increment appears to be far below the conservative consumption estimate of 1 million m3/year. Forest plantations would have to cover at least 100,000 ha if they were to meet even the most conservatively estimated demand.

2.03 Accurate data on firewood use in rural areas, where 95 percent of the population resides, are unavailable 2/. Estimates of average annual wood consumption per capita range from .25 m3/year to 1 m3/year. Given Burundi's population of about 4.2 million, this would place total wood consumption at between 1.0 million m3/year and 4.5 million m3/year. Actual consumption is likely to be closer to the low end of the range, given what is known about supply. Total marketed firewood has been estimated at 156,000 m^3/year 3/, but most firewood is gathered, not marketed. Marketed firewood supplies the principal towns and rural institutions, such as missions and hospitals, and rural industries, such as tea factories.

2.04 In urban areas, per capita consumption (accounting for charcoal in terms of the wood used to produce it) is estimated to be much higher,

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1/ USAID Bururi Forest Paper Project, 1981.

2/ The current IDA forestry project includes a sample survey in progress which will provide data on use of wood and agricultural wastes in rural households.

3/ "Burundi Rapport Sur le Sous-Secteur Forestier" by M. J. G. Devitt, 1977.

due to the unavailability of alternative fuels like agricultural wastes, the inefficiency of charcoal production, and the higher cash incomes. Charcoal is the principal cooking fuel of the low and middle income groups in Bujumbura. A recent survey 1/ showed that 87% of the households used charcoal as the principal cooking fuel. Most of the rest cook with firewood. Most of those surveyed in Bujumbura purchased the fuel they used for cooking, whether they were charcoal users or firewood users. The amount spent per month per person on charcoal for cooking was about 240 BuF. This is equivalent to about 10 to 15% of the amount spent on food. Total annual charcoal consumption for Bujumbura can be estimated at roughly 20,000 metric tons/year or the amount produced from about 200-300,000 m^3/year 2/ of wood. Bujumbura accounts for about 3.5% of the total population, but from 6 to 25% of total consumption of fuelwood depending on which average yearly consumption estimates is used -- .25 m^3 or 1 m^3.

2.05 The fuelwood scarcity has direct impact on food crop production, since the rural population is increasingly using agricultural residues to meet their fuel needs. In some cases, agricultural wastes are the primary fuel. This reduces soil fertility and crop yields which in turn increases pressure on land, and leads to shortened fallow periods, creating a cycle of soil degradation and falling production. The wood shortage has also affected the urban population, as charcoal prices increased from around 150 BuF/sack in 1970 to about 650 in 1980. This 333% increase compares with a less than 200% increase in the consumer price index for that period.

Institutions

2.06 The Forestry Department is under the Ministry of Agriculture. The Director of Forestry also deals with fisheries and wildlife. Forestry development has had low priority in budget allocation planning; protection programs have until recently been small and ineffective and Burundi has only one trained forester. The parastatal National Wood Bureau operates a sawmill and imports building wood.

2.07 A survey of wood use in Burundi is currently underway. It will provide essential data for planning the development of the forestry and fuelwood sectors. The survey will measure both urban and rural wood consumption for all purposes. A rural household sample survey will collect information on consumption of both firewood and agricultural

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1/ C. Tobias, "Household Cooking Practices and Fuel Use in Bujumbura", 1980. The survey included a random sample of 121 households at three income levels in Buyenzi, Ngagara, Nyakabiga and Zinama zones.

2/ Based on average monthly consumption of 12 kg per capita. This is a very rough estimate and could be too low since lower income households were disproportionately represented in the sample survey.

wastes. Once consumption patterns are known, it should be possible to set priorities for forestry and conservation projects on a regional basis.

2.08 The extension program in the forestry sector has been very limited. Although efforts are being made to strengthen that program, additional financing will be required to make a significant impact. Training and supervision of extension workers is generally inadequate. Little effort has been made thus far to teach the rural population to plant and manage woodlots, or how to conserve fuel when cooking. An audio-visual program consisting of a series of drawings accompanied by recorded training cassettes has been developed as a teaching aid on tree care, but only one copy has been made and it has not been used very extensively.

Forestry Extension

2.09 The seriousness of the fuelwood crisis in Burundi will of necessity make itself increasingly evident to the population over the coming years as more and more time must be devoted to gathering firewood and purchased fuel becomes more and more expensive. However, a well-designed extension program to teach people how to plant and care for woodlots, and to use more fuel-efficient cookstoves, could help diminish the effects of the crisis. There is a serious need for well-trained, well-supervised extension workers in Burundi. It is not essential that they be university-trained; in fact, such training may be counterproductive. Rather they must have a good basic understanding of the problems and potential solutions which are appropriate for local conditions. Students should be selected from the collines, and training should take place as near to their work sites as possible, with the understanding that their work is in the field and not in the cities. Current "moniteurs" (low level forestry employees) will need retraining. An increase in the budget of the Forestry Department will be required to allow adequate training and supervision. Well-trained and supervised extension workers could assist the rural population with energy efficient cookstove construction, woodlot preparation and care, and could help create an awareness both of the seriousness of the problem and of ways to decrease its impact on them.

Current Forestry Projects

2.10 A number of forestry projects are currently in progress in Burundi. Belgium and Saudi Arabia are co-financing a 12,000 ha reforestation project in Mugamba-Bututsi, in south-central Burundi. The European Development Fund will finance the reforestation of 3200 ha at Mumirwa and 6000 ha near Gihofi. The French Fonds d'Aide et de Cooperation is financing the planting of a 500-ha protection belt around the Zaire-Nile crestline in northern Burundi. An IDA project is financing a 2000-ha plantation near Bujumbura and 5000 ha near Vyanda, as well as 30 nurseries to produce seedlings for sale to communes and individuals and studies and technical assistance to strengthen forestry planning and the Forestry Department. Three IDA Rural Development projects also have forestry components, and FAO-UNDP will train 35 forestry technicians. Most of these projects have a regional rather than a sectoral focus, and they generally concentrate on tree planting rather than on extension work, conservation programs and training.

Fuelwood Conservation

2.11 Programs to improve the efficiency with which fuelwood is used can, in principle, conserve fuelwood much more cheaply than it can be produced by tree-planting projects. Relatively little has been done thus far in Burundi to develop and introduce better charcoal production methods or fuel conserving stoves for firewood or charcoal. Some current projects, including the IDA forestry projects, have, however, begun to address the issue.

2.12 Charcoal is produced primarily by small-scale entrepreneurs, who cut trees and make the charcoal in nearby earthen pits. Yields by this method are very low. A modern efficient kiln, which could utilize gases and liquids formed during the charcoal production process, could theoretically increase overall energy efficiency to about 80%. However, an imported steel kiln might not be appropriate in the Burundian context, and in any case it would be difficult to transport and use the by-products of charcoal production 1/. A simpler, less expensive improved kiln can provide 40 percent energy efficiency. A masonry kiln should be tested as should other models made of local materials 2/. At the present time, there is little incentive for Burundi's small-scale charcoal producers to invest in more efficient but more expensive kilns to conserve wood. Charcoal permits are issued for production of a specific number of sacks (27,000 BuF for 900 sacks currently). If permits were instead issued to produce charcoal from a specified forest area, producers would have an incentive to conserve wood by seeking more efficient methods. Once this incentive were set up, the task would then be to develop a kiln suitable for the Burundian charcoal makers. Some of them should participate in the selection and testing of various kiln models.

2.13 The typical cooking method with firewood consists of an open fire surrounded by three rocks, a very energy inefficient method. Enclosing the fire, regulating airflow into the stove and adding a chimney could increase efficiency by a factor of two. Various stove models have been developed which are low in cost and utilize available local materials. A large clay mass stove, known as the Lorena, is

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1 Three metal kilns were ordered in 1981 by the IDA-financed Forestry Project and their use should provide useful information on the potential for improved kilns.

2/ One such kiln was developed by Jos Mabonga-Mwisaka (Uganda) and could be tested in Burundi.

relatively sophisticated, yet can still be built for around $10. It is built of a clay-sand mixture and has dampers to control airflow. The chimney can be made of bamboo, bricks, metal, etc. The simplest improved cookstove is little more than a wall of clay to enclose the fire and focus heat into the cooking pot, with a small opening for a chimney.

2.14 The problems involved in any improved cookstove project are socio-economic and organizational as well as technical. Good extension work is crucial for the success of a stove dissemination project. An improved cookstove can be accepted and used if there is intensive field work to develop a model suitable for local conditions, heighten public interest and resolve day-to-day problems with stove use. Annex I outlines a pilot project designed to test the potential of the stove improvement approach. The first step is to do a household sample survey to evaluate current cooking and fuel use practices. Next this information is utilized in conjunction with technical designs of improved cookstoves to develop a model suitable for local conditions 1/. It is then field-tested. Almost daily interaction with the households testing the stoves is required for several weeks to detect problems early, and make appropriate design modifications 2/. A large scale stove dissemination project would require well-trained extension workers to carry out this necessary follow-up.

2.15 In rural areas it might be necessary for extension workers to go from colline to colline 3/ to demonstrate the stoves since there are no established villages. A model developed for Bujumbura would not necessarily be suitable for rural areas, where people cook with open fires. The open fires provide some light in the house and the smoke acts as an insect deterrent. Rural people should be directly involved in the development of a stove model designed to meet their specific needs, and constructed of locally available materials, primarily clay, at little or no cost.

2.16 Charcoal is currently used in Bujumbura in a small open grill of thin metal, called an imbabura, and much heat is lost both by conduction and by radiation. Charcoal grills can be improved simply and at very low

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1/ Prototype stores are being developed in Burundi by AIDR under control to the IDA-financed Forestry Project.

2/ This procedure proved successful on the USAID peat stove pilot project in 1980.

3/ Literally, hill. In Burundi, extended family units reside in compounds called rugos located on the hillsides. Each hill or colline is likely to have several rugos. Part of the family's farmland is located near the rugo. The collines are not like villages, and they are not officially recognized administrative units. The smallest recognized unit is the commune of which there are 79 in the country.

cost. One way is to make a double-walled stove and fill the space between the walls with clay, sand or pebbles which serve as insulation. If the design of the current imbabura were changed only slightly to focus the heat on the pot instead of allowing it to be lost by radiation out the sides, a greater fuel efficiency could be obtained.

2.17 An adapted metal charcoal stove might be successful in Bujumbura if the price is right (the average cost of the current imbabura is about 125 BuF1/), and it can be clearly demonstrated that the stoves are convenient and use less charcoal. A variety of models should be field-tested to determine which one(s) are best liked by local cooks. It might then be possible to introduce the improved stove on a large scale using local stove makers and sellers, with a smaller group of extension workers who will identify and help resolve problems with the new stove.

1/ Tobias survey mentioned above, 1980.

III. PEAT

3.01 Peat is a potential substitute for firewood for institutions and some small industries, and may also be developed as a household fuel. Although the proven resources are substantial, the exact extent of the exploitable peat reserves in Burundi is not presently known because not all the known bogs have been thoroughly surveyed and production problems may make the greater part of the resources unavailable or prohibitively expensive.

3.02 Burundi's major peat resources lie in an area known as the Akanyaru Basin (or Gran Marais) in the northern part of the country on the border with Rwanda. Recent estimates of the amount of peat in the basin range from 100-200 million tons to 1.5 billion tons. 1/2/ However, the peat is colloidal and the area is flooded or very swampy throughout the year, posing serious problems for extraction. In addition, there are several smaller highland peat deposits located in swampy valley along the Zaire-Nile crestline which are already in production. Estimates are that about one million tons exist in those areas. Another bog of four million tons was recently located east of Ngozi at Nyamuswaga. It will be considered separately due to its size.

Akanyaru River Basin

3.03 The full extent of the Akanyaru reserves is unknown since they are underwater and floating vegetation often makes exploration difficult, but the three valleys of Buyongwe, Ndurumu and Kirundo have about 30% of the peat in the Akanyaru and are drier than most of the peat-bearing areas within the basin. The quality is similar to Finnish peat, but the average ash content is higher, about 10 percent, although still within acceptable limits 3/. Manual extraction of this peat is not feasible because most of it is below the water table, but several methods are available for "hydraulic" peat mining, or extracting peat in the form of a slurry which would have a moisture content of 94 to 97 percent, depending on the technology chosen. The moisture content can be reduced by air drying to 30 percent, and mechanically compressing the dry peat

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1/ The low end is an estimate provided by the Irish survey team in 1979 and reported in Burundi Alternative Energy-Peat II. USAID, August 1980. The higher estimate is by EKONO, a Finnish consulting firm. It is difficult to determine the exact extent of the submerged Akanyaru reserves.

2/ Peat is conventionally measured by weight adjusted to a 35% moisture content basis. On this basis, its calorific value per unit weight is 25-30% of that of oil, so a ton of peat at 35% moisture has about the calorific value of two barrels of oil.

3/ EKONO sets 15% as the upper limit.

into pellets would reduce the moisture content to 25 percent. High temperature, high pressure processes can further upgrade the peat, but are not currently feasible for Burundi 1/. The scale of hydraulic peat mining operations requires a substantial market: the studies to date have been connected to a nickel project under consideration at Musongati, 160 km to the south. The EKONO study suggests that this project use peat from the Buyongwe bog, which can provide about 100 million tons of peat slurry containing 6% dry solids. Ndurumu bog is proposed as a potential backup and could double the amount of peat available for the project. Depending on the methods chosen for peat and nickel processing, the Buyongwe supply could last 8 to 29 years. An EKONO estimate that may be overly optimistic indicates that the cost of dredging, air drying and shipping peat in the loose, uncompacted state to Musongati would be $55.90/ton. Transport accounts for almost 30% of the price in the EKONO estimate.

3.04 Unanswered questions remain about the environmental effects of large-scale exploitation of the Akanyaru peat resources. It is not known whether the bogs can be drained without causing serious damage to the surrounding area, which includes densely populated farmland, or downstream areas, including parts of Rwanda.

Highland Peat Bogs

3.05 Resources in the highland bogs, excluding Nyamuswaga, are estimated to be slightly over one million tons. Five bog sites, Kishubi, Kitanga, Nyacijima, Kashiro and Kurunyange, have proven reserves of over 718,000 tons2/. The quality of the peat varies from bog to bog and even from area to area in the same bog. Ash content ranges from 15-40%. This peat cannot be clean cut due to the variation in quality. Instead it must be macerated, a process which mixes peat found at different levels to produce a uniform quality sod. Thus far, this process, and the forming of peat into sods or bricks for drying, has all been done manually. However, this does not appear practical for large-scale

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1/ A discussion of other methods for processing peat, some still in the experimental stage, can be found in the EKONO report. A report by Professor Bertel Myreen of JP-Energy Oy, Helsinki, discusses the wet carbonization process. That process, which is still in the experimental stage, would appear to produce high quality peat fuel, but at very high cost. Effluents produced by the process can cause major environmental damage if not properly treated. The energy yield of this process is predicted to be about 72%. A small amount of electricity from another source is required, but most of the electricity used can be generated at the processing plant by a back-pressure turbogenerator. This is the only process which uses anything but sun or air to dry the peat, which has been considered for Burundi. It does not appear recommendable.

2/ Burundi Alternative Energy - Peat II, USAID 1980.

production. The USAID project will test semi-automatic machines which will macerate the peat and form it into peat sods for drying 1/. A 12 ton fully automatic machine was to be tested in 1981 or 1982.

3.06 Most of the highland bogs are located in areas where all available land is used for cultivation. Boglands are especially suitable for dry season cultivation due to the water retention properties of peat. Adequate provision must be made for the farmers who are displaced during peat extraction operations. A layer of peat about 1.5 m in depth should remain after peat extraction is completed so that the bogs can be used for cultivation again.

Nyamuswaga Bog

3.07 Nyamuswaga bog may have four million tons of peat. The overall ash content is 17.1 percent -- in the high acceptable range -- but the standard deviation is large. Drainage problems at this bog will be very complex due to its size and a hydrological survey should be done in the near future to determine if and how the bog can be exploited. Draining the bog could seriously affect its capacity to store water which could lead to flood damage in case of heavy rain 2/. It appears likely that drainage should be carried out very slowly (at 1 m/year) to avoid disturbing the equilibrium of the bog 3/. The hydrological survey should make specific drainage pattern recommendations.

3.08 Nyamuswaga peat is located at a considerable distance from Bujumbura and transport costs may make it too costly for that market. Alternative potential markets should be analyzed to determine the economic feasibility of production at this bog. The possibility of producing briquettes near the bog site should be considered as a way to reduce transport costs.

3.09 Only 10% of this bog is currently under cultivation, but this may soon increase due to the high population density in nearby areas. This makes it essential to carry out the necessary studies as soon as possible. If the bog can be economically exploited now, it should be, while it is still possible to avoid disruption of cultivation and accompanying hardship for farmers.

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1 The USAID report contains a discussion of various types of machinery suitable for extraction and processing of peat from the highland bogs.

2/ One bog site, Kivogero, had to be abandoned due to damage caused by flooding which was partly due to improperly constructed drainage channels.

3/ See Justin McCarthy "Danida Prospection Project - Final Report", March 1981.

Potential Production

3.10 The development of the peat industry in Burundi depends on the results of the studies of the Nyamuswaga and Akanyaru Basin reserves. If only the highland bogs can be brought into production, then annual production would peak at 59,000 tons in 1990 and decline thereafter, falling to 42,000 by the year 2000. If Nyamuswaga bog, which has four times as much peat as all the highland bogs combined, were brought into production, both annual and total production could be substantially increased. Hydrological surveys have been undertaken, and pilot production with equipment capable of producing 6,000 tons per year is slated. If the Akanyaru reserves can be used, then the situation changes drastically. An annual production in excess of one million tons could be reached.

3.11 Consumption of peat thus far has been very limited due to the small amount produced. Table 3.1 shows sales for 1977-79. The Burundi army purchases 80% of all peat sold. Ten percent is sold to small brickmaking operations and to a bakery in Bujumbura. The remainder goes to missions located near the bog sites. In 1980 about 3,000 tons of peat were produced. Production in 1981 was about 6000 tons and is expected to reach 10,000 tons in 1982.

3.12 The potential market for peat is large, but projections of consumption are highly speculative. The USAID-financed Peat II Project is oriented exclcusively toward household users. The household market will require the greatest investment of time and resources to develop because it involves a change in cooking fuel in literally thousands of households. That market should probably not be developed unless the amount of exploitable peat reserves increases significantly. It should be easier to develop the institutional and industrial markets. The institutional market is projected to expand to include schools, hospitals and prisons, as well as a larger military market. Currently the army is the largest consumer of peat, but it is obliged to buy it. The industrial market will be a milk factory (AKIRAMATA), and two tea processing factories under construction. The EDF (European Development Fund) provided assistance for developing the Kigozi bog which will supply the EDF-financed tea factories. In exchange ONATOUR agreed to supply them with 4,600 tons of peat per year for 20 years. The COTIBU textile plant has indicated an interest in obtaining 22,000 tons per year of peat, and the projected brick factory and lime kiln may each be able to use 3,000 tons annually. Some firewood users have converted to peat and liked it, but found it was not always available. Others were not trained in how to use it and found that the peat damaged their ovens. The artisanal/commercial market includes bakeries, restaurants and possibly hotels, as well as brickmaking operations and lime kilns. Brickmakers have been generally happy with results obtained using peat. One restaurant has already had constructed a large clay stove for cooking with peat but ran into technical difficulties.

Table 3.1: Peat Sales 1977-1979

Year	Sales Receipts (Bu F)	Quantity 1/
1977	122,331	37
1978	3,720,230	1,501
1979	6,756,912	2,123

Source: USAID Burundi Alternative Energy-Peat II Project Paper, August 28, 1980.

1/ Unit of measure is not given in the source table. Probably metric tons.

3.13 If exploitable peat reserves expand to include Nyamuswaga then the urban household market should be developed. Peat is currently almost unknown as a household fuel in Burundi. If it is not well dried and properly stacked for burning, it smokes excessively. A low cost stove was developed for household cooking with peat in the summer of 1980 for the USAID peat project. It was a clay stove based on the Lorena model. The peat stove, which can also be used with wood, and with charcoal with minor adaptations, was tested in about 15 households and acceptance was generally good. The stoves were used continuously as long as the cooks had an available supply of peat. Since no small-scale retail marketing network currently exists for peat, and since it is too difficult to transport it from ONATOUR's storage area without a car or truck, stove-owning households wishing to purchase peat after October 1980 were unable to get it.

3.14 The successful introduction of both peat and stoves for household cooking will depend on an effective extension campaign to train both cooks and artisans in proper construction and use techniques for stoves and peat. A distribution network must be set up so that households may purchase a day's supply of peat very close to home, just as they now purchase charcoal. Although rural households may suffer more from the shortage of cooking fuel, it does not appear that they are likely peat users since they have little disposable cash with which to purchase any kind of fuel. The benefit to them will have to come via decreased use of fuelwood for charcoal for urban consumers, thus making more wood available in the countryside.

3.15 The largest potential market for peat in Burundi is the proposed Musongati nickel processing plant, which would require from 300,000 to 1,200,000 tons/year of peat depending on the processing alternatives selected. Peat supplies on this scale would have to come from the Akanyaru Basin.

Institution

3.16 The institution responsible for the peat industry is ONATOUR - Office National de la Tourbe. It was created in 1977 as a planning and coordinating agency for the sector. It has responsibility for all activities relating to the exploration, exploitation and commercialization of peat in the country. It is at present a very small institution and its future development will depend on how much exploitable peat actually exists in Burundi.

3.17 The USAID project is providing expatriate experts to assist in the operation of ONATOUR and to train counterpart staff. Given the scarcity of trained local personnel, it may be difficult to adequately staff ONATOUR, and expatriate staff may actually run the organization without adequately preparing their counterparts to take over management when they depart. However, until studies on the Akanyaru peat and the Nyamuswaga bog are sufficiently advanced that the scope for future peat development in Burundi seems clearer, it may be best to maintain ONATOUR as a small and flexible institution. Burundi cannot afford to have a large number of professionals specialized in peat if exploitable resources turn out to be limited to the current highland bogs. In the short-term, efforts should be focused on establishing good management and accounting practices, and training Burundi staff in their use. Additional technical training should be provided at bog sites. If large-scale production at Akanyaru and Nyamuswaga bogs is found to be feasible, then a corresponding development of ONATOUR would be necessary.

IV. PETROLEUM

4.01 The petroleum sector in Burundi is modest in scope. There is no domestic oil or gas production or refining activity, supply is entirely in the form of imported products. Demand is low, about 45 mn liters per year or 800 barrels per day.1/ The country is not entirely without petroleum exploration potential, but prospects in the limited prospective area are not very encouraging. The major issues in the sector are related to the very high cost of imported oil -- over $100 a barrel -- and the vulnerability of the supply routes to interruption. The government needs to consider measures to:

(a) reduce insofar as possible the prices paid for imports;

(b) prepare contingency plans for dealing with interruptions in supply, and

(c) make more efficient use of oil and exploit opportunities for substituting lower cost domestic or imported energy sources for oil.

Demand and Supply

4.02 Burundi's per capita consumption of oil products, about 11 liters per year, is low even in comparison with other countries at similar per capita income levels. While this primarily reflects unfortunate circumstances, the country's poor access to world markets and lack of a mineral or other resources base for oil-intensive development, it has moderated the effect of recent oil price increases on the national economy. Petroleum products in 1980 accounted for about 15.7% of total merchandise imports (c.i.f. basis), about three times the average for 1975 but still a much lower figure than those of many other countries.

4.03 The product mix of Burundi's oil consumption is heavily weighted toward vehicle fuels, gasoline and gas-oil account for over 90% of the total. The distribution of 1980 imports was as follows:

Premium gasoline	47.3%
Regular gasoline 2/	5.5%
Gas-oil	37.3%
Fuel oil	7.2%
Kerosene	2.6%

1/ For comparison, the Mombasa refinery is designed for a throughput of 95,000 barrels per day.

2/ The low utilization of regular grade gasoline is explained by the high cost of transporting fuel and the lower efficiency of engines burning regular gasoline compared to those using premium or gas-oil.

Not all of the vehicle fuels are used in vehicles; stationary engines and small boilers account for part of the demand. And an estimated 30% of the vehicle fuel consumption is accounted for by road construction contractors.

4.04 The largest single industrial consumer is the brewery, which uses about 2.4 mn liters p.a. or 5% of the nation's oil. The textile plant used about 0.46 mn liters in 1980, but is designed to use 7.2 mn liters p.a. in full production. Fuel oil is used primarily to raise steam in both the brewery and the textile plant, making it easier to replace than vehicle fuels.

4.05 While consumption levels may be low, the unit cost of oil to Burundi is particularly high. Product imports cost about $100 per barrel including freight but exclusive of taxes, or twice what many other countries have to pay. The premium price paid by Burundi reflects its geographic position, primarily through the high cost of the transport routes it requires but also through the disadvantage at which this puts the country in bargaining with a limited number of potential suppliers.

4.06 There are only two surface routes over which large quantities of petroleum products can be imported. The southern route, used for all oil imports through 1977, crosses Tanzania by rail from Dar es Salaam, where there is a refinery, to Kigoma, where oil is transshipped to barges for the trip up Lake Tanganyika to Bujumbura. The northern route began to be used for petroleum products in 1978 when floods and tankcar shortages (possibly related to Tanzania's operations in Uganda) reduced the capacity of the southern route. The northern route has been used for the bulk of petroleum imports since 1979. It runs from the Mombasa refinery by pipeline to Nairobi, where oil is loaded into tank trucks for a 1,500 km journey to Bujumbura via Uganda and Rwanda. Occasionally, products are imported by barge from Zambia.

4.07 Both routes are high cost and make Burundi vulnerable to interruptions in supply due to problems with refineries or transport links in other countries. The cost is particularly high for the northern route, about 25¢US/liter, or $40 per barrel. In addition to the cost of transport itself over this route, Kenya charges a premium price for exported oil products. Gasoline and diesel fuel purchased at spot market prices in the Persian/Arabian Gulf and shipped to Mombasa would cost about 9¢/liter, or $14 per barrel, less than the Kenyan export price.

4.08 Transport costs on the southern route are about a third of those on the northern route. An estimate of southern route costs for general cargo comes to $112/ton (9¢/liter or $14 per barrel of oil), and oil products can presumably be handled at lower costs. Tanzanian pricing policy, however, pushed the delivered cost of gasoline imported via the southern route above that of Kenyan gasoline in the Fall of 1979. Diesel fuel remained cheaper from the southern route than the northern route and for a period oil was imported from both sources. Imports from Tanzania are however limited by the capacity of the Dar es Salaam refinery, and Burundi is substantially reliant on Kenya and the northern route.

4.09 An alternative that Burundi might consider is to purchase refined oil products in international markets and bring it across Tanzania in transit. As Table 4.1 shows, this could reduce Burundi's oil bill by about one-third. Burundi has rights established under a colonial treaty to the use of the ports of Dar es Salaam and Kigoma and the rail line connecting them. In the past these rights have been exercised for general cargo only, but because Tanzania is currently unable to supply Burundi with oil products from its own refinery it may now be a favorable time to bring the matter up in discussions with the Tanzanian Government.

4.10 Consideration has been given to building a pipeline from the Indian Ocean to Burundi and/or Rwanda. However, the analysis given in Annex 3 shows that the only pipeline project in the region worth detailed study would be an extension of the Mombasa-Nairobi pipeline to Kampala, and this would have very limited benefit to Burundi.

4.11 Petroleum prices are regulated according to a complex "cost plus" formula. Table 4.2 shows the current structure of gasoline, kerosene, and diesel fuel prices. Petroleum consumption is not explicitly taxed or subsidized to a major extent in Burundi, but the practice of fixing prices on the basis of the higher of the Kenya and Tanzania bases is, under current conditions, equivalent to a tax on gasoline. The tax content of the final price of gasoline on this basis is about 32% and of diesel fuel about 10%, including a 5 BuF/liter road-user tax. Taxes on household kerosene contribute less than 5% to the retail price. There is a system of cross-subsidization of transport costs within the country, however, so that retail prices are uniform nationwide.

4.12 Petroleum products are imported by five foreign-owned companies. Fina, Mobil, Texaco, Shell and BP. These companies jointly own a sixth, SEP (Societe d'Entreposage de Petrole), which operates petroleum storage facilities near the port of Bujumbura. They are allowed 4.6 BuF/liter (19¢/gallon) margins at the wholesale level (including SEP fees) in a price structure that includes transportation and evaporation losses (from 1% for diesel to 3.5% for gasoline) under separate items. The wholesale margin may be excessive relative to the cost of the services provided, which are largely those of managing the importing and distribution activities and financing stocks and good-in-transit, and should be reviewed. The retail margins, on the other hand, at 2.5 to 2.8 BuF/liter (9.3 to 10.6¢/gallon), depending on the product, appear reasonable and perhaps even low in terms of general level, though their structure (flat rates per liter of each product) may encourage the operation of an excessive number of retail outlets in Bujumbura and an insufficient number in other areas.

Petroleum Stockpiles

4.13 Burundi's vulnerability to interruptions in the two surface routes was demonstrated in the first half of 1979, when the war in Uganda led to both routes being closed simultaneously. The possibility that this situation may recur has led to government concern over the adequacy of Burundi's petroleum stockpiles.

Table 4.1

Burundi: Cost of Principal Petroleum Product Imports, by Source, 1981
(US$ per barrel)

	Mombasa		Dar es Salaam		Open Market[1]	
	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel
ex-Mombasa/Dar es Salaam	64.0	59.7	(140)	(65)	(48)	(48)
Transportation	4.4	3.1			(13)	(14)
ex-Nairobi/Kigoma	68.5	62.9	146.6	72.5	(61)	(62)
Transportation[2]	36.6	35.9	1.3	1.4	1.3	1.4
Transit fees[3]	3.0	2.5	-	-	-	-
c.i.f. Bujumbura	107.9	101.1	147.9	73.9	62.3	63.4

Note: Parenthesized figures are Bank staff estimates. Items may not sum to totals due to rounding errors.

1/ Based on June 1981 spot market prices in Arabian/Persian Gulf market and freight rates.

2/ Includes insurance and evaporation allowance.

3/ Imposed by Uganda and Rwanda.

Table 4.2

Burundi: Price Structure of Key Petroleum Products
(BuF per liter)

		Premium Gasoline	Kerosene	Diesel
1.	Price ex-Nairobi ($/liter)	0.388	0.358	0.366
2.	(BuF/liter)	35.1	32.4	33.1
3.	Transportation	22.1	22.1	22.1
4.	Insurance	0.4	0.3	0.4
5.	Rwandan fees	0.2	0.2	0.2
6.	Evaporation allowance	1.1	0.8	0.6
7.	Sub-total	23.8	23.4	23.3
8.	(Border price)	(58.9)	(55.8)	(56.4)
9.	Import duties, fees	3.8	2.5	1.7
10.	National Highway Fund tax	5.0	0.0	5.0
11.	Leakage allowance	1.0	0.6	0.0
12.	Delivery charges	2.0	2.0	2.0
13.	Wholesale margins	4.6	4.6	4.6
14.	Retail margin	2.8	2.4	2.5
15.	Sub-total	19.2	12.1	15.8
16.	Kenya-based retail price	78.1	67.9	72.2
17.	Kenya-Tanzania base differential	28.9	n.a.a/	n.a.a/
18.	Retail price	107.0	68.1	72.5

Notes: Line 1 = Kenyan prices as of 6 January, 1981. These were raised 3-5¢/liter in February, 1982 but this has not been reflected in Burundi's price-setting. The difference is absorbed by the government through a compensation account.

Line 2 = line 1 at 90.45 BuF/US$
Line 3 = flat rate
Line 4 = Socabu (1.075% of line 2)
Line 5 = Ami Kigali (0.149) and Magerewa (0.100)
Line 6 = 2% (gasoline), 1.5% (kerosene), 1% (diesel) of line 2
Line 7 = lines 3 through 6
Line 8 = line 2 & line 7
Line 9 = BRB-SGS (1% of line 2) plus import duties and "statistical tax"
Line 10 = flat rate
Line 11 = 1.5% (gasoline), 1% (kerosene) of sum of lines 8, 9 and 10
Line 12 = includes 0.70 paid to company and 1.98 to equalization fund
Line 13 = SEP fees (0.1 unloading and 0.5 handling) plus 2.0 general expenses plus 2.0 profit margin
Line 14 = flat rates
Line 15 = lines 9 through 14
Line 16 = line 8 plus line 15
Line 17 = difference between line 16 and similar total based on shipments from Tanzania, if positive
Line 18 = line 16 plus line 17

a/ Discrepancies due to rounding errors.

4.14 Oil storage capacity is currently concentrated in the SEP facility near the port of Bujumbura, which holds about 12.5 million liters (78,000 barrels), or about three months of consumption; at the time of the mission this was reported to be full. Additional storage capacity of about 20 million liters (126,000 barrels) is under construction by the Government near Gitega. Arrangements for filling and maintaining this facility have not yet been made, but at the time of the mission the Government had begun discussions with SEP regarding a management contract and hoped to obtain oil from OPEC countries on concessional terms.

4.15 While it is clearly prudent for Burundi to maintain stocks of critical imported commodities such as oil, it is not clear that a 32 million liter stock (worth about $20 mn at the cost of imports from Kenya) is warranted. Determination of the optimum volume to hold in storage cannot be entirely objective, but it is useful to include in the analysis a comparison of the cost of maintaining stockpiles with the cost of air freight; this is because the risk facing Burundi is not that oil products will become totally unavailable but that they would have to be imported by air.

4.16 Annex 2 presents an analysis based on the assumption that the value of maintaining stockpiles is equal to the savings they can be expected to make on average or over the long run in air-freight costs. On this basis, it does not seem to be worthwhile to build up additional stocks unless there is more than a 15% chance of a cut-off in supplies, starting within six months and continuing beyond three months, the time covered by currently held stocks (assuming that both the stockpiled oil and air-freighted oil would come from Kenya). This level of risk implies, on average, a cut-off about every three and one-half years. If oil for the stockpile could be purchased at "open market" prices and brought by rail across Tanzania, the justification for additional stocks would be a 3.5% chance of a cut-off in six months, a long-run average of one cut-off about every 10 years. These figures and those corresponding to the assumption that air-freighted oil would come from West Africa or an equivalent distance are shown below:

	Source of Air-Freighted Oil	
Source of Stockpiled Oil	Kenya	W. Africa
Kenya	15% (3 1/2 yrs.)	4 1/2% (7 1/2 yrs.)
Open Market	3 1/2% (10 yrs.)	2% (17 yrs.)

Final determination of the appropriate level of stockpiles requires assumptions about the likelihood of supply interruptions of different lengths, but they can at least be used to relate stockpiling decisions to assumptions about the probability of interruptions. They indicate, for example, that substantial additions to the current stockpiles, which are equal to about three and one-half months of normal consumption and could be stretched considerably longer in an emergency, would seem to be justified only by a very pessimistic view (relative to recent experience) of the security of the oil supply lines unless the opportunity arises to obtain them at "open market" prices.

4.17 Careful management of the Gitega stocks will be needed not only to assure proper rotation but also to maintain precautions against fire and theft. SEP appears to have the experience and working relationships with the oil importers and distributors needed to fulfill these functions. Any of the oil companies operating in Burundi, or a newcomer, could also provide competent management, however, and the existence of an independently managed storage facility may make it easier to negotiate with importers for reductions in wholesale margins or for arrangements for handling oil purchased in international markets and brought across Tanzania.

Contingency Planning

4.18 Filling, or partial filling, the Gitega stocks should be preceded by contingency planning for their eventual utilization. While it is impossible to foresee the conditions under which a supply interruption would occur with sufficient precision to prepare a detailed plan, it is easier to make adjustments to a pre-set plan during a crisis than to start with no plan. Contingency planning, because it involves identifying the consumers and consumer groups who would benefit from the existence of the stock, would also be useful in determining how the stockpiles should be financed.

4.19 Contingency planning for a possible interruption in surface transportation might include the following steps:

(1) Definition of the contingency(ies) to be planned for. It is perhaps not necessary to have a precise definition, but planning must be based on assumptions regarding which routes that would be closed and which would remain open, the duration of the closure, the amount of advance warning to be expected, and the likelihood of occurrence.

(2) Identification of key imported commodities. Planning should focus on commodities that are imported over vulnerable routes in substantial quantities and for which domestic alternatives are not readily available.

(3) Identification of key import-dependent activities. The study should provide the basis for decisions about which economic activities should be maintained using stored goods, air freight, or domestic alternatives and which should be curtailed. Final decisions can only be made if and when the need arises and would no doubt be shaped in part by circumstances that cannot be foreseen in a contingency plan, but it should be possible to improve the speed and reduce the arbitrariness of these decisions if information has been gathered in advance on those activities that are most important in terms of import requirements, either in the sense that it is important that they be continued and the imported goods somehow obtained or in the sense that by suspending them an important reduction in import requirements can be obtained at relatively low cost. Elements that might be considered include:

(a) Whether an activity falls within a definition of "essential" services;

(b) value-added, or contribution to GDP;

(c) a short-run measure of economic value that would reflect the low cost of employing people, equipment, and partially completed construction projects which must be paid for in any event and cannot be put to other use and would also reflect the value of completing projects during the period in which transporting routes are blocked;

(d) requirements for imported goods, in tonnage as well as value; and,

(e) linkages to other activities as supplier or market.

(4) Recommendation on Demand Management Strategy. The study should propose a pattern in which it would be assumed for planning purposes that the import-dependent activities identified previously would be continued, reduced, or suspended. It should also indicate what type of rationing or other controls might be needed to obtain this pattern.

(5) Recommendation of Supply Strategy. Estimates of the quantities of key imports needed to sustain the assumed pattern and level of activity should be made. The study should also estimate the costs of alternative means of obtaining these supplies, including air-freight, maintaining stockpiles for this purpose, or using domestic alternatives or using stocks held for activities that would be suspended or reduced during the emergency.

(6) Recommendation of Preparedness Steps. Drawing on the preceding work, the study should summarize recommendations for action that needs to be taken well in advance of an emergency. These could include:

(a) additional freight handling facilities at the airport;

(b) construction of storage facilities, which might either be filled or simply kept ready for use in an emergency; and,

(c) agreements with air cargo operators that could assure faster access and perhaps better terms than could be obtained in an emergency.

Potential Alternatives to Petroleum Product Imports

4.20 Opportunities to develop domestic energy resources as alternatives to petroleum are limited to Burundi, but could help to reduce the country's vulnerability to supply interruptions. The limited petroleum exploration potential that exists in Burundi does not at this point appear to warrant the substantial expense that would be involved in further exploration. The cost, risks, and potential benefits of an exploration program are analyzed in Annex 4. Peat will probably not be available in quantities sufficient to allow significant substitution for oil unless either the Nyamuswaga or Akanyaru bogs can be developed. Peat could most easily be substituted for oil where oil is used to generate steam or process heat; the brewery and textile plant are probably the most important such installations in Burundi, but they account for only about 6% of national oil consumption. Some fraction of vehicle fuel requirements, which constitute well over half of total consumption, might also be met with peat through the use of producer gas generators.

4.21 Fuel import costs might at least be reduced by using coal from the Kalemie deposit in Zaire. The deposit is large (estimated at 50 million tons) and located near a port on Lake Tanganyika. Production reached 0.50 mn tons in 1955, but the local market is now small (primarily a cement plant) and production presently is only about 60 tons per day. The market for coal in Burundi is probably also small, and it may be charcoal that is replaced as much as oil. A preliminary estimate of $40 per ton as the cost of Kalemie coal delivered to Bujumbura has been made in connection with the Musongati nickel study, and comparing this with the price of charcoal (about $150/ton) and oil, it seems likely that a mutually beneficial trade could be developed in the relatively small quantities of coal that could be supplied without major investments in Kalemie. In the longer term, potential investors in the Musongati nickel project may wish to consider Kalemie as an alternative fuel source to peat.

4.22 Electric boilers are being installed at Bukavu, Zaire, but do not appear to be an economic option for baseload use in Burundi. The average cost of electricity from the marginal project over the medium-term (Rusizi II) appears to be about $0.05/kWh, or about $0.65 for the quantity required to produce as much heat as a liter of gas oil, which now wholesales for about $0.76 in Burundi but would cost only about $0.53 if supplies could be obtained on the open market and imported via Tanzania. It may, therefore, be worth considering off-peak use of electricity to generate steam or process heat in dual-fuel installations that would use electricity only when it was in surplus and switch back to oil at other times of the day and/or the year. This type of installation could be useful for utilizing electrical energy that would otherwise have to be wasted due to limitations on hydro storage capacity.

4.23 Solar water heating (or pre-heating) may be an economically viable means of saving on oil consumption by the brewery and textile plant.

V. ELECTRICITY

5.01 Per capita consumption of electric energy in Burundi is among the lowest in the world, about 12 kWh in 1981. Only about 2% of the population has access to electricity. Bujumbura accounts for about 95% of consumption and Gitega the remaining 5%. 1/ Most of the electricity consumed in Burundi is imported from Zaire, so it is not surprising that the government places a high priority on develoment of its own hydropower resources. In addition to existing and planned projects in the 2 to 20 MW range, various isolated minihydro plants (under 1 MW) are currently under construction or in the planning stages at sites selected primarily for their social benefit, near rural clinics and schools. Burundi also has geothermal potential but the costs of development are unlikely to be as low as hydro development in the near future.

5.02 Different organizations are responsible for electric energy distribution in urban and rural areas, the Regie des Distributions d'Eau et d'Electricite (REGIDESO), under the Ministry of Energy, Mines and Public Works, operates in Bujumbura and Gitega and adjacent rural areas, while the Department de l'Hydraulique et de l'Electrification Rurale (DHER), part of the Ministry of Rural Development, is independently developing a number of isolated rural electrification projects. Zaire's Societe National d'Electricite (SNEL) operates the transmission line that delivers most of the power used in Burundi to Bujumbura.

5.03 REGIDESO was formerly a Belgian enterprise. It became a public company in Burundi in October 1968 under the Ministry of Energy, Mines and Public Works with responsibility for the generation, transmissison and distribution of water and electricity and recently sanitation. In May 1981, there were 604 employees in the organization (Annex 5, Table 1) with 193 assigned to the electricity division, 205 assigned to water and 206 employees common to all three divisions (Annex 5, Table 2). The present management is competent to perform its present duties, but considerable strengthening will be reqired in view of the more complex projects now being completed, and the development of the proposed new Rwegura hydroelectric project. The mission recommends that a strong planning unit be established, possibly within REGIDESO, to coordinate the activities of the various agencies involved and to program investments efficiently.

5.04 The DHER was created in 1977 and physical progress on a number of its small hydro projects appears to have overtaken the institutional capacity needed to ensure proper planning, execution, maintenance and operation of these schemes. Locations for installations have been chosen on the basis of population concentration and the existence of social services such as schools, but without explicit economic studies. While

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1/ These figures do not take into account the small amounts of electricity that are produced by privately owned plants.

several of these projects are reportedly nearly in service. the policies that will govern their operation have not yet been defined. Financial and administrative arrangements have yet to be made for the maintenance and operation of the plants now planned and under construction, and a tariff policy that generates a reasonable return on investment is needed both to help finance future projects of this type and to demonstrate that these projects are worth more to their prospective beneficiaries (who currently contribute 10% of project costs) than alternative uses of the funds invested in them. Although proposed projects are verified with REGIDESO for possible conflict with larger projects, the mission considers that there is a need for better integration of REGIDESO and DHER activities in rural electrification. While DHER can continue to take responsibility for isolated projects, the proposed new planning unit in REGIDESO should first ensure that such projects are viable, and DHER should specify its operational and tariff policies.

5.05 Burundi is a member, together with Rwanda and Zaire, of the Communaute Economique des Pays des Grandes Lacs (CEPGL) headquartered in Gisenyi, Rwanda, and its affiliate, L'Energie des Pays des Grands Lacs (EGL), formed specifically to deal with energy matters affecting the three countries and having its offices in Bujumbura. Burundi is also a member of the Organization for the Management and Development of the Kagera River Basin (KBO) made up of Burundi, Rwanda, Uganda and Tanzania to foster development of the Kagera River. Its head office is in Rwanda. Each of these organizations has only a small staff seconded from their respective member governments, and there is a clear need for a strong planning unit to achieve better coordination.

Present Generation and Transmission Facilities

5.06 The main source of electricity for Burundi is the Rusizi hydroelectric generating station constructed by la Societe des Forces Hydroelectriques de l'Est du Congo on the Rusizi River on the border between Rwanda and Zaire at the outlet of Lake Kivu. Two 6.3 MW generators were installed in 1958, and two additional units of 7.8 MW were installed in 1972. This generating station is now operated by Zaire's electric utility, SNEL, and provides power not only to Burundi but to nearby areas of Zaire and to neighboring Rwanda (see map IBRD 15918).

5.07 REGIDESO owns a diesel-driven electric generating station in Bujumbura. The units, installed in the early 1950's, have a rated capacity of 5 MW but can supply only about 2 MW due to the deterioration of the equipment and lack of appropriate maintenance. The Belgian Government has recently provided a grant of about US$1.0 million to repair and rehabilitate the equipment, but difficulty in locating replacement parts is slowing this process, and even after rehabilitation, it is expected that the plant would only be able to operate on a standby basis.

5.08 REGIDESO also owns an isolated hydro-electric plant (0.85 MW) at Muramvya which began operation in September 1981 with financing by KfW.

In addition, REGIDESO operates a 0.5 MW diesel generating station at Gitega and 0.3 MW diesel generating station at Bururi, none of which are interconnected with Bujumbura. In addition, many isolated tea plantations and mission hospitals operate their own small diesel generators for lighting and refrigeration. A list of the existing REGIDESO and private generating facilities is given in Annex 5.

5.09 REGIDESO's transmission facilities are limited to local distribution at 6.6 kV (map IBRD 15918 and Annex 5). The 112 km, 70 kV main supply line from Rusizi has a capacity of about 9 MW and is owned and operated by SNEL. This foreign ownership has led to inadequate maintenance on the line, and delays in repair have occurred after power failures. On several occasions REGIDESO has provided replacement parts (because of Zaire's lack of foreign exchange), and at times the labor needed to make repairs.

Projects Under Construction

5.10 Germany is financing and supervising construction of a 1.2 MW hydroelectric generating plant with an estimated cost of US$2.1 million at Gitega to replace production from the existing diesel station. Although two of the three planned 0.4 MW units have been in operation since September 1980, they had not at the time of the mission performed satisfactorily 1/, and REGIDESO had not officially taken over the generating station. It was expected that the operating problems would be resolved during 1982.

5.11 The Chinese Government is financing and constructing a run-of-the-river hydroelectric generating station (estimated cost US$20.0 million) at Mugere about 25 km from Bujumbura. Although the installed capacity is 8 MW (four 2 MW units), only about 2 MW will be available during the dry season (July, August and September) due to low river flows. Originally scheduled for completion in June 1980, the project was delayed when unsuitable foundation conditions were encountered along the route of the pipeline leading from the intake to the powerhouse which necessitated additional tunnelling and there were further delays due to delays in the shipment of cement, which is brought from China. However, all the equipment has been delivered, and the transmission line to Bujumbura has been completed, so that power from the first two units of this project was available in January 1982. The remaining two units will be commissioned before the end of 1982.

5.12 KfW is also financing a 0.85 MW hydroelectric plant (estimated cost US$2.6 million) at Muyinga to be completed in 1983. Financing will also be provided for a 0.24 MW hydroelectric plant (estimated cost US$2.15 million) at Kirundo, which will provide power primarily for a major hospital. The KfW-financed plants are all isolated from each other and from the main supply to Bujumbura.

1/ Excessive frequency variations.

5.13. Presently, six small hydro projects ranging in size from 30 to 80 KW are under construction and five other sites are under study. The selection of proposed sites has been based on the Government's policy of encouraging the process of "villagization" around regional "development poles" and on the location of social services such as schools, as well as on the existence of small diesel driven electric generators that can be phased out as hydropower is developed.

5.14 The Japanese Government is providing 54 diesel generators ranging in size from 17 to 100 KW to be located at isolated hospitals and missions throughout the country. REGIDESO has arranged for their shipment and installation, but operation and maintenance will be the responsibility of the recipients.

Future Demand and Supply

5.15 Actual and forecast electricity sales for Burundi are given in Annex 5. The growth in the demand for electric power in Burundi has averaged about 10.5% during the past five years. Although the Government and REGIDESO expect a much higher growth rate in the future, the mission considers that the growth in demand for electrical power will remain at about 10-11% per annum during the 1980s.

5.16 Meeting this demand in Burundi depends not only on installation of new capacity inside the country but also on what happens to the demand in neighboring countries. The EGL and KBO countries have been studying alternative projects to augment the region's electric generating capacity. The interconnected system's supply and demand of electrical energy were closely balanced in 1981. With the commissioning of Mugere in Burundi, Mukungwa in Rwanda, and with Rwanda's Ntaruka back to full operation, there will be about 30% surplus of energy available by 1983, as shown in Table 5.1. However, without additional projects the forecast growth in demand indicates that during an average water year there would be no surplus energy in 1986. Consequently, three major hydro projects to meet the expected increase in the demand for energy after 1986 are now under consideration.

5.17 Two of these projects are outside of Burundi - the Rusizi II generating station on the Zaire-Rwanda border, and another at Rusumo Falls on the Kagera River along Rwanda's border with Tanzania. Progress on the Rusumo Falls project will largely depend on the efforts given to encourage the project by Tanzania. The Rusumo Falls project could producebetween 160 and 600 GWh/year, depending on how high the dam is constructed and the corresponding volume of water stored in the reservoir. In May 1981, the Heads of State of the four countries decided to study the low-head, run-of-the-river scheme, because of the large area which would be flooded and the resulting displacement of tons of thousands of people with the higher dam schemes. A source of funds for the study has not yet been identified.

Table 5.1

PROJECTED ELECTRICITY BALANCES FOR THE INTERCONNECTED SYSTEM, 1981-90
(million kWh)

	1982	1983	1984	1985	1986	1987	1988	1989	1990
WITHOUT NEW PROJECTS									
Existing Plants	158	158	158	158	158	158	158	158	158
Plants under construction									
Mugere (Burundi)	20	20	20	20	20	20	20	20	20
Mkungwa (Rwanda)	25	48	48	48	48	48	48	48	48
Ntaruka (Rwanda)		20	20	20	20	20	20	20	20
Total	203	246	246	246	246	246	246	246	246
Demand	158	189	212	235	259	281	305	331	358
Balance	35	57	34	11	-13	-35	-59	-85	-112
of which: Burundi	-32	-38	-45	-53	-61	-70	-79	-90	-101
Rwanda	-53	-19	-28	-37	-47	-58	-71	-84	-98
Zaire	120	114	107	101	95	93	91	89	87
NEW PROJECTS									
Rwegura (Burundi)	-	-	-	-	-	64	64	64	64
Ghira & Gisenyi (Rwanda)	-	-	-	-	-	-	-	23	23
Rusizi II	-	-	-	-	-	200	200	200	200
Balance (with all projects)	35	57	34	11	-13	229	205	202	175
(without Rusizi II)	35	57	34	11	-13	29	5	2	-25
(without Rwegura)	35	57	34	11	-13	165	141	138	111
CAPACITY AS PERCENT OF DEMAND									
Without new projects	128	130	116	105	95	88	81	74	69
With all new projects	128	130	116	105	95	181	167	161	149
Without Rusizi II	128	130	116	105	95	110	102	101	93
Without Rwegura	128	130	116	105	95	159	146	141	131

Rusizi II

5.18 As far as the region as a whole is concerned, the Rusizi II project, given the ample storage provided by Lake Kivu, is clearly the least cost method of providing additional power and energy. After considering several larger projects on the Rusizi, EGL has settled on a 40-MW site about 15 km from the first Rusizi powerhouse, and the feasibility study, engineering design, and contract documents for civil works and equipment have been completed. The bulk of the investment would be in a tunnel and a power house on the Zaire side of the river. There is, however, no institution to implement the project and later operate and maintain this international project.

5.19 At the cofinanciers meeting for this project, held in Brussels February 9 and 10, 1982, it was agreed that an international company would be set up, owned jointly by the three countries -- Burundi, Rwanda and Zaire -- to implement the project, and to operate and maintain it in the future. IDA has agreed in principle to participate in the financing of the Project, the total cost of which is estimated at 66 million European Units of Accounts (US $72 million). The average cost of electricity from this plant (based on a 10% rate of return on the capital invested and a five-year build-up of production before capacity is reached) would be about 5.0¢ US (BuF 5.5) per Kwh. Other cofinanciers would be the EDF, the African Development Bank, Italy, Belgium, the European Investment Bank and the Development Bank of the Great Lakes.

5.20 The Rusizi II project has been promoted primarily by Rwanda and, to a lesser extent, Zaire, while Burundi has only recently decided to participate. Burundi's active participation in the project would seem essential if Burundi is to obtain access to the power it can produce at a reasonable cost and on a timetable in accord with its own needs. Rwanda and Zaire could in effect postpone the construction of Rusizi II and accommodate growth in their own demand by reducing exports from Rusizi I to Burundi if it were not a participant.

Rwegura

5.21 To reduce its dependence on imported electricity, Burundi is pursuing a project for a new generating station (18 MW) at Rwegura, north of Bujumbura, which it hopes to have in operation by 1987. A survey of potential hydroelectric sites in northwestern Burundi (the region in which it could reasonably be expected to find the most suitable sites in Burundi for meeting incremental demand in Bujumbura) in 1979, identified Rwegura as the most favorable site. In addition to producing 18 MW of power and 64 GWh/year of electrical energy, the Rwegura project would provide water regulation that could benefit irrigation and future power projects downstream. Detailed feasibility studies on the project were completed in 1980. The cost of the Rwegura project is estimated at about US$90 million, or 15.5¢ US (BuF 17.1) per Kwh with a 10% p.a. rate of return.

5.22 During May 1982, REGIDESO advised the mission that they are proceeding with the Rwegura project in spite of its high unit cost in order to have a secure source of energy within the country and because of the uncertainties surrounding the timing of the Rusizi II project. With an expected contribution from the Kuwait fund, the financing of the Rwegura project would be complete and a call for tenders for the civil work and the electrical and mechanical equipment could be issued as early as July 1982.

Other Projects

5.23 Three mini-hydro schemes are contemplated for the isolated areas of Bururi, Cibitoke and Nyanza-Lac, but detailed planning has not yet started. It is planned in the context of an inventory of potential hydroelectric sites in the southern part of Burundi now being prepared by Coyne et Belier with Caisse Centrale de Cooperation Economique (CCCE) funds. This report together with the Siemens report on the northwest area should provide a basis for the development of future projects.

5.24 Transmission links need to be considered as well as generating plant projects. Upgrading of the Rusizi-Bujumbura line from 70 kV to 110 kV and a link between the Rwegura plant (when complete) and Kigoma, Rwanda, appear to be worth studying.

5.25 The Bank made a credit (Credit 1154-BU, July 15, 1981) in the amount of US$4 million to study the possibility of mining nickel in the southern part of Burundi. If this project were to proceed, it would be necessary to construct a hydroelectric plant in Mulembwe, the study for which was completed in 1978. This site is some distance from the existing interconnected grid, and would probably remain isolated during the initial years of operation.

5.26 Burundi is believed to have little geothermal energy potential. A recent survey team collected water samples from several sites considered to have good geothermal possibilities. Final results of the chemical analyses of the water samples are not encouraging.

Tariffs and Finances

5.27 The average tariff for electricity was BuF 4.3 per kWh until July 1, 1980, when the Government authorized a tariff increase to BuF 7.6 per kWh (see Annex 5, Table 4). This is a national tariff that averages the very large difference in costs between Bujumbura and the provincial towns. Until June 30, 1980, the cost of imported energy from Zaire was at the relatively low price of BuF 1.83 kWh (negotiations are now under way to raise this rate), while the cost of fuel alone for the 350 consumers in Gitega in 1979 averaged BuF 25 per kWh (or BuF 40 per kWh including all other costs).

5.28 The increase in the tariff allowed REGIDESO to remain financially viable. It is anticpated, however, that the higher cost of energy produced from the Rwegura and Rusizi II generating stations will require further increases in the tariffs.

VI. RENEWABLE ENERGY

6.01 A variety of renewable energy sources other than the small hydro and geothermal possibilities discussed in Chapter V can also be found in Burundi, but their potential for providing an economical, practical substitute for other forms of energy is generally limited in scale or unclear pending further study. The most promising potential application would seem to be solar water heaters to heat (or pre-heat) water for large industrial consumers such as the brewery and textile plant. The mission therefore recommends only very limited investment in these sources. Industrial use of solar water heating should be studied, and the research into solar, wind and biogas now being carried out at a research center at the University of Burundi, the Centre de Recherche des Utilisations des Energies Alternatives (CRUEA), should be strengthened, but no major attempts to develop these energy sources should be made until there is an analysis of the potential market. It may also be feasible to use Nyamuswaga bog peat for producer gas for vehicles and this too should be examined.

Wind and Solar

6.02 Insolation measurements covering four to eleven years at nine stations indicate that solar radiation averages four to five kWh/day/m^2 in Burundi. Seasonal variations appear to be relatively modest (monthly averages mostly within 20% of annual averages). Wind data are available for Bujumbura and several other stations. They indicate windspeeds generally insufficient to justify windmill development, although conditions may be suitable for windmills at certain sites along the Zaire-Nile divide.

6.03 CRUEA is doing preliminary investigations on both solar and wind energy potential in Burundi and the EGL is trying to obtain funds for basic equipment for testing sun and wind energy availability. At present, the greatest needs appear to be (a) wind measurements for the Rusizi plain, and (b) locating sites along the Zaire-Nile divide where exceptionally strong and consistent winds can be matched to local water pumping or electrical needs. Current CRUEA projects include the installation of a test windmill in Bujumbura for water pumping. However, water on the nearby Rusizi plain is generally found about 40 m below the surface, probably too deep for the light windmills most appropriate for the relatively weak winds found there. The several windmills already constructed in the interior were reportedly poorly located for optimal use of available wind, and consequently do not function well.

6.04 Since it is estimated that a large part of crops is lost to spoilage each year, CRUEA is looking into solar crop dryers and refrigeration as ways to reduce these losses. This work is still in its initial stages, but it can be anticipated that solar drying will be found much more practical than solar refrigeration.

6.05 Biogas is workable in Burundi but conditions for it are not ideal. Households generally own few animals and these are not kept in a corral except at night, so most of the dung produced is uncollectable. The most efficient raw material for biogas is pig manure, but there are very few pigs in Burundi, so experimental work is concentrating on other raw materials. AIDR, with EDF support, is testing a wide variety of plant materials in biogas digestors near Brussels and hopes to find suitable materials that are widely available in Burundi.

6.06 Unless the AIDR effort is successful it is unlikely that biogas will provide a significant substitute for other energy forms. The cost of digestors and the lack of a strong extension system that could teach people how to build and operate them are likely in any case to make biogas inaccessible to the poor rural households which make up the majority of the population. Rural institutions with access to suitable raw materials may, however, be able to use them, but the scope for this has yet to be evaluated.

Producer Gas

6.07 Producer gas made from wood, charcoal, coal, peat or agricultural residues can provide a satisfactory alternative to liquid petroleum fuels for running motor vehicles and stationary generators. It was used extensively in Western Europe as a vehicle fuel during WW II, and existing technology need only be adapted for locally available raw materials. It can be used to fuel both spark-ignition and diesel engines, although the latter may require a small amount of liquid fuel. The equipment can be made cheaply in small machine shops. Producer gas equipment requires more maintenance than liquid fuel systems, since ashes and deposits must be removed frequently, but this is not likely to be problematic in Burundi since the maintenance is relatively simple and low-cost labor is abundant.

6.08 Currently planned work on producer gas in Burundi is limited to fixed installations. Under an EGL project with 300,000 ecu (about US$400,000) in financing from EDF, the Dutch group TNO will test a variety of materials on two 250 KW installations in each of the EGL countries over a six month period. Additional funding for larger installations may later be sought.

6.09 Given the increasing scarcity of firewood and charcoal, these fuels are not likely to be available for producer gas generation. However, fuels such as peat or residues from certain agro-processing industries, for example coffee hulls, should be tetsted for both stationary and mobile installations. If the Nyamuswaga peat proves to be exploitable, producer gas would be one potential use for it and the feasibility study for the bog should include this possibility.

6.10 Use of wind, solar and biogas as energy sources are included in the research program of CRUEA. CRUEA was organized about two years ago at the University of Burundi. Its members are teaching personnel from the Science Faculty at the University and advisors on various development projects. The objectives of the Center are to: collect and centralize information on alternative energy sources, promote theoretical and experimental research on the use of alternative energy sources, promote the use of alternative energy sources for rural development, and teach, diffuse and popularize the available information and results of the research. Current projects include experiments with wind, solar and biogas energy; establishment of a library, development of a teaching program on alternative energy and sponsorship of conferences. CRUEA has a small regular operating budget provided by the University and also depends on grants from public or private donors, which have to date been very limited, as well as the enthusiasm of members who often finance part of their own work.

6.11 Thus far, CRUEA seems to have focused on hardware development without giving commensurate attention to the socioeconomic characteristics of the market for the technology they are developing. The scientific skills of CRUEA staff could be productively combined with those of an economist and sociologist or anthropologist to develop technology with larger scale benefits, such as cookstoves or charcoal kilns. In any event, CRUEA's work should be focussed on areas which provide more practical solutions to the country's energy problems.

Rural Cookstove Project

1. Adequate technical experimentation has been done on improved cookstoves to provide a selection of basic models, but problems of dissemination and acceptance have limited their impact on firewood conservation. The peat stove work carried out in Bujumbura, June to October 1980, demonstrated that an entirely new fuel and an entirely different cookstove could be accepted and used where accompanied by intensive field work to develop a model suitable for local conditions, heighten public interest and resolve day-to-day problems with stove use. The basic approach was to begin with a systematic evaluation of cooking practices and preferences, and then to develop and field-test various models. Daily focused interaction with households testing the stoves permitted early detection of problems and suitable modification of basic designs to increase consumer satisfaction. The success of that project, coordinated by a sociologist, indicates the important role of such specialists in improved cookstove dissemination. The rural cookstove project should be coordinated by a sociologist or anthropologist assisted by a technician. A cookstove expert will provide technical assistance early in the project.

2. The project should be carried out in one region selected on the basis of several criteria: high population density, evident shortage of firewood, accessibility from Bujumbura, and if possible a central meeting place for the selected region such as a periodic market. The project should prepare a group of local extension workers to carry out a similar effort in another part of the country.

3. The first stage of the project will be a household sample survey of cooking practices and preferences, and of energy use for light or heat. Information supplied by the survey will provide guidelines to the cookstove expert who will provide technical input on design. The cookstove expert will work closely with the sociologist/anthropologist to develop a cookstove model or models which are both technically satisfactory and suitable for the particular socio-economic characteristics of the area. Field-testing will be done during this phase to improve the basic model(s). The cookstove models should be field-tested in at least three or four households, more if possible. Feedback from this testing will allow adaptation of the basic design to make it more suitable for local cooks. It will also provide practical information on the availability and properties of local construction materials, which may also lead to necessary design changes. The technician will be closely involved in this work so that he/she can carry on after the stove expert leaves. Although the basic design(s) should be selected at this stage, it is possible that modifications will be required at a later date so the technician should be trained to make simple design changes.

4. The dissemination phase will begin with the identification and training of local extension workers. It does not appear that the current

forestry extension program could deal adequately with this additional task. Rather, the cookstove project might be viewed as a way of strengthening forestry extension by training a core group of new extension workers who could take on other assignments after the cookstove work has been completed. There will be two types of extension workers, those who will assist in the construction of the stoves, and those who will assist the cooks in learning how to use them. The role of the extension workers is crucial to the success of the project and efforts should be made to select and train them carefully. Once these early phases of the project are completed, large-scale cookstove dissemination work should begin. Expatriate advisors will exercise a supervisory role and will assess the success of the extension work so as to make changes where necessary, either in design or extension techniques. The goal will be to decrease the expatriates' role as quickly as possible by training counterpart staff. Dissemination will be carried out both by demonstrations in public places, such as markets, schools, or foyers sociaux, and by direct contact with households. Efforts should be made to locate some of the stoves in the homes of interested influential people who are willing to open their homes to their neighbors to demonstrate the stoves.

5. Once the counterparts appear able to work alone, the advisors will leave for two months. During that period, counterparts will continue the dissemination work. The two supervisors should be assessing the work as it proceeds to identify problems areas. The sociologist/anthropologist and technician will then return for three to four weeks to help resolve problems and develop a workplan for the remainder of the project. Advisors will then depart and local people will continue dissemination work alone. This group of trained extension workers should then be able to duplicate this effort in another part of the country.

Staff

Expatriate:

1. Social Scientist-Coordinator -- 32 person weeks. Requires experience with survey data collection in Africa. Also extension experience in introducing new technologies. At least one year of managerial experience supervising several persons. Good French.

2. Technician -- 26 person weeks. Should have field experience introducing and adapting a technological innovation in a developing country. Ability to work well with local artisans essential.

3. Cookstove Expert -- five person weeks. Technical background and degree. Should be familiar with most designs and construction materials for improved cookstoves. Should have good knowledge of procedures for testing fuel-efficiency of stoves in the field. Experience in developing country desirable. Good French, or other language in common with coordinator and technician.

Local:

Interviewers -- two four.

Extension Workers -- two types:

(a) those who will build stoves or teach others to build their own; and

(b) those who show women how to cook on the stoves and resolve day-to-day problems with their use.

One of each type must have knowledge of French and supervisory ability. They will take over project supervision after the advisors leave.

Schedule of Work:

1. Sample survey - six to eight weeks.

2. Selection of best model and field testing - five to eight weeks.

3. Locating and training of extension workers - five to six weeks.

4. Dissemination of stoves - eight to fourteen weeks.

5. Local staff continue work alone - eight weeks.

6. Social scientist and technician return to resolve problems - three to four weeks.

7. Local staff continue work alone - 12 weeks +.

This project might cost about $180,000-200,000 for 12 months work.

Petroleum Stockpiles

1. The basic premise underlying the analysis described below is that the risk facing Burundi is not so much that oil products will become totally unavailable during an interruption in normal supplies as that they would have to be imported by air. To the extent that air freight can be relied upon, it offers a "third choice" with reasonably predictable costs that is an easier alternative against which to measure the cost of maintaining stockpiles than the less easily measured costs of doing without petroleum in a prolonged supply interruption. In this analysis, the additional cost of holding stockpiles is treated as a kind of insurance policy of hedge against the possibility of having to pay the even higher price of air freight.

2. The principal factors that are needed to assess whether stockpiling is likely to save more money than its costs are (a) the expected frequency of supply interruptions and the probabilities of interruptions of various lengths, (b) the cost of maintaining stockpiles, and (c) the relative cost of oil products supplied by air and by surface routes. We will start by examining the cost elements and work back to the probabilities.

3. Bulk storage facilities for petroleum are inexpensive relative to the value of the oil they can hold, and we assume management fees are also negligible. The cost of maintaining a stockpile is, then, essentially equal to the cost of immobilizing the resources invested in the oil. We assume that the productivity of foreign exchange invested in Burundi is about 10% p.a. in real terms and that inventories of oil will in general appreciate in value at about 3% p.a. in real terms, so that the net annual cost of maintaining a stockpile is about 7% of its value. A significant exception would apply to oil purchased from Kenya and held in a stockpile if and when it becomes possible to import from the open market. These inventories would lose about three-eighths of their value at that point.

4. How the cost of maintaining stockpiles compares with the cost of paying for air freight on an as-needed basis depends on where the oil is purchased. If stockpiles are filled with oil purchased from Kenya and imported by truck, their cost will be about $100 per barrel. If purchases in the international market and rail shipment across Tanzania can be arranged, the delivered cost would be only about $62.50 per barrel. Air-freighted oil would probably cost from $125 to $175 per barrel, depending on whether it could be flown in from Kenya or had to come from

a more distant source such as West Africa1/. The percentages by which these costs exceed those of oil supplied via surface routes are as follows:

Source of Stockpiled Oil	Source of Air Freight: Kenya	Source of Air Freight: W. Africa
Kenya	25%	75%
Open Market	100%	180%

5. Holding a stock to cover requirements during the nth month of a supply interruption raises the regular cost of supply by one-twelfth of 7% above the normal cost but eliminates the possibility that a 40 to 90% premium would have to be paid to get supplies in an emergency. Whether it is less costly in the long run to pay the low but regular cost of storage or the high but occasional cost of air freight depends on how often supply interruptions occur that last as long as n months. By dividing the 7% p.a. estimate of the cost of maintaining stockpiles by these estimates of the cost premium attached to air freight, we obtain the probability in annual terms that needs to be attached to the need to use a stock (or bring oil in by air to justify holding it:

Source of Stockpiled Oil	Source of Air Freight: Kenya	Source of Air Freight: W. Africa
Kenya	0.28	0.09
Open Market	0.07	0.04

6. It is probably more convenient to consider these probabilities in terms of periods shorter than a year, because stock levels can be readjusted more frequently than annually, and because there may be reason to believe that a supply cut-off is more or less likely in the immediate future than in later months. It may also be easier to judge the reasonableness of a given probability by considering it in terms of the average number of years there would be between supply interruptions if the current level of risk continued indefinitely. The table below shows the

1/ The 1980 IBRD Report on the International Transportation Bottlenecks Affecting Rwanda and Burundi: estimated air freight costs for general cargo as $470/ton from Dar-es-Salaam and $1,535 from Europe. There are about eight barrels to the ton, averaging between gasoline and diesel fuel. The low end of the range is based on the assumption that oil could be purchased in Nairobi for $65 per barrel and air-freighted for $60. At the high end of the range, we assume that $1,000/ton or $125/barrel would be sufficient to air freight oil from a variety of more competitive sources where it might be purchased for $50.

same probabilities as the table above, but expressed in terms of likelihoods over a six-month rather than an annual period and in "once every X years" form.

Source of Stockpiled Oil	Source of Air-Freighted Oil: Kenya	Source of Air-Freighted Oil: W. Africa
Kenya	15% (3 1/2 yrs.)	4 1/2% (7 1/2 yrs.)
Open Market	3 1/2% (10 yrs.)	2% (17 yrs.)

Extension of the Mombasa-Nairobi Pipeline

1. Transportaton of goods into and out of the Great Lakes region is a problem that affects Burundi in terms of both cost and reliability. Petroleum products account for about 25% of imports in terms of tonnage and, presumably, a comparable fraction of inland freight charges. Because petroleum products are essential for many economic activities, the reliability of their supply is especially important.

2. Measures that might be taken to reduce the cost and delays involved in transportation between the Great Lakes region and the Indian Ocean coast are discussed in a recent Bank report1/ and a forthcoming UNCTAD study. A variety of improvements in railway service between Nairobi and Kampala and between Dar es Salaam and Kigoma as well as highway and port improvements are recommended in the Bank report that would lower the cost of bringing in oil as well as other products.

3. An additional project that may be work consideration is an extension of the Mombasa-Nairobi pipeline. A first approximation of the investments that could be justified by cost savings on successive extensions to Kampala, Kigali and Bujumbura under alternative assumptions about costs on competing routes is computed in Table 1. The results indicate that only the Nairobi-Kampala leg is worth detailed consideration, and that even it is not likely to produce a substantial reduction in petroleum transport costs to Burundi.

4. The Dar es Salaam-Ndola pipeline could conceivably be used to supply the Great Lakes region via a spur to a port on the south end of Lake Tanganyika and barge transport to Bujumbura. However, this pipeline carries crude oil, so use of this route would require construction of a new refinery, most likely in Bujumbura. The small size of the market (Rwanda, Burundi and parts of Zaire total less than 2,000 bbl/day) and the lack of a market for the residual fuel oil that would be produced make this alternative uneconomic.

5. For Burundi, improvements in the ports of Dar es Salaam and Kigomia and in the railway service between them appear to offer the best prospects for a reduction in the transport costs associated with imported oil. Burundi might also explore the possibility of using this route to import products from Persian/Arabian Gulf refineries.

1/ A Report on the International Transportation Bottlenecks Affecting Rwanda and Burundi, IBRD Report No. 3224-EAF, December 1980.

Table 1: Cost Savings Associated With Extension of Nairobi Pipeline

	With Rwanda[1/] and Burundi Traffic			With Rwanda[1/], Without Burundi		Uganda only
	Nairobi-Kampala	Kampala-Kigali	Kigali-Bujumbura	Nairobi-Kampala	Kampala-Kigali	Nairobi-Kampala
Volume (000 tons p.a.)[2/]	325	85	25	300	60	240
Road/Rail Cost ($ 1 ton)[3/]	55	80	100	55	80	55
Annual Savings ($mm p.a.)	17.9	6.8	2.5	16.5	4.8	13.2
Capitalized Savings ($mm)[4/]	179	68	25	165	48	132
Distance (km)[5/]	854	586	283	854	586	854
Capitalized Savings ($000/km)[6/]	209	116	88	193	82	155

1/ Zaire assumed to be supplied via Rwanda.

2/ At approximate 1980 levels of clean products imports. Ugandan imports were as high as 400,000 tons in 1972.

3/ Assumed tariffs for rail service to Kampala and road transport from Kampala to Bujumbura. Based on Bank transport study figures adjusted to 1981 fuel prices. Rail service does not now exist to Kampala, but could be reopened more easily than a pipeline built.

4/ At 10% p.a. Capital recovery factor and indefinite service life.

5/ Road distances. Pipelines would generally be shorter.

6/ Compare to costs likely to exceed $200,000/km.

Note: These estimates are intended only for an initial screening. A more detailed analysis would take into account projected market growth, the marginal costs rather than tariff levels of the alternative transport modes, and route- and capacity- specific estimates of pipeline costs.

Petroleum Exploration

1. Basement rock covers most of Burundi's territory. Only the Rusizi Plain, a 200 km portion of the Tanganyika Graben (West Branch of East African Rift), is sedimentary.

2. Indications from elsewhere along the Graben (Jurassic oil shale and Kalemie coal formations in Zaire, "asphalt" seepages along the shores of Lake Tanganyika) suggest that rocks capable of generating hydrocarbons exist along the Graben, Drilling, however, has been limited to water wells and 12 shallow wells on the Ugandan shore of Lake Mobutu and has been inconclusive.

3. Burundi's portion of the Graben is small and may not contain any geological prospects that might hold hydrocarbons in quantities sufficient to attract foreign operators. The only on-shore seismic survey made (1968) was also inconclusive (outdated equipment, impossibility of moving explosives near the Zaire border, financial difficulties). A recent (1981) seismic survey in Lake Tanganyika found possibly interesting geological structures, but only to the south of Burundi and under prohibitive water depths (about 1200 m).

4. Further exploration should proceed in steps, with the decision to continue at each stage based on an analysis of the expected value of future costs and benefits as estimated in view of the results obtained in previous steps. The major decision that will be required if the aeromagnetic survey discussed in paragraph 9 yields positive results is whether or not to contract for a new onshore seismic survey.

5. We approximate the infinite variety of possible outcomes of a decision to proceed with seismic and their associated probabilities by working with four cases representative of the wide range of possibilities:

(a) Seismic reveals no structures; exploration abandoned.

(b) Seismic reveals structures; three exploratory wells are drilled and find nothing; exploration abandoned.

(c) Seismic reveals structures; three wells are drilled and traces of hydrocarbons are encountered; five more wells are drilled in an unsuccessful attempt to find a commercial deposit; exploration abandoned.

(d) Seismic reveals structures; three well program encounters traces; the fifth additional exploration well makes a discovery; five delineation wells and ten development wells are drilled and oil production is established at the rate of 7 thousand barrels per day.

Table 1: Estimates of Costs and Benefits of Oil Exploration
(Values in 1981 $)

		Undiscounted Costs (US $ mn)	Discounted Costs, by Case[2/] (A)	(B)	(C)	(D)
1981	decision	-				
82	seismic	3.8	3.5	3.5	3.5	3.5
83	3 expl. wells	19.9		16.4	16.4	16.4
84	5 expl. wells	27.1			20.4	20.4
85	delineation[1/]	19.8				13.5
86	development	35.4				22.0
	Total	106.0	3.5	19.9	40.3	75.8
Before Seismic	Probability		0.50	0.33	0.15	0.02
	Contribution to EV		1.8	6.6	6.0	1.5
	Expected Value of Costs		15.9			
After Successful Seismic	Probability		-	0.66	0.30	0.04
	Contribution to EV		-	13.1	12.1	3.0
	Expected Value of Costs			28.2		

	Discounted Benefits, Case D			
	Million Barrels Production	Price[3/] ($/Barrel)	Discount Factor[4/]	Discounted Value ($ mn)
1987	2.56	35.8	0.564	51.7
88	2.56	36.9	0.513	48.4
89	2.56	38.0	0.467	45.3
90	2.56	39.1	0.424	42.4
91	2.56	40.3	0.386	39.7
92	2.30	41.5	0.350	33.5
93	2.07	42.8	0.319	28.2
94	1.86	44.1	0.290	23.8
95	1.68	45.4	0.263	20.0
96	1.51	46.7	0.239	16.9
97	1.36	48.1	0.218	14.2
98	1.22	49.6	0.198	12.0
99	1.10	51.1	0.180	10.1
2000	0.99	52.6	0.164	8.5
01	0.89	54.2	0.149	7.2
02	0.80	55.8	0.135	6.0
03	0.72	57.5	0.123	5.1
04	0.65	59.2	0.112	4.3
05	0.58	61.0	0.102	3.6
06	0.53	62.8	0.092	3.0
07	0.47	64.7	0.084	2.6
08	0.43	66.6	0.076	2.2
09	0.38	68.6	0.069	1.8
10	0.35	70.7	0.063	1.5
11	0.31	72.8	0.057	1.3
Total	32.97			433.3
Before Seismic: Probability				0.02
Before Seismic: Expected Value				8.7
After Successful Seismic: Probability				0.04
After Successful Seismic: Expected Value				17.3

1/ Includes completion of one exploration well ($1.3 mn)

2/ Cases defined in para 5 of text.

3/ Based on $30/bbl price in 1981 (net of operating costs and transportation charges) and 3% p.a. real price increases.

4/ Discounted at 10% p.a.

6. Associated with each of these possibilities are estimates of costs and benefits and a probability of its occurrence. These are summarized in Table 1 and indicate that the expected value of a decision to do a seismic suvey is negative1/. From this we conclude that the risk is not worth taking at this time.

7. If the parameters involved in the computation were such that a positive expected value were obtained, we could not conclude directly that seismic was worth pursuing, but would have to consider the attractiveness of potential sources of finance of the further investments in exploration that would be necessary to investigate any structures that may be located. It may prove impossible to finance the heavier investments in drilling exploration wells if, to make the risk worth taking, a private firm would have to count on being allowed to earn and export a high share of the profits in the event of success.

8. A 3% p.a. escalation in the constant dollar price of oil is assumed in these computations. Other factors held constant, the oil price would have to increase 51% (i.e., reach the predicted 1995 price) for seismic to appear worthwhile. Because the analysis shows that it would not be a worthwhile risk to drill exploration wells even if a seismic survey located appropriate structures2/, the result would not be changed by assuming that seismic costs could be substantially reduced, e.g. by conducting a survey jointly with Zaire. To alter the result obtained here would require some discovery that led geologists to greatly increase the probability associated with case D and/or the size of the discovery taken as representative of what might be found3/. An oil discovery elsewhere in the Graben could lead to such a change of view.

9. An aeromagnetic survey might also be used to compare the Rusizi plain area with the part of the lake where large structures have been identified by seismic. If the geomagnetic characteristics of the areas are found to be sufficiently similar, the probability attached to a large discovery might be sufficiently enhanced to justify a seismic survey. Because mobilization costs would be a large share of the total cost of an aeromagnetic survey of such a small and remote area, it is recommended that Burundi wait for an opportunity to share them with neighboring countries. With shared mobilization, an aeromagnetic survey would cost about $100,000.

1/ Expected value of costs: $15.9 million.
Expected value of benefits: $8.7 million.

2/ Expected value of remaining costs: $28.2 million.
Expected value of benefits: $17.3 million.

3/ Other parameters held constant, a probability of success of 4.2% would be necessary for the expected value of benefits to exceed that of costs. The probability would have to be raised to 5.6% to justify post-seismic costs on the basis of an 80% share in the eventual output which may be the most that an outside investor could expect to obtain.

ANNEX 5

Electricity

ANNEX 5
Page 1 of 5

INTERCONNECTED SYSTEM

Forecast of Energy Requirements and Generation Sources

GWh per Annum [1/]

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Burundi										
Diesel	5	5	5	5	5	5	5	5	5	5
Mugara	-	20	20	20	20	20	20	20	20	20
Rwegura	-	-	-	-	-	-	64	64	64	64
Total	5	25	25	25	25	25	89	89	89	89
Demand	51	57	63	70	78	86	95	104	115	126
Imported	46	32	38	45	55	61	6	15	26	37
Rwanda										
Gatsaka (Diesel)	3	3	3	3	3	3	3	3	3	3
Ntaruka	-	-	20	20	20	20	20	20	20	20
Mukungwa	-	25	48	48	48	48	48	48	48	48
Gisenyi	-	-	-	-	-	-	-	-	8	8
Chira	-	-	-	-	-	-	-	-	15	15
Total	3	28	71	71	71	71	71	71	-	94
Demand	73	81	90	99	108	118	129	142	155	169
Imported	70	53	19	28	37	47	58	71	61	75
Zaire										
Ruzizi I	150	150	150	150	150	150	150	150	150	150
Ruzizi II	-	-	-	-	-	-	200	200	200	200
Total	150	150	150	150	150	150	350	350	350	350
Demand	28	30	36	43	49	55	57	59	61	63
Available for Export	122	120	114	107	101	95	293	291	289	287
Burundi plus Rwanda Total Imports	116	85	57	73	90	108	64	86	87	112
SURPLUS	6	35	57	34	11	-	229	205	202	175
DEFICIT	-	-	-	-	-	13	-	-	-	-

1/ Includes transmission and other losses assumed to be 15%

Table 2

Interconnected System

Electricity Sales (MWh) in Burundi

Year	Domestic	% Change	Private Industry	% Change	Public Building Services	% Change	Regideso Pumping and Internal Uses	% Change	Public Lighting	% Change	Total	% Change
1975												
1976	10,291	-	7,612	-	4,719	-	3,739	-	97	-	26,458	8
1977	10,628	3	9,408	23	5,384	14	4,177	12	105	6	29,702	12
1978	11,691	10	11,445	22	5,915	10	4,801	15	154	46	34,006	14
1979	13,445	15	12,011	5	5,557	-6	4,698	-2	117	-24	35,828	5
1980	14,950	11	14,101	17	6,237	12	4,849	3	34	-70	40,171	12
FORECAST												
1981	16,400	10	16,200	15	6,900	10	5,000	3	100		44,600	11
1982	18,100	10	18,700	15	7,600	10	5,000	3	100		49,500	11
1983	19,900	10	21,300	14	8,300	10	5,300	3	100		54,900	11
1984	21,900	10	24,300	14	9,100	10	5,500	3	100		60,900	11
1985	24,100	10	27,800	14	9,900	8	5,700	5	100		67,600	11
1986	26,500	10	31,800	14	10,600	8	6,000	5	100		75,000	11
1987	29,200	10	34,700	10	11,500	8	7,000	17	100		82,500	10
1988	32,100	10	38,100	10	12,400	8	8,000	14	100		90,700	10
1989	35,300	10	42,000	10	13,400	8	9,000	12	100		99,800	10
1990	38,800	10	46,400	10	14,500	8	10,000	11	100		109,800	10

Table 3

List of Generating Units Owned by REGIDESO

Site	No	Type	Owner	Rated Capacity	Available Capacity (kW)
Bujumbura	1	Diesel		320	
	2	Diesel		1500	
	3	Diesel		440	About 2000 kW
	4	Diesel		440	
	5	Diesel		440	
	6	Diesel		440	
	7	Diesel		920	
	8	Diesel		1000	
				_550	
Gitega	1	Diesel		120	120
	2	Diesel		200	0
	3	Diesel		240	240
				560	360

List of Privately Owned Generating Equipment

Site	No	Type	Owner	Rated Capacity	Available Capacity (kW)
Taza	1	Hydro	Tea estate	340	200
	2	Diesel	Tea estate	300	300
	3	Diesel	Tea estate	300	300
				940	800
Rwegura		Diesel	Tea estate	200	200
Cibitoha		Hydro	Mission	80	80
Mugera		Hydro	Mission	60	60
Mwaro		Hydro	Sanatorium	80	80
Imbo		Diesel	Farm	200	200
Kihonga		Diesel	Mission	60	60
Ngozi		Diesel	Mission	80	80
		Diesel	School	40	40
Burasira		Hydro	Mission	20	
Miscellaneous missions		Diesel	60 Missions	360	360
Provincial head-quarters		Diesel	7 provinces	40	40
Hospitals		Diesel	5 hospitals	100	100
Post & Telephone Offices		Diesel	17 offices	100	100
Others		Diesel	Private	100	100
TOTAL				8520	7480

Table 4

Electricity Tariffs

Low Voltage

Electricity tariffs were amended as follows:

Year	Applied tariffs
1965	4.5 FBU/kWh (up to 360 kWh/month) 2.5 FBY/kWh + 720 Frs of royalties: (tariff from 0 to 900 kWh per month) (request of 3.30 FBU/kWh above 900 kWh/month: client
1969	4.5 FBU/kWh
July 1, 1980	7,60 FBU/kWh

High Voltage

Electricity tariff for high voltage consumers was as follows:

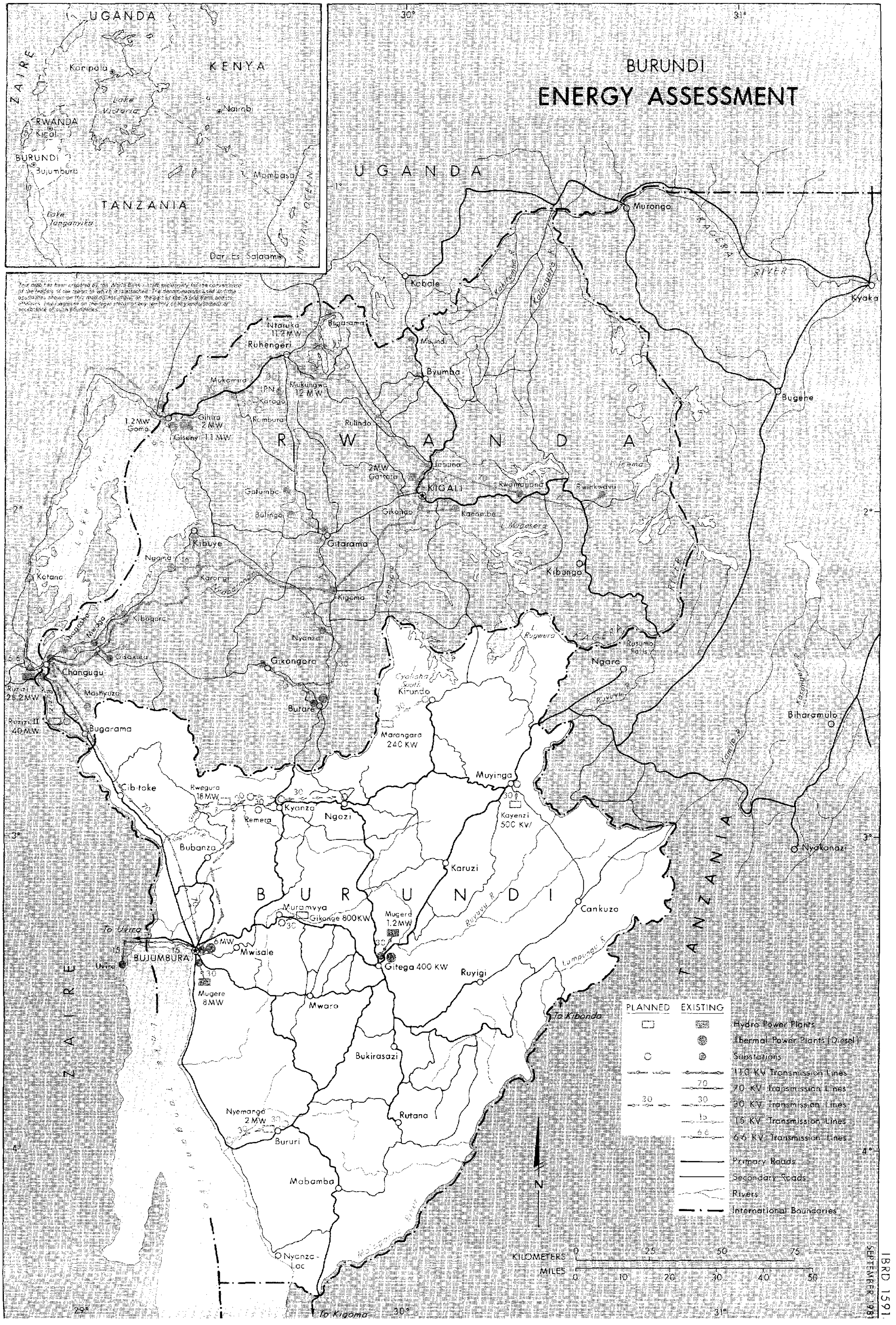
1965	1/4 hour peak:	FBU 250 up to 80 kW FBU 200 above 80 kW
	Energy :	2/5 FBU up to 125 kWh 2 FBU 126 to 250 kWh/month 1/5 FBU above 250 kWh/month
	Minimum price per kWh - 3.20 FBU	
1975	1/4 hour peak:	250 FBU/kW
	Energy :	2.8 FBU/kWh
	Minimum price per kWh - 3.50 FBU	
1980	1/4 hour peak:	600 FBU/kW
	Energy :	6.00 FBU/kWh up to 150 kWh/month 5.50 FBU/kWh from 150 to 300 kWh/month 5.00 FBU/kWh above 300 kWh/month
	Minimum price per kWh: 6.00 FBU	

Table 5

REGIDESO

Number of Staff - May 25, 1981

	Management	Department Heads	Office Staff	Operating Staff	Laborers	Total
Management	1		1	6		8
Administration & Finance	1					1
Personnel		1	2	13	17	33
Purchasing		1	5	12	6	24
Sales		1	6	14		21
Accounting		1	4	6		11
Technical	1		1	10		12
Electricity Dept.	1	11	9	108	64	193
Water Dept.	1	4	10	155	35	205
Civil Engrg.			2	40	7	49
Garage & Work-shop			2	41	4	47
TOTAL	5	19	42	405	133	604



BURUNDI
ENERGY ASSESSMENT
UGANDA
KENYA
ZAIRE
RWANDA
BURUNDI
TANZANIA
Kampala
Lake Victoria
Nairobi
Kigali
Bujumbura
Mombasa
Lake Tanganyika
Dar Es Salaam
INDIAN OCEAN
U G A N D A
R W A N D A
B U R U N D I
T A N Z A N I A
Z A I R E
Murongo
Kabale
Kyaka
Ntaruka 11.2 MW
Ruhengeri
Byumba
Mukungwa 12 MW
Bugene
1.2 MW Goma
Gihira 2 MW
Gisenyi 1.1 MW
KIGALI
2 MW Gatsata
Rwamagana
Kibuye
Gitarama
Kibungo
Kigoma
Nyanza
Gikongoro
Changugu
Ruzizi 28.2 MW
Ruzizi II 40 MW
Bugarama
Butare
Kirundo
Marangara 240 KW
Ngara
Rusumo Falls
Biharamulo
Cibitoke
Rwegura 18 MW
Kyanza
Remera
Ngozi
Muyinga
Kayenzi 500 KW
Nyakanazi
Bubanza
Karuzi
Muramvya
Gikonge 800 KW
Mugera 1.2 MW
Cankuzo
To Uvira
Uvira
BUJUMBURA
6 MW
Mwisale
Gitega 400 KW
Ruyigi
Mugere 8 MW
Mwaro
To Kibondo
Bukirasazi
Nyemanga 2 MW
Rutana
Bururi
Mabamba
Nyanza-Lac
To Kigoma
KAGERA RIVER
PLANNED
EXISTING
Hydro Power Plants
Thermal Power Plants (Diesel)
Substations
110 KV Transmission Lines
70 KV Transmission Lines
30 KV Transmission Lines
15 KV Transmission Lines
6.6 KV Transmission Lines
Primary Roads
Secondary Roads
Rivers
International Boundaries
KILOMETERS 0 25 50 75
MILES 0 10 20 30 40 50
IBRD 15913
SEPTEMBER 1981

Joint UNDP/World Bank Energy Sector Assessment Program

Reports Already Issued

Country	Date	No.
Indonesia	November 1981	3543-IND
Mauritius	December 1981	3510-MAS
Kenya	May 1982	3800-KE
Sri Lanka	May 1982	3794-CE
Zimbabwe	June 1982	3765-ZIM
Haiti	June 1982	3672-HA
Papua New Guinea	June 1982	3882-PNG