Report No. 5230

Energy Issues and Options in Thirty Developing Countries

August 1984

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

JOINT UNDP/WORLD BANK ENERGY SECTOR ASSESSMENT PROGRAM
REPORTS ALREADY ISSUED

The First Thirty Reports

Country	Date	No.
Indonesia	November 1981	3543-IND
Mauritius	December 1981	3510-MAS
Kenya	May 1982	3800-KE
Sri Lanka	May 1982	3792-CE
Zimbabwe	June 1982	3765-ZIM
Haiti	June 1982	3672-HA
Papua New Guinea	June 1982	3882-PNG
Burundi	June 1982	3778-BU
Rwanda	June 1982	3779-RW
Malawi	August 1982	3903-MAL
Bangladesh	October 1982	3873-BD
Zambia	January 1983	4110-ZA
Turkey	February 1983	3877-TU
Bolivia	April 1983	4213-BO
Fiji	June 1983	4462-FIJ
Solomon Islands	June 1983	4404-SOL
Senegal	July 1983	4182-SE
Sudan	July 1983	4511-SU
Uganda	July 1983	4453-UG
Nigeria	August 1983	4440-UNI
Nepal	August 1983	4474-NEP
Gambia	November 1983	4743-GM
Peru	January 1984	4677-PE
Costa Rica	January 1984	4655-CR
Lesotho	January 1984	4676-LSO
Seychelles	January 1984	4693-SEY
Morocco	March 1984	4157-MOR
Portugal	April 1984	4824-PO
Niger	May 1984	4642-NIR
Ethiopia	July 1984	4741-ET

FOR OFFICIAL USE ONLY

Report No. 5230

ENERGY ISSUES AND OPTIONS IN THIRTY DEVELOPING COUNTRIES

August 1984

ENERGY ISSUES AND OPTIONS IN THIRTY DEVELOPING COUNTRIES

Preface

In November 1980, the United National Development Programme (UNDP) and the World Bank launched the Energy Sector Assessment Programme to assist governments in evaluating the main energy issues and options in 60 countries and to serve as a framework for multilateral and bilateral technical assistance in the sector.

This volume presents summary material drawn from the first 30 country reports prepared under this programme. These countries are: Bangladesh, Bolivia, Burundi, Costa Rica, Ethiopia, Fiji, The Gambia, Haiti, Indonesia, Kenya, Lesotho, Malawi, Mauritius, Morocco, Nepal, Niger, Nigeria, Papua New Guinea, Peru, Portugal, Rwanda, Senegal, Seychelles, Solomon Islands, Sri Lanka, Sudan, Turkey, Uganda, Zambia, and Zimbabwe. For some of the assessments completed early in the programme, a review of recent energy sector developments (prepared under the follow-up UNDP/World Bank Energy Sector Management Assistance Programme) has been included. In addition, a recent Energy Balance and an overview of the economic situation in each country is given.

To introduce the summaries, this volume begins with an overview of worldwide priorities for dealing with the challenges of the energy transition in developing countries and a brief description of the Energy Sector Assessment Programme itself.

The 30 reports, as well as this volume, have a restricted distribution and their contents may not be disclosed without authorization from the UNDP or the World Bank. Further information on the Joint UNDP/World Bank Energy Sector Programmes is available from:

Division for Global and Interregional Projects
United Nations Development Programme
One United Nations Plaza
New York, N.Y. 10017

or

Energy Assessments Division
Energy Department
World Bank
1818 H Street, N.W.
Washington, D.C. 20433

Table of Contents

The Energy Transition..... i

The Energy Assessments..... ix

Bangladesh..... 2
Bolivia..... 24
Burundi..... 42
Costa Rica..... 52
Ethiopia..... 60
Fiji..... 80
The Gambia..... 88
Haiti..... 96
Indonesia..... 110
Kenya..... 124
Lesotho..... 140
Malawi..... 146
Mauritius..... 154
Morocco..... 162
Nepal..... 172
Niger..... 180
Nigeria..... 194
Papua New Guinea..... 204
Peru..... 218
Portugal..... 234
Rwanda..... 246
Senegal..... 260
Seychelles..... 274
Solomon Islands..... 280
Sri Lanka..... 288
Sudan..... 300
Turkey..... 310
Uganda..... 322
Zambia..... 338
Zimbabwe..... 354

The Energy Transition 1/

1. The world entered an era of higher energy costs a decade ago. The transition was an abrupt one and most developing countries have still not adjusted their energy consumption and production patterns fully to reflect the higher costs of energy, and particularly imported oil whose price has increased fivefold in real terms since 1973. This adjustment process entails a wide range of actions: increasing the efficiency of energy use through rational pricing and other demand management measures; undertaking a vastly expanded and more diversified program of investments to develop indigenous energy resources where these are cheaper than imported energy; reorienting industrial, agricultural, and transport development strategies to take account of the higher costs of energy; and strengthening the institutional and management capability in the energy sector to carry out these tasks effectively.

The Global Setting

2. The transition process is particularly difficult for the oil importing developing countries. They must raise the resources for an expanded program of energy investments to reduce their dependence on oil imports while, at the same time, continuing to pay for these imports until the investments mature. The issues are similar in several oil exporting developing countries. They, too, must restrain the growth of oil consumption and promote the utilization of other energy resources in order to maintain the flow of oil export revenues.

3. Developing countries account for one-fourth of the world's production and one-fifth of the world's consumption of commercial energy. Their shares of both consumption and production are rising rapidly. By 1995, they will account for one-third of the world's production of commercial energy and one-fourth of the world's consumption. Thus, as a group, the developing countries will continue to be net exporters of commercial energy to the rest of the world. These projections are, of course, subject to many uncertainties and assume that developing countries will take strong action to improve the efficiency of their energy use and will be able to undertake the necessary investments to exploit economic opportunities for substituting imported oil by other cheaper energy sources--domestic or imported.

4. The urgency of these measures is not alleviated by the recent softening in international oil prices. Although oil prices have dropped sharply from their peaks, they remain considerably higher than the prices that prevailed only four years ago. Moreover, while the movement of oil prices remains unpredictable over the short term, most analysts agree

---

1/ Adapted from the World Bank Policy Paper, The Energy Transition in Developing Countries, August 1983.

that oil prices are likely to rise again in real terms during this decade. Energy strategy and investment planning decisions must be made on these expectations about price in the last 1980s and the 1990s. Hence, a temporary decline in the price of oil should not distract attention from the longer-term importance of reducing dependence on imported oil that is considerably more expensive than many available alternatives.

5. Different countries in the developing world face very different energy problems and prospects, and have correspondingly different priorities for action. One classification is shown in the table below. It distinguishes oil exporters, who have seen a major increase in inflows of foreign exchange but who generally face the macroeconomic challenge of maintaining the production of exportable goods other than oil, from oil importers, who have had varying degrees of difficulty and success in coping with the impact of higher oil prices on their balance of payments. About half of the oil importers, including many of the poorer ones, rely on imported oil for over three-fourths of their commercial energy requirements; these countries have been especially badly affected by higher oil prices. Low and middle income economies are distinguished on the table because it is the poorest countries which have in general the least scope for reallocating resources from other parts of the economy to pay for energy imports and the least flexibility in borrowing commercially to pay for higher oil import bills in the short run or to develop their own energy resources. The magnitude of economically developable commercial energy resources relative to the country's energy needs forms the basis, admittedly imprecise, for the classification shown in the table between "limited," moderate," and "substantial" energy resource groups.

Increasing Energy Efficiency

6. Recent experience and analysis have shown, however, that in spite of the many variations there are a number of priority areas for action that are common to most developing countries in all groups, and among the most important of these is to take advantage of opportunities to improve the efficiency with which energy is used in virtually all sectors. This requires a wide range of measures, of which rational energy pricing has proved to be particularly important. A review of the current state of energy pricing shows that oil importing developing countries have, in most cases, already passed on the higher costs of imported energy to final consumers. But most oil exporters continue to price oil in their domestic markets below its opportunity cost. In both groups of countries, there are still imbalances in the relative price of petroleum products and substantial improvements need to be made to bring the price of domestically produced fuels (principally electricity, but also coal and gas) more in line with the opportunity costs of supply.

7. Experience has shown that appropriate pricing usually needs to be supplemented with other demand management measures such as promotional or educational efforts along with training and technical assistance. Effective demand management programs must be selective in their focus and

COMMERCIAL ENERGY POSITION OF DEVELOPING ECONOMIES

Energy Resources or Options (relative to country size)	Oil Exporters: Large Producers	Oil Exporters: Small or medium	Oil Importers — Net oil imports as a percentage of primary commercial energy consumption in 1980: 0–25	26–50	51–75	76–100
LIMITED			Middle Income *Lesotho Namibia		Low Income *Burundi Kampuchea Lao PDR *Nepal *Rwanda	Low Income Bhutan *Ethiopia *The Gambia +Guinea Bissau *Haiti *Niger Somalia *Sri Lanka Swaziland Togo Upper Volta Middle Income Barbados Cuba Cyprus Dominican Republic *Fiji Hong Kong Israel +Jamaica Jordan Lebanon +Liberia +Mauritania Singapore Uruguay +Yemen AR Yemen, PDR
MODERATE		Middle Income Syria, AR	Low Income Zaire Middle Income *Botswana Korea, PDR Vietnam *Zambia *Zimbabwe	Low Income Ghana Pakistan Middle Income Brazil Chile Guatemala +Ivory Coast Mongolia	Low Income *Bangladesh Central Afr. Rep. Chad Equatorial Guinea *Malawi Mozambique *Uganda Middle Income *Costa Rica El Salvador Honduras Korea, Rep. of +Paraguay +Portugal *Turkey	Low Income +Benin Guinea Madagascar Mali Sierra Leone *Sudan +Tanzania Middle Income Greece *Kenya *Mauritius *Morocco Nicaragua Panama *Papua New Guinea Philippines *Senegal +Thailand
SUBSTANTIAL	Low Income China Middle Income *Indonesia Iran Iraq Mexico *Nigeria Venezuela	Middle Income Algeria Angola Congo, PR Ecuador Egypt Gabon Malaysia *Peru Trinidad & Tobago Tunisia	Low Income +Burma India Middle Income Argentina Cameroon Colombia	Low Income Afghanistan Middle Income Yugoslavia	Middle Income *Bolivia	

Notes: Not shown are economies with less than 500,000 population in 1980. "Oil exporters" are economies whose official earnings from net oil exports exceeded 10 percent of total export earnings in 1980-81. "Large producers" are those whose 1980 oil production exceeded 70 million toe.

* Country included in this volume. Also included are Seychelles and Solomon Islands.

\+ Energy assessment work in progress. Work is also underway on Cape Verde, St. Lucia, St. Vincent, Tonga, Vanuatu, and Western Samoa.

employ specifically designed strategies to meet the needs of different sectors or user groups. For the larger energy users--such as large energy-intensive industrial plants, large public and private transport enterprises, and electric power utilities--direct government assistance and support may be necessary to identify and realize the substantial savings that can be achieved through better energy management, maintenance, and other low-cost improvements as well as through large investments in retrofitting and process change. For the smaller users in all sectors, the priority is to develop the relevant policies conducive to conservation as well as suitable institutions to provide them with the information, incentives, and know-how to improve their own energy efficiency.

Increasing Energy Supply

8. Developing countries can reduce energy costs significantly by investing in their indigenous energy resources. A review of the supply potential and market requirements in developing countries indicates that their production of commercial energy could rise from 1.7 billion tonnes of oil equivalent (toe) in 1980 to 3.1 billion toe in 1995. Approximately, 32 percent of this increase would be in the production of oil, 27 percent in coal, 22 percent in natural gas, and 19 percent in primary electricity (mainly hydro and nuclear power). Achieving such a sizable increase in energy output will require action on several fronts. First, most developing countries need to formulate clear strategies on how to use the several available means of accelerating the identification, evaluation, development, and marketing of each indigenous energy resource. Second, they must embark on a focused program of preinvestment work to minimize the possibility of expensive mistakes in large, complex energy investments. Third, there is a need to strengthen the management of the energy sector, both in national planning and policy formulation as well as in the capacity of individual energy enterprises to implement and operate projects of growing complexity. Finally, and most important, a massive effort is required to mobilize both domestic and external resources for financing investment.

Energy Investment

9. A sectoral analysis of financing requirements and of past external flows highlights the need for a quantum increase over current levels in the external capital flows for oil and gas investments. This problem is particularly severe for the oil importing developing countries whose petroleum investment requirements are rising sharply and where the prospects for direct equity investments or for nonrecourse project financing are much more limited. Financing from all sources, both official and commercial, will need to be increased if the financing gap in this sector is to be filled.

10. The Bank estimates that achieving the projected level of energy output in developing countries requires an average annual investment of about $130 billion (in 1982 dollars) over the next decade, or a doubling

of the share of energy investments in GDP from about 2 to 3 percent of GDP during the later 1970s to an average of about 4 percent of GDP over the next decade. This is a major financing problem even allowing for a reallocation of resources from other sources, and it underlines the need for a greater effort to mobilize energy financing from all possible sources; these include both official and commerial financing, debt, and equity. This effort will be necessary and justified under a wide range of plausible scenarios concerning future oil prices. The bulk of the projected investments would still be advantageous to developing countries even if the price of oil settles at a relatively low level (say $25 per barrel in 1983 dollars). Thus, the $130 billion of investment requirements constitutes a reasonable planning assumption.

11. About half of the projected investment requirements, that is $64 billion per year, is in foreign exchange. This foreign exchange requirement compares with an estimate of $25 billion for the actual flow in 1982 of external capital to finance energy investment in developing countries. 2/ Hence, these flows will need to expand by about 15 percent a year in real terms to meet developing countries' foreign exchange financing requirements over the next decade.

12. Over half of the foreign exchange required for energy investments is in the middle income oil exporting countries, which are generally in a better position to raise commercial loans and attract direct investments. However, financing for the low income countries is much more constrained; they are estimated to require 16 percent of the foreign exchange flowing to all developing countires, but receive only 9 percent of publicly guaranteed external credits and an even smaller share of other external capital. For these low income countries in particular, it is essential that greater support from official sources be provided, particularly in the form of concessional credit consistent with their overall debt servicing capacity.

13. The mobilization of adequate local resources for energy investment will be as important as securing the necessary foreign exchange. Appropriate pricing policies will be critical to ensure a reasonable degree of internal cash generation to meet domestic investment requirements. Past reliance on budgetary transfers to the energy sector has had adverse effects on the autonomy and operational capacity of energy enterprises in many developing countries. Improving domestic resource mobilization is vital given the likely scarcity of external capital which makes it unrealistic to rely on external financing of domestic costs, except in the most unusual circumstances. To a large extent, the mobilization of adequate domestic resources will be attained only if the prices

---

2/ Based on available date on flows of publicly guaranteed debt in 1980 and making some allowances for the addition of nonguaranteed debt, direct private investments, and real growth in guaranteed debt from 1980 to 1982.

of electricity, coal, oil, and gas fully reflect economic costs of supply. Further, augmenting operational efficiency and strengthening the financial structure and procedures of energy enterprises should also make a substantial contribution to resource mobilization.

Energy Sector Strategies

14. Making more efficient use of available financial resources requires the explicit formulation of a development strategy in the sector and a program for policy reform and institutional strengthening. Experience indicates that these issues are most effectively addressed for the energy sector as a whole, establishing relative investment priorities and pricing policies that take account of substitution opportunities among different fuels. Mobilizing domestic and external financing and developing a framework to focus the use of external technical assistance are also better handled at the sectoral level. However, a number of specific issues also need to be tackled in each energy subsector.

15. The power sector illustrates the need to improve strategic planning even in the most established energy subsector in developing countries. The increase in oil prices and the greater capital intensity of nonoil-based power generating capacity have increased the complexity of power system planning. There is also a greater need to improve plant operating efficiency and reduce transmission and distribution losses. These measures are particulary cost effective and significant not only because power is usually the largest item in the public investment programs of developing countries, but also because changing the mix of electricity generation will probably be the most potent means of achieving interfuel substitution in most developing countries. Between 1980 and 1995, oil-based electricity generation is projected to decline from 26 percent to 7 percent of total generation, with shares of coal- and gas-fired thermal, hydropower, and nuclear electricity all rising to offset this change.

16. A sharp acceleration in oil exploration and development is required, particuarly in the oil importing developing countries. To achieve this, governemnts need to formulate clear and realistic petroleum development strategies which would define the contribution that could be made by various sources of technological know-how and finance. These sources include domestic and international private oil companies, commercial and official credit agencies, and the national oil company. Countries must identify acreage suitable for promotion to international oil companies and the measures needed to establish and attractive contractual and operating environment; to establish a national capacity to monitor and manage exploration, activity in the country; and, where appropriate, to strengthen the ability of the national oil company to engage directly in petroleum exploration and development.

17. Natural gas resources exist in about 50 developing countries, including about 30 which are currently oil importers. However, there has been little systematic exploration specifically aimed at discovering

natural gas. Even when gas discoveries have been made, development has been slow because of market considerations, lack of infrastructure, and the absence of a coherent gas development program. In general, the cost of gas production is lower and the potential domestic demand higher and more diversified than previously believed. However, the economics of gas use are highly site and project specific and the formulation of a national gas development strategy requires complex and difficult analysis. Thus, in parallel with efforts to explore and appraise gas reserves, an active effort is needed to promote the use of gas, to clarify pricing and related contractual arrangements, and to provide the necessary infrastructure to use this fuel. Few developing countries have either formulated such an integrated strategy for the exploration and utilization of gas, or developed an institutional capability for doing so.

18. In nearly all coal producing countries, recurrent constraints are the absence of a coherent strategy; poor coordination among coal production, infrastructure, and utilization projects; and institutional framework which is characterized by limited managerial expertise and a range of bureaucratic obstacles. Similar problems also affect the planning and implementation of programs to import coal as a substitute for more expensive oil. Without major improvements in these areas, it is unlikely that many developing countries can take advantage of coal's substantial competitive advantage over oil.

19. Geothermal resources are widely distributed, but only nine developing countries have so far constructured geothermal power generation facilities. Several other countries have good geological prospects and a sizable potential market for geothermal electricity, but the development of this resource is limited by a lack of data and institutional drive. A carefully phased program of reconnaissance work, market surveys, geophysical surveys, and exploratory drilling is needed to realize the geothermal potential of these countries. However, several institutional issues, including pricing, will need to be addressed before such a program can be effectively implemented.

20. In all developing countries, a major effort will be needed to counter the overcutting of trees to provide fuelwood or charcoal. These fuels are the principal sources of energy for a large proportion of developing country households, including low-income families in urban areas. Recent studies have confirmed earlier evidence on the extent and severity of a growing fuelwood crisis in a large number of developing countries. The need to expand dramatically reforestation efforts and to improve the efficiency of wood use through better designed cookstoves and charcoal kilns is now widely recognized. However, even though recent experience has identified the constraints that need to be overcome, the mounting of effective large-scale programs of afforestation and improved cookstove dissemination has been slow and often ineffective. These constraints include an inadequate infrastructure and institutional capability, the difficulties of mobilizing strong local participation in tree planting programs, and the lack of appropriate technical packages

for specific areas. It is also clear that greater emphasis should be placed on low-cost approaches to tree planting that are more closely attuned to people's perceived needs and better integrated with their agricultural pursuits. Moreover, many countries need to give higher priority to fuelwood and rural energy problems generally. Stronger international technical and financial assistance is also called for to help step up investment efforts and strengthen national institutions.

21. The recent anticipation that developing countries would be able to harness the enormous potential resources of renewable energy has not yet been fulfilled for two principal reasons. First, the development, adaptation, and application of certain technologies such as photovoltaics and biogas digesters, has proved more difficult, and their costs have not come down as quickly as was initially forecast. Second, the institutional and policy framework for assessment and commercialization of suitable technologies has been weak. Heightened national and international efforts in the areas of resource measurement; planning and marketing studies; research, development, and testing; and pilot and demonstration projects can all help materially to spread the use of the solar, biomass, wind, and other renewable technologies that are already commercially viable for many uses.

The Energy Assessments 1/

1. The international community has responded to the energy problems of the developing countries by establishing energy as a priority sector and by substantially increasing programs for financial and technical assistance to this sector. To enhance and speed up the flow of this assistance, the World Bank and the United National Development Program have jointly launched the Energy Sector Assessment and Energy Sector Management Assistance Programs. 2/ The objective of these programs is, first, to help developing countries establish a realistic strategy for energy sector development and management and, second, to assist these countries, as well as donor agencies and private investors, in implementing the priority investment and technical assistance activities included in this strategy.

2. The Energy Sector Assessment Program, started in November 1980, produces reports diagnosing the most serious energy problems faced by individual developing countries and evaluating the options for alleviating these problems.

- analyze the scope for changes in pricing, institutional arrangements and other policies to encourage economically profitable production from indigenous energy sources, fuel substitution and more efficient energy use;

- assess the investment priorities in the energy sector; and

- provide a framework for official and private assistance to the sector;

Important or unique features of the assessment process include the following:

- it is based on a request by the government of the relevant developing country and a commitment by this government to the process as well as to implementing the recommendations;

1/ Adapted from the Annual Report: Achievements and Future Directions, the UNDP/World Bank Energy Sector Programs, February 1984.

2/ Finance for both programs to date has been provided by the World Bank, the UNDP and bilateral agencies. Countries which have made or pledged initial contributions to the programs through the UNDP Energy Account, or through other cost-sharing arrangements with UNDP, are the Netherlands, Sweden, Australia, Switzerland, Finland, United Kingdom, Denmark, Norway, Canada, France, the EEC, and New Zealand.

- it is directed to meeting the most pressing problems in the energy sector and consequently is neither designed nor intended to include comprehensive coverage of all aspects of the sector;

- it builds on the work of others inside and outside the country, producing practical recommendations on the basis of existing information rather than developing new data;

- it is managed and carried out by an 'in-house' staff of experts brought together for this specific purpose; and

- the final reports are available for review and evaluation by other experts, donors and investors.

How Assessments are Done

3. Most energy assessments pass through six principal stages; these are designed to ensure thorough preparation and co-ordination of internal and external inputs and an effective review process. Briefly, these stages are:

*Country Selection. In selecting the countries to be covered under the program and in scheduling the assessments, priority has been given to countries whose development is seriously constrained by their energy situation, and where governments are committed to making necessary institutional, structural, and policy changes.

*Preparation. A review is made of all available information on a country's energy sector, so as to build on, rather than duplicate, work that has previously been done on the sector.

*Reconnaissance Mission. A short reconnaissance mission to the country to familiarize government officials with the assessment concept and process reaches agreement on the priority issues, scope and depth of analysis needed, confirms the government's commitment to the exercise and its follow-up, identifies counterpart staff and initiates data collection.

*Assessment Mission. The assessment mission works in the country for up to four weeks in close consultation with country officials.

*Draft Report. A draft Energy Sector Assessment Report is prepared on the basis of the information gathered by the mission and sent to the country for review by the government; the mission leader then visits the country for discussions with the government. This discussion generally leads to agreement between the government and World Bank/UNDP staff on program of measures to be taken in the energy sector and the steps to be taken to mobilize whatever external assistance is deemed necessary.

*Final Report. This is distributed to the government and the Executive Directors of the World Bank and is available to members of the UNDP Governing Council and bilateral and multilateral agencies dealing with energy.

What the Reports Contain

4. The tangible output of the Energy Sector Assessment Program is a series of Energy Sector Assessment Reports. Their coverage is selective and the scope and depth of recommendations made reflects, inter alia, the importance of particular issues in the country concerned, the availability of information, and the areas in which the government is especially seeking assistance. However, almost all of the reports deal with four basic, interrelated areas:

- energy-economy linkages;
- energy demand management;
- energy supply options; and
- energy sector institutions.

Regardless of the specific content, the focus is on identifying the appropriate "next steps" for both the government and the development assistance community

5. Analysis of energy-economy interactions is based on the use of energy balances as a check on the consistency of macro-economic and energy sector plans. These balances trace the flow of energy through an economy, accounting not only for the sources and uses of each energy form but also for losses in the processes of energy transformation (e.g. charcoal making, oil refining or electricity generation from thermal power stations) and, when possible, estimates of the end-use efficiency of energy. 3/ The energy demand projections build on the evaluation of existing information on the country's economic development and energy conservation potential; energy supply projections involve a judgement by the mission on the levels of output and imports which may be considered feasible. Alternative "scenarios" are presented in most reports to illustrate the effect of different development patterns and to demonstrate the importance of specific projects and policies. Analysis of the implications of these projections and 'scenarios' for the balance of payments and investment requirements has revealed in some countries a need for substantial realignments in energy strategy.

3/ A technical paper is available on this subject: 'Guidelines for the Presentation of Energy Data in Bank Reports,' Energy Department Paper No. 7, World Bank.

6. Coverage of energy demand management includes an analysis of domestic energy pricing, complemented when appropriate by an appraisal of the potential for increasing the efficiency of energy use. The recommendations which follow from these analyses focus on the relative prices of different energy forms as well as on overall price levels; in many cases they discuss specific energy efficiency projects and the institutional arrangements for their implementation.

7. Energy supply options considered in the assessments include the development of domestic resources, energy transformation investments, and measures to reduce import costs. The discussion includes a review of the country's energy resource base and planned or potential energy investment programs. Where the available information permits, the reports make recommendations on major pending decisions; in other cases, recommendations consist of either defining further work to determine the technical, economic and financial feasibility of what are judged to be priority projects, or advising to delay or abandon further work on non-priority projects.

8. The reports comment on the strengths and weaknesses of energy sector institutions in general and their planning capabilities in particular and recommend specific measures to strengthen them; technical and management assistance and training requirements are identified where possible. In some countries, the assessment missions discuss with government officials the potential for major structural changes, such as creating a new institution or realigning the roles and responsibilities of existing institutions.

9. There has been a growing emphasis in energy assessments on the rural and household sector. On the demand side, the reports evaluate existing programs for dissemination of more efficient cooking stoves and charcoal kilns and make recommendations for improvements based on cross-country experience. On the supply side, more detailed analyses are being made of woodfuel production options (including agro-forestry and peri-urban woodfuel plantations) and the prospects for alternative households fuels. Attention is also being devoted to the recovery of forest logging and sawmill residues through upgraded forest industry management as well as the use of agricultural residues. Rural energy is one of the priority areas for action cited by the United Nations 1981 Nairobi Conference on New and Renewable Sources of Energy; the growing emphasis on this area helps to implement the Conference's recommendations by defining priority investment possibilities.

BANGLADESH: COMMERCIAL ENERGY BALANCE FY, 79/80
(thousand tonnes of oil equivalent except as noted)

	Coal	Crude Oil (thousand long tons)	Petroleum Products (thousand long tons)								Natural Gas	Electricity	Total
			LPG	Gasoline	Naphtha	Jet Fuel	Kerosene	Diesel	Fuel Oil	Total			
Supply													
Primary Production		-	-	-	-	-	-	-	-	-	1,033	50	1,083
Imports	177	1,209	-	-	-	40	72	296	22	452	-	-	1,838
Exports & Bunkers	-	-	-	-	-70	-	-	-17	-64	-156	-	-	-156
Transformation and Losses													
Thermal Power Generation	-	-	-	-	-	-	-	-104	-96	-203	-365	143	-429
Oil Refining		-1,209	3	62	70	4	312	151	513	1,154			
Energy Sector Use & Losses	-	-	-	-	-	-	-	-	-	-	-	-77	-77
Net Supply/Demand	177		3	62	-	44	384	326	375	1,247	668	115	2,207
Demand													
Industry	137	-	-	-	-	-	-	8	269	274	330	73	814
Transportation	40	-	-	62	-	44	-	226	59	411	-	-	451
Agriculture	-	-	-	-	-	-	-	92	-	96	-	3	99
Commercial	-	-	1	-	-	-	-	-	-	1	23	16	40
Residential	-	-	2	-	-	-	384	-	-	419	62	19	500
Other Sectors	-	-	-	-	-	-	-	-	47	46	-	4	50
Non-energy uses	-	-	-	-	-	-	-	-	-	-	253	-	253

toe = 10.333 mn kcal.
KWh = 860 kcal.

BANGLADESH 1/

1. Bangladesh faces two energy crises, one involving commercial and the other traditional fuels (agricultural waste, firewood and cow dung). Although it has one of the world's lowest per capita energy consumption levels (100-130 kg. of oil equivalent, of which over two-thirds is traditional), its net oil imports of around 1.6 million tons in 1980-81 cost about US$460 million, using about 60% of its total foreign exchange earnings. At the same time, the country's forest reserves are being rapidly depleted and the availability of other traditional fuels is declining. Fuelwood prices have increased dramatically over the last 10 years. If present trends continue, a fuelwood crisis in many rural areas is likely in the near future.

2. The country has no known oil reserves, no economically exploitable coal, and limited hydropower potential. However, it has substantial economically recoverable natural gas reserves (about 10 trillion cubic feet) which at present consumption levels would last for several decades. The rapid and effective use of this major resource could be a crucial element in alleviating the country's current payments problems and enhancing its energy outlook.

3. Despite low levels of energy consumption, Bangladesh uses its energy inefficiently. There are substantial losses in the conversion, transmission and distribution of power as well as frequent and costly power outages; the security of supply of natural gas is inadequate; production from the oil refinery does not match domestic demand, and there is considerable scope for improving industrial energy efficiency. Many of these deficiencies, and the difficulties in addressing them, stem from major institutional and policy shortcomings, including shortages of skilled managers and technicians in the country's energy agencies, inadequate energy price levels and related serious financial problems, and an inadequately designed and maintained physical plant for the production, transformation, distribution and consumption of energy.

4. The potential is large for improving the country's energy situation through proper management and the development of programs based primarily on the following principles:

(a) Expanded production, distribution and use of natural gas, particularly for power generation and industry, to meet growing energy demands and to substitute for more costly imported fuels;

(b) Major improvements in domestic oil refining facilities;

1/ Adapted from Report No. 3873-BD, October 1982.

Economic Context

Bangladesh covers some 55,600 sq. miles, or an area about half the size of Italy. Most of the country consists of the fertile delta of the Padma-Jamuna (Ganges-Brahmaputra) River system. The latter divides it into an eastern and western zone. Because of the huge width and the shifting, alluvial nature of the river beds, there are no bridges between the two zones. This strongly affects commercial fuel consumption patterns because the eastern zone is rich in low-cost natural gas while the west depends largely on high-cost imported petroleum products. Most of the country is very flat, and, therefore, subject to annual monsoon flooding. In bad years, as much as 40% of the total land area is under water for up to six months. On the other hand, during the dry periods, agricultural production depends on additional irrigation, mainly from pumps which affects energy use.

With a population of some 90 million in 1981, and an average density of 1,620 persons per square mile, Bangladesh is the most densely populated country of the world, a situation exacerbated by the continuing high rate of population growth (2.7% per year). Over 90% of the population lives in rural areas and agriculture accounts for 80% of total employment. Land holdings are generally very small and the share of landless agricultural laborers is high. The country's Planning Commission estimates that four-fifths of the population cannot obtain minimum nutritional requirements and lives below the poverty line.

Of the adult population, 76% is illiterate, and only five percent of the labor force has graduated from high school or advanced institutions of learning. There is a critical shortage of technically skilled persons and there are only about 30,000 scientists, engineers and technicians plus 100,000 skilled workers in the country. Out-migration rates to the Middle East are high. This shortage of skilled manpower seriously affects the proper operation and maintenance of energy supply systems as well as other sectors of the economy. On the positive side, however, these high migration levels do result in significant foreign exchange remittances to the country.

Bangladesh is one of the world's poorest countries with a per capita GDP in 1981 of only US$133 (in 1980 dollars). About 50% of its GDP is generated by agriculture, 30% by the service sector and only 14% by industry. Industry's share of total output has remained essentially stagnant since the mid-1970s. Between FY76 and FY81 total output increased at an average rate of 4.8%. However, it was subject to considerable swings, mainly as a result of year to year variations in agricultural output.

(c) More efficient use of energy through better control of conversion and distribution losses and industrial energy conservation;

(d) Increases of energy prices to economic levels, particularly for electricity, petroleum fuels and gas; and

(e) Reforestation and improved development of fuelwood and charcoal production.

5. These courses of action, supported by and based on appropriate preparatory studies, technical assistance, capital investment (amounting to about US$2.05 billion over the next five years) and policy changes, would moderate growth of energy demand, lead to the use of less costly energy sources, improve the reliability of supply systems, alleviate the problem of traditional energy shortages and limit the growth in energy imports. Historic and tentatively projected commercial energy balances are summarized in the table below.

6. The major factors highlighted in this table are:

(a) Though commercial energy demand growth is expected to be about 8.8%/year between 1979/80 - 1984/85, this would be achieved with a negligible increase in net oil imports, which should increase at only 1.7%/year.

(b) Virtually all of the increase in commercial energy demand over this period would be met by increased domestic gas production growing at a rate of about 16.3%/year between 1979/80-1984-85.

(c) The level of commercial energy losses is estimated to show some improvement over the period in question, declining from 20% (561,000 toe) of commercial energy supply in 1979/80 to about 15% (720,000 toe) in 1984/85. This is in large part due to the expected improvement in power losses being instituted by BPDB.

(d) With net oil imports expected only to rise marginally to about 1.64 million toe in 1984/85 the estimated cost of these net imports would be about US$520 million (1981 $) compared to US$460 million (1981 $) in 1980/81.

7. In the longer term, Bangladesh should aim at using its gas reserves to spearhead its export earnings.

PAST AND FUTURE COMMERCIAL ENERGY BALANCES

	1979/80		1984/85		Annual Growth Rate, 1979/80-84/85
	('000 toe)	(%)	('000 toe)	(%)	(%/year)
Domestic Energy Demand					
Residential/Commercial	546	24.7	686	20.4	4.7
Industrial a/ (energy & non-energy)	1,061	48.1	1,903	56.6	12.4
Transport	451	20.4	539	16.0	3.6
Agriculture	99	4.5	221	6.6	17.4
Other	51	2.3	16	0.5	-20.7
Total Final Demand	2,208	100.0	3,365	100.0	8.8
Domestic Energy Supply					
Production					
Natural Gas	1,035		2,205		16.3
Hydro	50		67		6.0
Net Energy Imports					
Petroleum (Crude plus products)	1,505		1,641		1.7
Coal	177		177		0.0
Less					
Conversion and Transmission Losses	561		723		5.2
Total Energy Supply b/	2,206		3,367		8.8

a/ Both energy and non-energy uses of fuels in the industrial sector are aggregated. The major non-energy use being gas used as fertilizer feedstock.

b/ These figures do not exactly match to demand number due to rounding errors in coversions to oil equivalent.

Management of Public Sector Energy Companies

8. Many of the major problems identified by the mission that need to be addressed urgently in the petroleum, gas and power sectors arise directly because of:

(a) a serious hemorrhage of skilled manpower through migration because of inadequate levels of remuneration for key skills;

(b) the need to update and up-grade the technical and management skills at both senior and middle management levels through the institution of training programs.

9. The management of the public sector energy enterprises cannot be significantly improved unless government confronts these issues directly and undertakes measures to alleviate them. Specific recommendations for each of the sub-sectors and for national energy planning are given in the main body of this report.

Gas Development and Utilization

10. Natural gas supplies are substantial and gas is an ideal fuel in many applications. The Government therefore should put a substantial effort into developing gas as the primary commercial energy source in the country.

Oil/Gas Exploration and Development

11. Given Bangladesh's limited capability in mounting an exploration program on its own, it would need to make concerted efforts to secure the participation of foreign oil companies in this area. Further, so as to attenuate the existing energy imbalance between the eastern and western zones, exploratory effort, at least in terms of seismic work, needs to be stepped up in the western zone. Even a modest discovery of natural gas in the western zone could significantly ameliorate the existing situation. In addition, in the producing gas fields in the eastern zone, seismic work should be undertaken using modern methods and technologies.

Gas Supply

12. Of immediate concern is the security of gas supply and the safety of its distribution. The Dacca gas distribution system is currently vulnerable, because it is relying on a single source of supply, a single transmission line and has no boosting or storage capability. In the event of failure of either the transmission line to Dacca, the city gate station or the gas field, supply to the city could be quickly lost. If gas supply is to continue its rapid rate of expansion the need for "back-up" is critical, including an alternative supply to the Dacca city gate station. Theoretical network analysis has shown that pressures in the distribution system in the centre of Dacca could be as low as 7.7 psi even with normal pressures at the city gate. It is of paramount importance that the following actions be undertaken as a matter of urgency:

(a) Investment in additional gas production walls to provide reserve "back-up" capacity to the gas system.

(b) A second gas supply and transmission system to Dacca needs to be put in place.

(c) Measures need to be taken to strengthen the Dacca gas distribution system (e.g., through cross connections and looping of the network) to improve the physical reliability of the system.

Gas Utilization

13. Measures already underway include the construction of the East-West electricity interconnector which will provide gas-generated power to the West and will substantially reduce fuel costs in that area. In addition, the IDA-financed Bakhrabad-Chittagong pipeline will lead to the replacement of fuel and diesel oil in power generation and industrial uses in Chittagong and adjoining areas. Also, gas is now being used as a feedstock for the manufacture of urea which would ultimately result in the total substitution of imported nitrogen-based fertilizer by domestic production.

14. The most important constraints to increased gas utilization are first, the rate of capacity expansion of the gas distribution sector and the training of qualified staff who can handle this potentially dangerous fuel; second, the high cost of gas infrastructure; and third, the high cost of gas as a transport fuel and as a fuel for small isolated demand centers.

Development Opportunities

15. There are some new and challenging ways to even out the peaks and troughs in the fluctuating gas demand profile. These include gas-driven stationary automobile engines for local power, gas-driven water pumps (for pumps close to major pipeline networks), air conditioning, and gas compressors for refrigerated stores and freeze centers. (These latter two are particularly suitable for interruptible gas loads). Country brick kilns are another example of good load growth customers, provided the seasonal variations can be accomodated within the system, the correct tariff is charged to counter seasonal demand and the kilns are close to the pipeline network. It should be noted, however, that with the commissioning of the Ashunganj and Ghorasal power plant extensions fluctuations in gas demand would decrease relatively.

Gas to the West

16. There are two alternatives to take gas to the West. One is the construction of a pipeline; the other is the supply of LPG to selected distribution centers. The first alternative requires very high capital investment and faces the problem of limited markets relative to economic pipeline sizes in the absence of an export contract with India, as well as exceedingly difficult technical problems in crossing the major river systems. The second is much more flexible, less capital-intensive, and and can be tailored to marketing requirements. It can also be imple-

mented more rapidly. Furthermore, LPG can possibly be distributed at reasonable cost to rural villages. Potentially the greatest risk facing an east-west pipeline is that low-cost gas be discovered in the west long before the pipeline investment was fully amortized. Secondly, the economics of such a pipeline to meet solely the west zone's gas needs has to take full account of the east-west electricl interconnector, since the transmission of large blocks of power to the west preempts one the most important gas markets in the west - namely, that of power generation.

LPG Recovery from Natural Gas

17. The Titas and Bakhrabad fields might produce up to about 30,000 tons of LPG per year at gas production levels of about 500 MMCFD per day. This would require the construction of gas separation plants. LPG could be economically transported by river to strategic locations where bottling stations would be established. Use of LPG could be promoted to displace kerosene used for cooking in urban areas. LPG supply of about 30,000 tpy could displace about 8-10% of present kerosene demand, which is the estimate of present kerosene use for cooking amongst higher income households in urban and rural areas without access to gas. Other potential uses of LPG include substitution for gasoline in spark ignition engine vehicles, as well as substitution for diesel oil in irrigation pumps. In the case of the former, this would tend to exacerbate the already large gasoline/naphtha surpluses. In the case of the latter, spark ignition engined irrigation pumps would be required in place of pumps based on compression ignition engines. A further potential use of LPG is as a substitute for kerosene as a lighting source in non-electrified households. Here, pressurized LPG lamps would have to be introduced to replace the conventional kerosene wick or pressurized kerosene lamps. All of these options need to be evaluated to determine the end-use that maximize the overall benefits to the country.

Compressed Natural Gas (CNG)

18. A pilot study of compressed natural gas use in the transport sector is being financed by IDA. It appears that rail transport offers particularly attractive possibilities for the utilization of CNG. The volume of petroleum product consumption in the railways' diesel engines is currently 100,000 tons, of which two-thirds is fuel oil and the rest diesel. The replacement of fuel oil by CNG would require about 10 MMCFD of gas per day and would increase the life of the engines.

Other Potential Domestic Gas Uses

19. A further possibility might be the production of single cell protein (SCP) which would require large quantities of gas converted first to methanol and subsequently manufactured into animal feedstocks. There would be a large home market and scope for export. Methanol also has potential as a cooking and transport fuel; however, further international research into its potential for these uses as well as for lighting has to be undertaken before the economic and technical feasibility of these options in Bangladesh can be proven.

Gas Export

20. Even on the basis of the very preliminary investigations undertaken so far, the supply of gas is likely to remain well in excess of Bangladesh's expected internal needs for a substantial period of time. Export options include the following:

(a) export gas through a pipeline to India;

(b) export gas after liquefaction; and/or

(c) attract export-oriented industries which are energy intensive e.g., methanol production and/or use natural gas as a feedstock.

The first of these would require an East-West gas pipeline, and the solution of a number of political, financial and technical problems. The second option may also be viable but an LNG plant capable of liquefying 500 MMCFD of gas, including tankers, is likely to cost more than two billion dollars. In addition, considerable investment would be required to create a deep-sea terminal or make alternative arrangements, as Chittagong harbor is incapable at present of accepting LNG tankers. In any event, new gas reserves will have to be delineated before an LNG plant can be given serious consideration. For purposes of determining the resources which would need to be deployed for increasing the economy's absorptive capacity for gas and also for evaluating the various options available to the government in terms of gas export, including methanol production and gas liquefaction, a detailed study should be carried out.

Refinery Improvements

21. The 1.5 million tpy refinery at Chittagong is unsuited to meet current and projected petroleum fuel requirements of the country as it has neither the processing flexibility to match the market demand profile nor the processing capacity. For example, BPC's production program for 1981 envisaged the purchase of 2.6 million tonnes of crude oil, of which 1.3 million were to be processed by the Chittagong Refinery and the balance by the Shell Eastern Refinery, Singapore. This large crude oil throughput from both refinery operations would give a surplus of 780,000 tons of fuel oil and 230,000 tons of naphtha which would have to be disposed of on the world market at relatively low prices.

22. With the expansion of the natural gas substitution program the major petroleum product that will be replaced is fuel oil. This will increase the surplus of fuel oil from th erefinery and increase the pressure for modifications of the refinery to permit conversion of fuel oil to needed middle distillates. To deal with these problems, the following refinery program appears promising:

Immediate Savings

(a) Spiking. By spiking the imported crude oil with deficit products up to the technical limitations of the Chittagong refinery, immediate savings of about US$5-7 million per year could be realized.

(b) Blending. To reduce the export of surplus naphtha and increase the production of middle distillates, some blending of heavy naphtha with middle distillates is feasible. This would require construction of a naphtha splitter to obtain the heavy naphtha component for such blending. The estimated annual saving would be about US$2.0 million for an investment of about US$4.0 million.

(c) LPG Recovery. At present LPG is recovered only from the crude unit of the refinery due to plant limitations and shortage of storage facilities. Thus, of the 15,000 tons/year of LPG which are available, only 4,000 tons are being recovered. The unrecovered LPG is used as refinery fuel or flared. About 75% of the LPG from the refinery is presently marketed in the Chittagong area and the remaining 25% is distributed throughout the country. Consumer demand for LPG is limited at present only by availability. It has been estimated that for tobacco-curing alone an additional 15,000 tons of LPG would be required. An investment of about US$11 million to recover this additional LPG and add storage facilities would offer an attractive rate of return.

Medium Term Option

Debottlenecking. Debottlenecking the refinery to increase the capacity to 45,000 barrels per stream day and increasing the quantity of spikes could yield savings of more than US$10 million per year. The estimated additional investment is about US$20.0 million at 1981 prices.

Longer Term Options

Cracking. Of various possible long term options examined by the mission, the one that would likely provide the greatest operating flexibility would eliminate net fuel oil output completely whicl giving the lowest import costs. This option (costing about US$140 million in 1981 prices) includes a hydrocracker complex with a hydrodesulphurizer and a deasphalter. A detailed study needs to be undertaken of this option as well as for the debottlenecking of the refinery as a matter of high priority. However, it needs to be stressed that decisions about secondary refining (cracking) investments are fraught with uncertainty at present due to the current state of the oil market and the differential between fuel oil and distillate prices remains sufficiently wide.

Energy Efficiency, Losses and Conservation

Power Outages and Losses

23. The frequency of power outages in the Bangladesh Power Development Board (BPDP) systems is very high. In 1979/80 the probability that any one of the west side distribution feeders would be inoperative at any given time was in excess of 14%. A random sample over six months of a feeder in the Dacca Region showed a total outage time of 14%. In a sample month of its first operational year REB experienced power cuts at its sub-stations on 10 out of 30 days. One reason for the high level of outages has been the absence of firm capacity in the east and west zones.

24. Net losses to industrial activities due to outages in 1980/81 may have amounted to some US$30 million. BDPB and the Government are trying to reduce these losses by a program to build special feeder lines to important industrial plants (e.g. 65 jute and 13 textile mills) and by authorizing the installation of captive or stand-by generating equipment in others. Captive plant capacity at present amounts to approximately 30% of total operative BPDB capacity.

25. The BPDB system is also subject to substantial energy losses that have fluctuated between 36 and 40% of total generation in recent years including station auxiliary use. In spite of contractual commitments to reduce these, the various measures adopted have apparently been successful so far (or new sources of losses have nullified ongoing reduction measures). These losses contribute substantially to the dismal financial performance of BPDB. The actual costs of such losses are even higher than the measured discrepancy between production and recorded sales, because such losses occur mainly during peakload hours, thereby contributing significantly to overload and outages.

26. Losses are mainly caused by four factors: first, excessive distribution line losses from faulty or overloaded equipment; second, faulty or non-functioning meters; third, errors or fraudulent practices in meter readings and accounting; and, fourth, theft through meter tampering and illegal connections. Given the technical characteristics of the BPDB systems, it has been estimated that total losses (including auxiliaries) should be no higher than 23%. The remaining 13-17%, then could be subject to appropriate remedial actions. A major problem is that BPDB lacks adequate metering capability to monitor the energy dispatch through its various distribution feeders. For example, in the Western Zone, it was found that out of 46 sub-stations only four had functioning meters. This means that in many cases the location of losses cannot be identified.

27. Outright theft is generally concentrated in major urban areas (mainly Dacca). These customer groups, however, contribute only about 10% of recorded sales, which means that the actual consumption rates in these areas may be more than 100% higher than recorded sales. These con-

ditions are likely to worsen as a result of the projected rapid urban growth.

28. Specific measures are to be undertaken by BPDB to reduce system loss rates to around 18% by 1985 and to 16% by 1990. This plan of action includes the separation of technical and financial losses and proposals to reduce each category; it also sets out annual targets against which BPDB 's performance can be monitored. The commencement of these loss reduction measures is a condition of credit effectiveness for IDA financing of the recently negotiated Ashunganj power project.

29. Gas Losses. Apparent consumption of gas for domestic use is substantially higher, perhaps by four times, than cooking needs and the number of connections would indicate. A "loss" of about six percent of Titas gas sales is implied, with an economic value of about US$1 million annually, one half of Titas's pre-tax profits in 1979/80. The causes could include inadequate identification of total system losses, faulty meters, theft, or inadequate statistics. Efforts should be made to identify the causes of these losses, and corrective action taken.

Industrial Energy Conservation and Fuel Substitution

30. Preliminary audits of selected energy intensive industries (paper, steel, bricks, cement, textiles and ceramics) indicate considerable scope for energy savings through improved housekeeping (potentially 10% of total energy consumption or about 26,000 tons of fuel oil annually), fuel oil substitution by natural gas (up to about 260,000 tpy of fuel oil) and possibly further savings by process change or modification in certain industries, e.g. steel. The mission surveyed three categories of energy intensive facilities:

Category I - Those facilities in and around Chittagong currently using fuel oil but which will have gas available by 1983.

Category II - Those facilities in and around Dacca and Sylhet currently using gas, and

Category III - Those facilities such as the newsprint mill in Khulna (west zone) where gas is not expected to be available over the next several years.

31. Total fuel oil savings resulting from substitution of fuel oil with gas in the Category I facilities would be 101,000 tonnes/year (about 38% of total industrial fuel oil demand in 1979/80). The net value of these savings would be about US$14.1 million/year after accounting for the value of the gas replacement fuel. Investments amounting to some US$3.34 million would be required to retrofit these facilities and would have a pay-out period of only some three months. Clearly, top priority needs to be assigned to undertaking these investments to substitute fuel oil by gas. In the case of the Category II facilities surveyed, improved

housekeeping measures would result in natural gas savings varying from 22% of gas consumed at the Meghna textile mill, to ten percent at the Luxmi Narraynn textile mill, and to 1% at the Sylhet cement factory. The total gas savings from such measures would amount to only some 16.8 million CF/year, resulting in cost savings of only about $24,000/year and requiring an investment of some US$56,000. Thus, while conservation measures in these types of facilities appear less attractive than those in Category I or III, they still promise a rate of return on investment which is substantially higher than the cost of capital.

32. The case for housekeeping is strongest for the Category III facilities - those for which the prospects for gas substitution are low over the next several years. At the Khulna newsprint mill, for example, about 11% of current fuel oil demand (49,000 tonnes/year) can be saved by improved energy management, yielding a saving of about US$1 million/year for an investment of $230,000.

Energy Pricing 2/

Electricity

33. Bangledesh Power Development Board (BPDB). Historically, the revenues of the Bangladesh Power Development Board have been insufficient to cover the cost of operations. This is basically the result of insufficient tariff adjustments to reflect changes in the underlying cost structure, particularly the costs of fuel. In 1978/79 net losses of TK 293.6 million amounted to some 45% of total revenues of TK 649.8 million; in 1979/80 net losses (before TK 130 million government subsidies) increased to TK 376.1 million, or 42% of total revenues of TK 895.3 million. These accounting deficits understate actual losses since depreciation is charged at the low rate of 3.2% of book value (31 years life) and interest charges are based on subsidized terms for concessional loans and a nominal rate of 5% for government-financed portions of the investment program. Some long-term relief with respect to rising fuel costs is in sight (fuel accounts for 69% of total expenses and petroleum for 58%), with the hoped-for completion in 1982/83 of 200 MW of new, gas-fired and hydropower plants and the completion of the East-West interconnector, which will reduce the share of oil-fueled western generation by gas-hydro generation in the east. The existing tariff, introduced in July 1982, though lower than that based on long-run marginal costs, will go some way towards improving the financial situation of BPDB despite the constraints of high system losses. This tariff, however, will not realize a net internal cash generation sufficient to finance a reasonable percentage of BPDB 's investment programme. As a result of this GOB and BPDB have

---

2/ The exchange rate was 22 Taka (TK) = US$1 in July 1981 and 19TK = US$1 in October 1981.

agreed wtih external financing agencies to institute appropriate increases in real terms in the BPDB tariff to ensure realization of net internal cash generation sufficient to finance at least 20% of BPDB 's capital expenditure in FY83, 25% in FY84 and 40% in FY87. The mission welcomes this agreement. However, the agreed increases in BPDB tariffs may be inadequate to achieve these objectives if electricity sales turn out to bo lower than expected.

34. Rural Electrification Board (REB). Tariffs of the REB system are set on an individual PBS basis. The general principle underlying the tariff structures of each independent PBS is that they should be self-financing after a grace period of five years. This requires temporary subsidies by the Government to the REB system. These are estimated to amount to an average of TK 0.381/kWh during the first year of a new PBS operation, falling to TK 0.106/kWh by the fifth year and to zero thereafter. This assumes that average charges will rise from TK 1.00/kWh now to TK 1.778/kWh then. However, the recently negotiated bulk tariff from BPDB to REB of TK 0.78/kWh does not cover the economic costs of supply. These, at the 33 KV entry point, were estimated to amount to TK 1.61/kWh in domestic terms and TK 1.2/kWh in border prices. In other words, the REB system initially will obtain its bulk energy at less than half of the economic costs of supply. GOB has, however, recently agreed with IDA that a study of the bulk and retail tariffs of all supply authorities in the power sector will be carried out by December 1984; they will be based on long-run marginal costs and new tariffs will be implemented by July 1, 1985, for BPDB and PBS, based on the recommendations of the study. It was also agreed that until this new tariff is implemented, the average price per kWh sold by by PBS shall not be less than the average price per kWh sold by BPDB. The mission considers it important that the above time schedules be adhered to so that the many new REB customers do not develop a vested interest in continued public subsidies.

Petroleum Products

35. The Bangladesh Petroleum Corporation (BPC) endeavors to price petroleum products so that total financial costs of supply are recovered from sales. This is not always the case as needed price adjustments are often delayed. Furthermore, depreciation allowances and insurance coverage for the refinery are presently based on historic costs; they should be based on a replacement cost basis instead. The mission commends the Government on the recent measures to increase petroleum prices. This has removed the economic subsidies on diesel oil and kerosene which existed to June 1982. There is also the need to establish an automatic trigger mechanism to pass along to consumers any additional increases in costs of imported crude oil and petroleum products, as well as changes in the costs of the refinery operations.

36. The increase in LPG supplies from the refinery and natural gas separation will add to the inter-fuel pricing problem, because gasoline retail prices are more than four times higher than those of LPG on a volume basis. This differential could attract considerable conversions

from gasoline to LPG use in spark-ignition engines. With these levels of financial incentives legal enforcement of a possible prohibition of LPG use in vehicles will be difficult, as experience elsewhere has shown. At present the low level of market penetration of LPG is largely due to non-availability. This product should be priced at its full opportunity cost which implies a price increase at the ex-refinery level of over 200%.

Natural Gas

37. The issue of what is the long run opportunity cost of natural gas in Bangladesh is the first issue to be addressed. The country has very large gas reserves relative to domestic demand for at least the next couple of decades. This implies that the high-value uses of gas as a fuel oil substitute can easily be accomodated and, unless massive quantities of gas can be exported (a prospect that can, at best, only be considered very modest over the next several years), the opportunity cost of gas will fall to its long-run supply cost. For such a depletable resource, this supply cost includes both production costs and "user costs", which represents the foregone future value of the gas due to depletion. Given the major uncertainties involved in large-scale gas exports, either overland to India or as LNG to other countries, the mission considers that the opportunity cost of gas in Bangladesh is represented by its long-run marginal supply cost including a depletion allowance. Although the latter cannot be calculated precisely in the absence of a full macro-economic model, the mission calculated in range of estimates to indicate the order of magnitude. When these estimates are added to the long-run marginal supply cost to bulk consumers in the eastern zone of Bangladesh, the range of the total economic costs of gas shown below was obtained.

ECONOMIC SUPPLY COST PLUS DEPLETION FOR NATURAL GAS
FOR REPRESENTATIVE REPLACEMENT FUELS (1981 PRICES)
LEVELLIZED COSTS, 1981-2000
(Discount Rates 6% and 12%)

Replacement Fuels a/	Total Costs Per MCF			
	Discount Rate 6%		Discount Rate 12%	
	Taka	US$	Taka	US$
Fuel Oil at $194/ton	36.88	1.94	21.42	1.13
Coal at $71/ton	24.53	1.29	17.05	0.90
Natural Gas at $1.50/MCF	12.56	0.66	12.49	0.66

a/ Replacement Fuels and their costs in the year 2000.

38. Of the three possible fuels (fuel oil, coal and gas) which could replace existing low-cost gas in the eastern zone at the point in time that depletion of current proven and probably gas reserves becomes binding (about 2000), the most likely, from a technical standpoint, is

newly discovered gas for which development and production costs would be about three times higher, in real terms, ($1.50/MCF) than presently proven and probable reserves. The imported coal scenario is much less credible and the fuel oil scenario the least possible. On this basis the range of the total economic costs of gas to bulk consumers in the eastern zone is estimated to be between US$0.66/MCF and US$0.90/MCF assuming a 12% discount rate. The floor of this range is represented by new gas as the replacement fuel; the upper limit by imported coal.

39. Gas tariffs in July 1982 to the major bulk users (power and fertilizer) were about 75% of the lower level of this range. This suggests that these tariffs be increased. Clearly the minimum level of this tariff should be the "floor" of the range US$0.66/MCF to US$0.90/MCF. However, whether the tariff to bulk consumers should be increased above the "floor" and if so, by how much, depends on the issue of general resource and government needs to collect a larger share of the rent for development of other sectors, as well as ensure that the resource is not being sold below its economic cost to any consumers.

40. In the case of domestic and commercial consumers, the joint cost of service to these consumers was estimated by the mission, for the year 1979/80, to be about TK 45.89/MCF (US$3.11/MCF) compared with average revenues from these groups of TK 14.66/MCF (US$0.99/MCF). This implies that commercial and domestic consumers taken together received subsidies amounting to about US$2.12/MCF in 1979/80, or around US$7.4 million in total. This is to be compared wth Titas Gas Company's pre-tax 1979/90 profits of US$2 million. Arguments of distributional equity that are normally used to justify such subsidies to these consumer groups appear unjustified when it is recognized that these benefits accrue to less than 0.8% of all households in the country. Clearly a series of significant upward adjustments in the tariffs for domestic and commercial comsumers are called for. Since these tariffs have to be raised about 200% in real terms merely to cover costs they would have to be instituted over a period of time. It should be noted that raising domestic and commercial tariffs by about $2/MCF to cover their supply costs would mean that residential gas would still be about half the price of kerosene.

Renewable Energy Resources

Fuelwood

41. Fuelwood resources, both in Government forests and private woodlots, are being overexploited to meet the increasing demand. If the present trend continues there is every likelihood of a fuelwood crisis in many of the rural areas in the near future. Fuelwood prices increased in the period 1971-78 by an average annual rate of about 40% as compared to an inflation rate of about 18% annually. The need for taking up a massive tree-planting program in the rural areas is urgent. The success of such a program can be assured only if it is implemented with the active

involvement of the local people. The ADB is currently financing a Community Forestry Project along these lines. Further such projects should be considered, including tree-planting on private lands, strip plantations along roads, canal banks and railway lines, and fuelwood plantations involving the replacement of existing damaged forests with fast-growing fuelwood species.

42. Also, 2.4 million acres of unclassified forests in the Chittagong Hills tracts have been seriously denuded by shifting cultivation, reducing the cycle of cultivation drastically due to soil erosion, and leading to a diminishing return from the land. The consequent rapid siltation of the Kaptai reservoir will seriously affect the generating capacity of the Kaptai hydro-electric project. Rivers arising from this catchment area are also heavily silted up and floods have become a regular feature in -ecent times. A project for large-scale afforestation and for settling tribal groups on permanent land in this watershed could be initiated, resulting in improvement in the economic condition of the tribal people, substantial increases in wood production, establishment of forest-based industries, and creation of employment opportunities, in addition to soil and moisture conservation and general environmental improvements.

43. A note of caution, however, needs to be raised about projects in the Chittagong Hill Tracts which are populated by several ethnic minorities. Extreme care would have to be exercised to ensure that any projects in this area are not executed to the detriment of the tribal people. This is a critical issue.

Other Renewables

44. The Government is committed to the development of renewable energy resources; it has recently established a Rural and Renewable Energy Section (RRES) in its Planning Commission and included survey, R&D and extension components in its Second Five-Year Plan. These encouraging actions should be vigorously pursued, but there is an urgent need to clarify the terms of reference of RRES, strengthen it through more qualified staff and greater financial support, and review its priorities. The ranking of renewable energy activities needs to be based on: (a) those urgent needs of the rural sector which can be realistically met by delivery systems of near-term applicability in the Bangladesh context; (b) the degree to which project components can be determined and their net contribution appraised; and (c) the limitations of current planning and implementation capabilities. Given these criteria, the mission considers that the GOB should concentrate its efforts on large-scale dissemination of improved cooking stoves, community tree-planting schemes either in homestead or marginal land, charcoal conversion of logging wastes in the Kassalong Forest area, solar drying of grains, fish, fruits and vegetables and possibly biomass fuels. Biodigesters should be of lower priority and probably limited to animal feedlots.

45. Apart from a rural energy survey included as a component of the proposed technical assistance for energy to be financed by ADB and UNDP, and the USAID planned energy survey work to start in 1982, other areas of project activity for possible donor financing include a technical assistance program for the strengthening of the RRES for popularization of improved woodstoves (chulas) and for field testing demonstration of solar dryers, solar water heaters and solar pumps.

Energy Investment Program

46. The Government's proposed five year (FY80-85) energy sector investment program envisages expenditure of about US$2.05 billion. The mission has the following observations on this proposed program.

(a) Gas transmission and distribution investment of some US$180 million accounts for about 47% of total hydrocarbon investment. This may have to be increased if the urgently needed steps to enhance the security of supply of the Dacca gas distribution system are to be undertaken as well as the development of a second gas supply and transmission system to Dacca.

(b) The allocation for the rural electrification program (about US$230 million) represent about 23% of power sector investment. Given the significant scaling down of the program in its early years, investment in this area would be lower than envisaged. This could allow investment in distribution to be increased, which is a high priority, given the urgent need to reduce system losses.

(c) Investment in petroleum product production and distribution of about US$47 million (12% of hydrocarbon investment) appears low given the need to invest in recovery and storage fo LPG from the refinery (around US$11 million) and in a naphtha splitter (about US$4 million).

(d) Over US$50 million is allocated for atomic energy which is inordinately high given that this electrical energy source cannot compete with gas-based power in Bangladesh. This over-funding of atomic energy is further highlighted when compared to allocations for gas field development (about US$60 million) and petroleum product production and distribution (about US$47 million).

Energy Planning

47. There is a need for a medium-term energy investment plan for the period 1984-88 to be prepared similar to the medium-term foodgrain

production plan. The first step towards formulating such a plan would be a "stocktaking" of ongoing and proposed studies and projects and identification of other investment possibilities as components of such a plan. This medium-term investment plan would complement the longer-term comprehensive energy plan being financed by ADB and UNDP.

Energy Sector Developments, October 1981-November 1983 3/

Energy Demand and Supply Trends

48. The growth of commercial primary energy demand averaged 7.3% per year between FY78 and FY82 with large yearly fluctuations. In FY83, however, overall energy demand actually declined by 4%, due mainly to depressed economic conditions; GDP grew by only 2.5% in FY83 compared to 5.9% in FY81. The major recent change in the composition of energy supply has been the replacement of imported petroleum by domestic natural gas. Between FY81 and 83, petroleum demand declined by 14%, while natural gas demand grew by 36%. However, petroleum imports are still very costly to the economy, accounting for about 60% of export earnings mainly due to poor export performance. Currently, total commercial primary energy demand is on the order of 3 million toe with the following shares by fuel: natural gas, 51%; petroleum, 42%; and the remainder (coal and hydro) 7%.

Energy Pricing

49. Petroleum Products. The prices of all major petroleum products have been raised at or above their economic cost. Furthermore, the Ministry of Energy and Mineral Resources is now authorized to increase petroleum prices by up to 10% automatically, in response to increasing costs.

50. Natural Gas. The Energy Assessment made preliminary estimates that the levelized cost of gas to bulk consumers in the Eastern Zone of Bangladesh ranged from TK 17.05/MCF (US$.90/MCF) to TK 12.4/MCF (US$0.66/MCF). The July 1982, tariffs for bulk consumers were raised to about 80% of the lower level of this range. Recently, the long run marginal supply cost of gas was recalculated by IDA staff to take account of depreciation of the Taka between 1981 and 1983 and capital goods import inflation. The estimate now ranges from TK 16.3/MCF to TK 27.0/MCF. Based on these costs, bulk tariffs after the July 1983 increases amount to 70% of the lower end of this range. The Energy Assessment also pointed out that tariffs for residential consumers were about one-third the cost of servicing them. In June 1983, monthly

---

3/ Report No. 015/84, Bangladesh Energy Assessment Status Report, April 1984.

charges for unmetered consumers were increased from TK 35 to TK 45 for one burner households (28%) and from TK 65 to TK 80 for two burner households (23%). The extent to which natural gas prices should be raised will depend on various factors including the cost of supply, the amount of domestic financial resource mobilization required and the potential impacts on consumer. A gas tariff study will soon address this issue.

51. Electricity. Although progress has been made in raising tariffs, the average BPDB tariff increase from TK 0.99/kWh in FY82 to TK 1.30 in FY83 still brings electricity tariff levels to about 75% of the present LRMC estimate (TK 1.75/kWh). The most recent tariff structure reflects an average tariff increase from TK 1.33 in FY83 to TK 1.48/kWh in March 1984. At the same time an automatic fuel price adjustment clause of up to 10% was added to the tariff-structure. Also, there are plans for restructuring tariffs to reflect costs associated with peak and off-peak loads and a changeover to time of day metering is under implementation. A new tariff proposal is now under study by the Bank.

Energy Sector Organization

52. Recent developments include the start, in August 1983, of a ADB/UNDP financed Energy Planning Project to assist the Planning Commission formulate a long-term energy plan covering the next 20 years. The Bangladesh Petroleum Institute (BPI) has been created to centralize training, geological data analysis and advisory services for hydrocarbon exploration and development. A director has been appointed but BPI is not yet fully staffed and GOB needs to determine the extent to which similar functions currently performed by Petrobangla and the Geological Survey should be transferred to BPI. There have been two developments in the organization of renewable energy work: renewable energy planning is now the responsibility of the recently established Renewable Energy and Energy Economics section of the Planning Commission and project implementation in this sector is now carried out by the Energy Division of the Ministry of Energy and Mineral Resources. Also within the Ministry, an Energy Monitoring Unit (EMU) has been established to oversee energy conservation activities.

Energy Investment in the SFYP

53. During the April 1982 Aid Group Special Session on Energy, IDA offered assistance to the Government of Bangladesh (GOB) in preparing a detailed Priority Investment Program for Energy (PIPE) for the near term FY83-85. This project subsequently was carried out under the UNDP/World Bank Energy Sector Assistance Management Program (ESMAP). PIPE resulted in an energy investment project portfolio put together by GOB, IDA and other aid agencies. Most of the PIPE projects have been included in the latest version of the Second Five Year Plan (SFYP) which indicates total energy investment in 1979/80 prices of TK 20.52 billion (US$1.3 billion) or 18.5% of all public sector investment for the period from FY81 to

FY85. This allocation is about 30% lower than that indicated in the original SFYP, reflecting GOB's tight budget, but it still accounts for about a fifth of all public sector investment over the plan period.

54. The electric power sector accounts for about 70% of total energy sector investment. Of the total TK 14.36 billion (US$0.92 billion) allocated to this sector, 86% is for BPDB's generation, transmission and distribution program. The rest is for Rural Electrification Board (REB) programs of electricity distribution through consumer cooperatives (Pally Bidyut Samity or PBS). Most of the TK 6.14 billion (US$0.39 billion) allocated to the hydrocarbon sector (95%) is for Petrobangla's exploration and development programs with the remaining 5% divided among the Bangladesh Petroleum Corporation (for extending LPG recovery, a lubricating oil plant and new tankers), the Geological Survey of Bangladesh and the Ministry of Energy. The rest of the energy allocation, TK 1.49 billion is for renewable energy development.

this page blank

BOLIVIA: ENERGY BALANCE, 1981
(thousand tonnes of oil equivalent)

	Fuelwood	Charcoal	Bagasse	Crude Oil, Condensate, and N.Gasoline	LPG	Gasoline	Kerosene-Jet Fuel	Diesel	Fuel Oil	Natural Gas	Electricity	Total
Primary Supply												
Production	798		189	1095						2483	310	4875
Exports (Net)					(23)	(11)				(1862)		(1896)
Imports								39				39
Consumption in Export Pipeline										(180)		(180)
Total	798	-	189	1095	(23)	(11)	-	39	-	441	310	2838
Transformation and Losses												
Gas Plants				105	115					(242)		(22)
Oil Refining				(1162)	57	644	208	197	13	(28)		(71)
Fuel Blending						(151)	(16)	51	116			-
Thermal Power Generation								(60)		(102)	148	(324)
Charcoal Production	(49)	16										(33)
Transmissions & Distribution Losses						(3)	(1)	(11)	(1)	(15)	(24)	(55)
Inefficient Bagasse Use			(63)									(63)
Statistical Adjustment and Changes in Stock				(38)	3	(90)						(125)
Net Supply/Demand	749	16	126	-	152	389	191	216	128	54	124	2145
Demand												
Industry	4	17	126		8		28	34	116	54	32	419
Residential-Commercial	745				140		62				55	1002
Transport												
Road					4	375		150				529
Air						14	98					112
Rail & Barge							1	15	3			19
Mining							2	17	8		37	64

toe = 10 mn kcal
kWh = 2867 kcal at production level
860 kcal at consumption level

BOLIVIA 1/

1. Bolivia has a large energy resource base (1230 million TOE) relative to its present internal needs (1.9 million TOE). The hydropotential is by far the largest known resource, but only 287 MW of a total potential of 18,000 MW have been developed. Its hydrocarbon resources, including probable as well as proven resources, consist mostly of natural gas (some 6.7 TCF or 176 million TOE) and a more modest amount of oil and condensates (187 million bbls or 25 million TOE).

2. Bolivia is a net exporter of energy. The weight of energy in foreign trade has increased over the decade, despite the fact that the exportable oil surplus has ceased to exist and that Bolivia depends now on the willingness of one customer (Argentina) to buy its natural gas. Hydrocarbon exports, which in 1981 accounted for 32% of total exports, consist almost entirely of natural gas sales to Argentina. Hydrocabon imports, essentially diesel oil at the same time comprised 31% of total imports.

3. The modern Bolivian economy is based on liquid fuels, which currently supply almost four-fifths of commercial energy requirements. Natural gas has been recently introduced and its share is still less than 10%. Incremental demand of commercial energy will have to be provided through a balanced development of gas and hydropower production, transport and utilization facilities, in such a way that the domestic and export market potential can be achieved while minimizing the strain on the country's borrowing capacity.

4. The available options to increase energy supplies will have to be complemented by a massive program to assist energy users to increase the substitution of gas for liquid fuels, to reserve the scarcer liquid fuels to priority uses where their value is highest, and to increase the overall efficiency of energy use. The essential condition to stimulate this substitution process is the pricing of the individual energy forms at a level that reflects their opportunity costs. In addition, this will require an active and carefully directed program of demand management.

5. Although each region has a good energy resource base, the Altiplano has currently a huge energy deficit. The Altiplano valleys have a substantial hydropotential and the highlands itself have good solar irradiation but these resources have not been fully developed and no hydrocarbon deposits have been found in this region. The rural population suffers from an acute shortage of fuel, because of the almost complete absence of forest cover (depleted since colonial times). The urban population and the energy intensive mining and metallurgical

---

1/ Adapted from Report No. 4213-BO, April 1983.

Economic Context

Bolivia has a population of 5.7 million and an area of 1.1 million km^2, divided in three regions with distinct economic and trade patterns. Agriculture accounts for about 16% of GDP, provides employment for over 45% of the labor force and contributes 10% to exports. Mining and hydrocarbons account for 11% of GPD and 90% for exports, but employ only 5% of the labor force. Manufacturing contributes only 14% to GDP and 7.5% to employment. The service sector's share is about 60% in GDP and 40% in employment.

About half of the population is located in the Altiplano, (a highland three to four thousand meters high) occupying about one third of the country's area in the west and southwest. The valleys (Ungas) and the tropical lowlands (Llanos) in the east and north account for 49% of the population and 65% of the area. The lowlands have a low population density but experienced remarkable economic growth during the 1970s, largely based on the exploitation of this region's hydrocarbon resources. In addition, they benefit from relatively virgin agricultural lands with high productivity. This region maintains close trade relations with Brazil and Argentina whereas the Altiplano is better connected with the Pacific through Peru and Chile.

Bolivia is currently going through one of the most difficult phases of its economic history. Since 1979, the country has been facing severe foreign exchange constraints, caused by declining prices for its mineral exports and the increasing cost of foreign debt service. In 1981, the per capita GDP was already 6% lower than in 1978 and urban unemployment has been growing while capacity utilization has continuously declined since 1979.

The Bolivian government has made and will need to continue to make difficult choices to gradually redress the economy. It has curtailed the allocations of foreign exchange, devalued the Bolivian currency by a factor of eight over a nine month period, and eliminated subsidies on basic foodstuffs. Prices for hydrocarbon products were increased by about 200% and electricity tariffs by 300%, restoring a more adequate level of revenue to finance the crucial investments required to meet projected energy demands.

activities depend on liquid fuels (65% of Bolivia's total consumption), which are met by supplies from the lowlands through a well developed pipeline system. Also, the Altiplano region is now being connected with the eastern electric power system based on natural gas. This offers the choice between expanding the generating capacity by developing the Altiplano hydropotential or importing electric power from the eastern lowlands.

6. The rural population of Bolivia still relies mostly on fuelwood for their energy needs. In the Altiplano, this population suffers from a century old shortage of fuelwood which has contributed to its total deforestation and substantial degradation of its soil. This has also extended to the adjacent valleys, which are now largely denuded, especially near the traditional mining areas of the southern Altiplano. Although the improvement of this situation must be supported by a long-term program of reforestation and utilization of agricultural wastes, the energy issue cannot be considered in isolation from integral rural development and long range agricultural resettlement policies.

7. Overriding these energy problems, Bolivia faces a critical balance of payments disequilibrium that has paralyzed the country and threatens future growth prospects. This makes it urgent to evaluate the energy sector's capability to increase foreign exchange earnings; present gas exports to Argentina already provide 30% of these earnings.

8. A long-standing proposal for a gas export project to Brazil is currently being negotiated. The decision to go ahead depends on the certification of sufficient reserves and on the agreement of a mutually acceptable price for gas.

9. The mission has evaluated the data on gas reserves and considers that on the basis of present information on the resource base, there are sufficient grounds to be confident that the new export commitment can be satisfied. A reserve evaluation study, shortly to be contracted, will provide further guarantees.

10. The exportable gas surplus has been estimated on the basis of internal requirements over a 30-year period (2.7-3.1 TCF) and the existing gas export commitment to Argentina (0.8 TCF). The internal demand is estimated under an extreme scenario assuming that final energy requirements would grow at 4% p.a., that oil supplies would decline by 2% per year and that incremental power requirements would be gas-generated. It has further been assumed that Bolivia would build a commercial sized ammonia-urea complex in the 1990s and possibly a plant to convert gas into methanol or gasoline, and operate these plants over 20 years.

11. The gas export project to Brazil is based on a supply commitment of 400 MMCFD or 2.9 TCF over 20 years. If reserves of gas are substantially less than the present estimate for proven (5.0 TCF) and probable reserves (1.7 TCF) or if exports to Argentina continue after

7991, there could well be a supply gap. Therefore, appraisal activities to prove up reserves in known fields and intensive exploration to discover new resources must take place in the event the export project is implemented. On the other hand, 30% of the internal estimated gas requirements correspond to power generation, which could alternatively be supplied through a carefully balanced hydropower development program.

12. The price negotiations are crucial for the export project and difficult because of the present oil surplus in international trade and because of Brazil's efforts to restructure its internal energy market. In principle, the two governments had agreed in 1978 to price the gas in terms of the thermal equivalent of the liquid fuels to be replaced in the Sao Paulo area. In the short term, this means that the gas will be related to the price of industrial fuels, mainly fuel oil. There are several possible interpretations to this agreement, and they produce an estimated price range for gas of US$3.67-5.30/MCF (at 1010 Btu/CF) in Sao Paulo and a border price range from US$2.30-3.92/MCF in 1982 dollars. This compares with a current border selling price to Argentina of US$4.27/MMBtu.

13. The large price ranges indicate the difficulty of reaching a favorable agreement. At the lower end of the price range, the project would not cover Bolivia's long term economic costs, considering that the production and transport cost of gas to the border is US$1.65/MCF and that the incremental capital cost of switching to hydropower is equal to some US$0.94/MCF. Another aspect to consider is the net effect on the trade balance. Even at the lower price, the project would generate an increase of about US$200 million in net foreign exchange earnings, assuming that the project's cost (US$800 million) will be financed through international loans and repaid during the first ten years of the project. Other elements to be taken into account in the negotiations are the security of supply which this project would provide Brazil and the contribution that gas would have on the air quality of Sao Paulo.

14. The mission also reviewed gas conversion processes (ammonia-urea and liquefaction to methanol and gasoline) and found that at present, neither of these provide a realistic alternative to direct gas exports. These projects have a poor rate of return, in some cases even negative net back values for gas, because the domestic market is too small to provide a reasonably guaranteed scale of production and the international market has a high risk because of the excess supply likely to occur during the second half of the 1980s.

15. However, there exists a real possibility of industrial complementarity between Brazil and Bolivia. Both governments agreed in 1978 to enter into joint ventures for processing gas. On the basis of this precedent, the mission strongly recommends that Bolivia continue to explore the joint development of a fertilizer and/or a methanol plant with Brazil.

Domestic Market

16. In 1981, Bolivia consumed internally about 2.8 MMTOE of primary energy and exported 1.9 MMTOE. Natural gas exports to Argentina represented 98% of the exports, the rest consisted of LPG, gasoline and naphthas.

17. The long range projection of future energy demand is particularly difficult for Bolivia because the energy sector and the economy are undergoing major transitions. In order to provide an analytical basis on which to assess policy options, three alternative demand scenarios were developed. These were based on the assumption that economic recovery would be slow until 1983 and that thereafter the economy would grow on an average rate of 5% per year.

Oil Deficit

18. Projections of oil supply and historic demand trends indicate that a supply deficit of over 13 MBD equal to 40% of the demand for oil products will occur by 1990. This will exacerbate the qualitative imbalance which Bolivia already faces between the refinery yields and the type of products demanded by the market.

19. The mission recommends a three-pronged approach to avoid the long term oil deficit: (a) supply-oriented investments to compensate for the rapidly declining oil production and so postpone the onset of a major oil deficit; (b) investments in gas transport to substitute for oil; and (c) demand management measures, including pricing policies, to induce energy users to change their pattern of consumption and use energy more efficiently.

20. The mission proposes, as a minimum objective by 1990, the reduction of Bolivia's dependence on oil from the current 77% to 44% of total final commercial energy consumption, compensated primarily by increasing the direct use of natural gas from 4% to 10% and of LPG derived from gas from 9% to 23%.

Investment in Increased Oil Supply

21. The investment requirements to maintain an adequate supply of liquid hydrocarbons for the domestic market have been estimated at US$440 million (1980 prices) during the period 1982-1990. During the first years, emphasis should be on the development of already discovered condensate fields and on enhanced oil recovery projects. Some of these projects have already been delayed and their further postponement would lead to an unmanageable oil deficit by 1985. The mission fully supports the early implementation of the Vuelta Grande development project, and suggest that other recently discovered fields, such as Tacobo and Montecristo, be evaluated. Similarly, the mission supports the Bolivian

national oil company (YPFB) in its endeavour to obtain financing for the Monteagudo and La Pena secondary and tertiary recovery projects and for the LPG extraction plant at Vuelta Grande. It further suggests that feasibility studies for enhanced recovery projects be made for the oil fields of Caranda, Camiri, and Cambeiti, which still contain significant amounts of oil.

22. The actual proven reserves-to-production ratio for liquid hydrocarbons is close to a minimum acceptable level (12 years). Therefore, exploration efforts during the first period should be concentrated on defining the extensions of the fields already discovered and confirming the existence of probable oil and condensate reserves. The prospects of finding new oil fields in conventional structural traps are modest and only stratigraphic traps offer the potential for large additional resources although the exploratory risk is high. YPFB has an interest in initiating this type of risky exploration activity, but the mission considers that while this program may be economically justified it should be postponed to the second half of the decade unless private companies are willing to take most of the risk.

23. It is the mission's opinion that the results of the negotiations with Brazil do not affect crude and condensate production, because it is less dependent on the expansion of the gas market than originally thought. The already developed condensate fields provide the bulk of present oil and gas production. During the next 10 years oil production from these fields can only be sustained if gas is reinjected to achieve maximum recovery of liquids. Consequently, their net gas production will increase slowly. During this time, new export commitments will have to be supplied from new and mostly dry gas fields, developed specifically with that objective, and these do not contain large amounts of liquids. This opinion must be validated by a detailed reservoir engineering study for each field with a large gas production potential. Such a study will also provide the basic input for an optimization model, required to program the orderly development of Bolivia's hydrocarbon resources.

Investment in Gas Pipelines

24. The Altiplano region uses 90% of the fuel oil and 60% of all petroleum products consumed in Bolivia. Therefore, this region must be the prime target for substitution by gas. There are two separate pipeline projects for the Altiplano with a total investment cost estimated at US$170 million. The first (US$130 million) is a new line from Santa Cruz to Cochabamba and the reconversion of an existing oil pipeline to extend the service from Cochabamba to Oruro and La Paz. IDB has approved a loan for this project, which would have an initial capacity of 33 MMCFD and a final design capacity of 90 MMCFD. 2/ The

---

2/ In the meantime, YPFB has modified the design of the Altiplano pipeline and will therefore have to renegotiate the loan.

second project resulted from an emergency decision taken by YPFB, induced by the delay in the disbursement of the former loan. This project is to extend the existing southern Altiplano line Monteagudo-Sucre not only to supply Potosi, but also Cochabamba and connect there with the reconverted line to Oruro and La Paz. This line (US$40 million) is planned to have a gas carrying capacity of 25.7 MMCFD.

25. The simultaneous construction of both projects will result in an initial excess capacity in Cochabamba of 39 MMCFD 3/ and in high transport costs. On the other hand, the capacity of the southern emergency line will be fully used by 1985, thus limiting the substitution process in the following years. In view of the investments already made in the expansion of the Monteagudo-Sucre line, the mission recommends that this line be completed and that the decision on the new Altiplano pipeline be postponed to 1985-86, when the market trends become clearer.

26. The mission considers that the project to build a pipeline network in the Tarija department is not justified at this time.

Demand Management

27. There is scope for energy and specifically oil, conservation in all sectors of the Bolivian economy, but main emphasis should be placed in the transport and industrial sectors, including the latter metallurgy and the energy sector itself.

28. The transport sector should be given priority because it accounts for 60% of total final demand for refined petroleum products. A 15% reduction in the projected 1990 consumption in transport would save enough liquid fuels to supply the requirements of the household sector, without having to develop gas distribution pipelines in Bolivia's major cities. Among the immediate measures should be included:

(a) improving traffic flow in urban areas, by introducing and enforcing parking and stopping regulations, staggering work hours to spread commuter rush over a longer period; introducing priority lanes for mass transports;

(b) continuing the import ban on diesel-engine vehicles;

(c) sustaining an effort to rehabilitate the road infrastructure and improve road maintenance to increase the efficiency of transport. At the same time, the mission recommends that a study be made to evaluate the feasibility of replacing part of the asphalt (most of which must be imported) used in road paving by mineral sulphur, to reduce the cost of paving; and

---

3/ Capacity of 55 MMCFD at Cochabamba versus an immediately connectable demand of 16.1 MMCFD, in Cochabamba, Oruro and La Paz.

(d) carrying out studies to improve truck capacity utilization (increasing load factors) in interregional freight traffic.

29. In the industrial sector, the expected changeover to natural gas in major plants offers an opportunity to survey their energy requirements and to plan the conversion program in a way that the efficiency of energy utilization (gas, liquid fuels and even electricity) is increased to a level consistent with the best current practice. The mission suggests that YPFB create a technical advisory service to promote and assist industries in their conservation projects.

30. Energy surveys and audits should immediately be made in about two dozen major industrial plants, including tin smelters, cement, glass, paper, ceramics, sugar plants and the oil refineries. At the same time, it is suggested that the scope for product waste recovery be pollution control equipment be assessed. Once potential savings are identified and quantified, YPFB should provide technical assistance to evaluate and implement projects and credit lines should be opened to those enterprises which have agreed on a conversion-conservation project with YPFB.

Foreign Trade

31. Currently, the oil industry has a surplus of gasoline and LPG and confronts and increasing shortage of diesel and fuel oil. This imbalance between refinery yields and the structure of demand cannot be solved through refinery modification. However, in the long term, the substitution by gas will considerably alleviate the problem. 4/

32. In the meantime, YPFB tries to barrier its surplus with neighboring countries. Despite high transport costs, which probably cannot be reduced without considerable investment, Bolivia could profitably expand its foreign trade if its industry could use fuel oils with higher sulphur content. The mission recommends that YPFB study the characteristics of the fuel oil burning equipment of its major industrial clients.

Electric Power

33. In early 1983, the national power company (ENDE) reassessed its expansion program and modified its 1981 investment plan, to take into account the lower than expected growth in energy demand, the country's

---

4/ The Bolivian crudes yield on the average 62% of light fractions, 33% of middle distillates and 5% of fuel oil, while the domestic market demands 52% of LPG and gasolines, 38% of kerosene and diesel and 11% of fuel oil.

present financial constraints and the transfer of the La Paz market to ENDE.

34. In the new version of the electric plan, it is estimated that demand for electricity would grow at 5.2% per year during 1982-1985, increasing to 6.5% p.a. in the period 1985-1990. Under these assumptions, ENDE considers that, with the capacity additions currently being executed, energy and peak demand can be supplied until 1986, and that final decisions on further capacity expansion and on the choice of the primarily energy source for power generation can be postponed a few years.

35. The economic choice between gas-based thermal generating capacity and hydro-power expansion depends on the opportunity cost of natural gas. The mission has estimated (assuming a 12% discount factor) that if the export value of gas in Santa Cruz is above US$3.30/MCF then the least cost solution for future expansion is the development of Bolivia's hydropower potential.

36. The mission, therefore, recommends that the hydropower projects be postponed until the negotiations with Brazil have been completed and Bolivia's economic prospects have become clearer. This would also provide the necessary time to resolve the technical issues related to two specific hydropower projects (Icla and Misicuni) and to revise the cost estimates of other projects, including the geothermal alternative. In the meantime, additional capacity requirements can be supplied by the installation of gas turbines or combined cycle.

37. Most of the isolated and rural power systems depend on scarce diesel for power generation. ENDE is gradually assuming responsibility for the power supply in these systems, and should consider the possibility of connecting them with the integrated system and/or study the feasibility of installing small hydro plants or other renewable-based generating equipment.

Fuelwood and Other Renewable Energy Sources

38. Bolivia has considerable forest resources and exports about 90,000 m^3 high quality wood products per year. However, these resources are located mainly in the scarcely populated tropical lowlands. In the Altiplano, there is practically no remaining forest cover and the large rural population relies on shrubs and animal waste to satisfy their energy requirements, with consequent adverse effects on the already highly eroded environment. In the southern tip of Bolivia (Tarija), uncontrolled past deforestation has caused an erosion problem of major proportion. In some of the Altiplano valleys, soils are not suitable for sustained agricultural activities and reforestation could provide the local population a means to increase their agricultural revenue through the sale of timbers, fuelwood and charcoal.

39. Total fuelwood consumption is estimated at 2.1 MMton in 1980, of which 42% is in the Altiplano and 29% each in the valleys and the lowlands. In addition, some 2,500 tons per year of charcoal are being produced, most of which comes from the Santa Cruz and Chaco regions and is consumed in Bolivia's tin smelters some 1,000 km away. In the Altiplano unconventional energy technologies, such as biogas, windpower and solar energy, are expensive relative to the income of the rural household and require a social and technical environment that can only be brought about through continuous technical support. Furthermore, the conditions of the Altiplano limit considerably their potential to serve as fuel for cooking. The mission therefore recommends that the energy problem of this region be treated as a part of integral rural development programs and energy technologies be adapted taking into account the conditions of each location.

40. A national forest program needs to be developed to improve the supply of energy, protect the soils from erosion and to rationalize the exploitation of tropical forests. The mission has identified three specific areas of action.

(a) In the Altiplano, it is suggested that the already existing and successful reforestation projects LOS OMASUYOS/LOS ANDES be expanded to meet the demand for seedlings and technical assistance of the intended local population. Furthermore,, assistance is required for agricultural research of multipurpose crops (food and energy) and applied forestry research to identify new trees which would survive in the harsh Altiplano climate. In addition, a site should be identified near ORURO to develop a reforestation program with fast growing fuelwood species in order to guarantee supplies of charcoal at lower cost to the tin smelter of VINTO.

(b) In the Tarija Valley, the current soil recuperation program should be expanded to avoid further loss of agricultural lands. (It is estimated that some 800 ha of land are being lost per year). It is suggested that small woodlots and strategically located industrial forest plantations be developed to take the pressure off the few remaining wooded areas and allow regeneration. The program has to be complemented by protection from overgrazing and civil construction works.

(c) In Chuquisaca, the regional development corporation has been successful in developing a reforestation and conservation project in an area which has almost been completely deforested. This project promotes planting of small woodlots near the local ceramics industry, and, thus, reduces the cost of firewood to these companies, creates immediate employment, provides a cash income for the rural population, and improves oil conservation and water management. Technical and financial assistance to increase the capacity of the nurseries, improve

species selection, reforestation techniques and monitoring activities and expand into new rural areas are required.

(d) In the tropical lowlands, technical assistance should be provided to rationalize exploitation of industrial woods and to improve the efficiency of charcoal production. This program should include forest management techniques, harvesting practices, transport, and use of waste wood.

Policy Implications

41. The considerable investment requirements, the level of energy prices in the internal market and some institutional weaknesses are the main constraints to achieving the sector's objectives. Therefore, the mission recommends some policy changes to overcome these limitations.

Investments

42. The minimum energy sector investment requirements for the decade are estimated at US$2,300 million, assuming that the gas export project to Brazil is implemented. The annual capital expenditures would raise from about US$210 million per year during the period 1982-86 to about US$300 million per year for 1986-1990. This would represent approximately 53% and 60%, respectively, of the estimated total public investment budgets for both periods. These shares for energy are extremely large considering the need for stimulating the other sectors of the Bolivian economy and the country's limited borrowing capacity, and indicate that the alternative strategy of increasing private participation in the development of the sector should be considered.

43. Under the assumption that the pipeline project does not materialize, the minimum investment requirements in energy would decrease to about US$1,000 million, with annual average expenditures of US$82 million during 1982-86 and US$142 million during 1986-1990. This represents 21% and 28%,respectively, of estimated total public capital spending. The difference between the two scenarios is mainly due to the direct cost of developing the gas fields and building the export pipeline and to the switch from gas to hydro for expanding the generating capacity of the electric system.

Energy Pricing

Hydrocarbons

44. There are two different pricing problems to be solved in the hydrocarbon sector: the absolute price level and the relative price structure.

45. On November 6, 1982, the Bolivian Government increased domestic oil product prices by about 200% to an average of about US$16 per composite barrel. Although these prices are still 50% below their opportunity cost, the measure is a significant step towards restoring the financial position of the oil corporation (YPFB). The mission recommends that prices be pegged to the dollar and raised gradually and periodically at a higher rate than internal inflation and that the Bolivian Government adopts the objective of setting prices at the opportunity cost level.

46. The relative prices of oil products and natural gas must be structured so as to give the right incentives to interfuel substitutions. The price of gas should reflect its opportunity cost or its supply cost. Fuel oil and diesel prices must be increased to the level of gasoline in energy equivalent terms to reflect their scarcity. Simultaneously, the kerosene price and the price of domestic LPG should be increased to avoid their use as substitute fuels in the industrial sector.

47. The opportunity cost of natural gas depends on whether or not a pipeline to Brazil is built. Immediately, the price of gas should be doubled to US$2.00/MCF, to cover its production and transport costs. At that level, it would be equivalent to a fuel oil price of US$11.50/bbl and allow an adequate margin for recovering the expenditures in conversion equipment. Once the exports to Brazil take place, the price of gas in Bolivia should be raised to the equivalent of the export net back in Santa Cruz plus transport cost. Under the lowest price assumptions, this value should be in the order of US$2.80-3.65/MCF.

Electric Tariffs

48. ENDE is in a very strained financial position. Although the Electricity Code guarantees a 9% rate of return, the corporation achieved only a 6.8% rate of return in 1981. In 1982, the Government authorized a 517% increase in tariffs (54% in February and 300% in November). However, the average bulk tariff (US¢3.7/kWh) is still below the estimated long run marginal cost (US¢5.85/kWh under the hydro-based expansion alternative) and does not permit meeting ENDE's objectives of a 9% rate of return and level of self-financing of 44%. Thus, the mission recommends that tariffs be gradually adjusted upwards by a rate higher than internal inflation with the objective of reaching the level of the long-term marginal costs.

49. Furthermore, there are considerable differences in the tariffs applied by the regional distribution companies, both in terms of the levels of the energy and demand charges and of their structure. The mission urges the Government to proceed as soon as possible with a national tariff study.

Institutions

50. To meet future energy needs, the Ministry of Energy and Hydrocarbons has to fully assume its responsibility for formulating energy policies, coordinating plans and monitoring the execution of projects within the energy corporations. To this end, a strong and capable planning department must be created, adequately staffed and trained.

51. To achieve the desirable changes in the pattern of consumption, the support of the Bolivian population must be obtained through a public information campaign, technical assistance, a legal framework, and credit lines for conservation project evaluation and implementation.

52. In the hydrocarbons sector, the policy regarding private participation in the activities of the sector must be more clearly defined. The general Hydrocarbon Law and/or its regulations should be revised to adjust the contract model to the current features of international contract formulas. It is suggested that attention be given to forms of private sector participation that, while not conferring any title to production, would directly link contractor remuneration to successful increases in petroleum production. It would also be advisable to modify the tax laws and change the taxable income basis from gross to net revenues. These measures would enhance interest in marginal prospects and induce private participation in peripheral activities.

53. The loss of professional staff in YPFB, the inadequate delegation of authority and accountability and the lack of coordination between operating and financial objectives are serious problems that hamper the national oil company's performance. The mission recommends that the following measures to strengthen the institution be implemented:

(a) Definition of the specific functions of each managerial and operating unit, with clear formulation of objectives, staff requirements and control systems.

(b) Reform of the salary structure, directly relating salaries of management and technical personnel to the level of responsibility, productivity and to the competitive levels in the private sector in and outside Bolivia.

(c) Outline of a career development program, taking into account YPFB's long-term managerial and technical personnel requirements.

(d) Introduction of new and upgrading of already existing administrative and financial control systems and methods, in order to provide management with up-to-date and continuous information on stocks, flow and inputs and outputs, and on financial transactions.

(e) Introduction of modern analytical tools (models) to plan and evaluate investment strategies and to optimize present operations.

(f) Contracting an outside productivity and performance expert, with sufficient authority to induce changes that will result in cost savings.

54. In the power sector, the long standing issues with the Bolivian Power Company have apparently been solved by the Government's announced decision to nationalize this private company. The integration of the largest market (La Paz) into the national power company (ENDE), was an additional reason for revising that company's development program. In addition, the Mission recommends that a national tariff study be performed.

55. A sustained and orderly effort must be made to improve rural energy supply. The Institute of Rural Electrification does not have the technical and financial capability to execute such a policy. The mision recommends that an alternative institutional arrangement be sought for executing the rural electrification programs.

Technical Assistance

56. The main areas in which external assistance is required and not yet provided can be grouped as follows: (a) planning at the global energy level as well as in specific fields of the hydrocarbon, power and forestry sectors (b) demand management, including energy surveys and audits; and (c) specific studies. This assistance should emphasize training of local personnel to insure continuity of action. Priorities include:

Ministry of Energy and Hydrocarbons (MEH)

1. Consolidation of the energy planning unit and set-up of an Energy Data Bank.

2. Organizational study to strengthen DINE and DNH.

3. Review of the legal framework (laws and regulations) for contracting hydrocarbon prospects with private companies.

4. Design of an energy conservation policy: legal aspects, financial incentives and information campaign.

5. Urban transport study to enhance efficient energy use.

6. Organization study of YPFB to improve coordination and efficiency of integrated operation. It should include the following aspects:

   (a) Analysis of the company's organizational structure, functions and objectives of each managerial and operational unit, evaluation of present and future staff requirements, and control systems.

   (b) Analysis of salary structure and development of a career development program.

   (c) Development of a management information system.

   (d) Introduction of modern analytical planning and optimization models, including refinery model and an investment model for scheduling development of oil and gas fields.

7. Fixed term productivity expert to induce cost saving measures.

8. Set-up of a conservation advisory group to provide technical assistance to the Bolivian industry in the implementation of energy conservation and conversion projects. Training in energy management techniques.

9. Evaluation of LPG reserves and investment requirements for extracting, transporting, and distributing LPG.

10. Pre-feasibility study for the use of compressed natural gas (CNG).

<u>National Power Company</u>

11. Preparation of a cost manual to uniform cost estimates of power projects and enable valid comparison among alternatives.

12. Study of the national electric tariff level and structure.

13. Organizational study of the electric sector.

14. Formulation of a national rural electrification plan.

<u>Ministry of Agriculture</u>

15. Formulation of a reforestation program, including the following specific projects:

    (a) Intensive reforestation in ORURO for charcoal production.

    (b) Extension of the reforestation projects in the rural areas of the Altiplano, Chuquisaca and Tarija.

    (c) Applied research in agro-forestry.

(d) Training in forestry management and charcoal production.

Special Studies

16. Options increase benefits from international hydrocarbon trade.

17. Evaluation of energy efficiency in sugar plants. Economic analysis of the uses of surplus bagasse including alcohol production.

18. Pre-feasibility study on the use of mineral sulphur for road paving.

This page blank

BURUNDI - COMMERCIAL ENERGY BALANCE, 1973-80
(tons of 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	128910	15270	13700	18050
Kerosene	3200	2500	1700	1700	1040	1310	1070	910
Diesel & Fuel Oil	6500	9900	7000	9100	9210	12290	11750	16300
Petroleum Products	19500	25900	18800	23500	23140	28870	26520	35260
Electricity	5990	6170	6330	6720	7540	8630	9100	10200
Total	25490	32070	25130	30220	30680	37500	35620	45460
Thermal Power Generation								
Petroleum Products Used	-370	-370	-340	-340	-340	-400	-400	-470
Electricity Produced	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

toe = 10.5 mn kcal
kWh = 2670 kcal

BURUNDI 1/

1. 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.

2. 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 m^3 fuel wood equivalent, and traditional fuel consumption accounts for at least 90% and perhaps over 95% of the total energy consumed. 2/

3. Three-quarters 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.

4. 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.

5. Commercial energy consumption per capita and per unit GNP 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

---

1/ Adapted from Report No. 3778-BU, June 1982.

2/ A conservative consumption estimate of .5 m^3/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 1m^3/person/year, the total would be 1,050,000 TOE or 96% of total energy consumption in 1980.

Economic Context

Burundi is a small, landlocked country of 27,820 km^2 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 km^2, 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.

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.

imports imposed by the country's geographic position and partly to the low energy intensity of its productive sectors.

6. 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 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.

7. 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

8. 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

9. 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

10. 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.

11. 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.

12. 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

13. 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.

14. 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 US19¢ 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

15. 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.

16. 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.

Energy Sector Developments, May 1981 - August, 1983 3/

17. In the forestry sector, the Forestry Department and the major aid agencies have agreed that the formulation of a consistent national forestry policy is a high priority. When completed, the current survey of woodfuel needs by the SNES (Service National des Etudes et Statistiques) should help in designing this policy. Formulation of the policy should take into account basic constraints that could adversely affect its implementation, such as a lack of reliable statistics, a lack of trained personnel and management expertise, low salary levels for civil servants, and a lack of coordination among government entities and the international donor community. The lack of trained personnel in particular remains a critical obstacle in all forestry work, including coordination of ongoing reforestation. As the strengthening of forestry administration is considered essential, the European Development Fund (EDF) is providing technical assistance to restructure the Forestry Department. Efforts to reduce the demand for woodfuels, e.g. through improved cooking stoves, are just beginning, mostly on a limited scale in various locations. However, two larger scale improved stove programs are being launched: the production and dissemination of an improved version of the traditional, metal charcoal stove in Bujumbura, under the IDA Urban Development Project and the production of a portable clay stove for dissemination in three rural areas under the IDA Forestry Project. In both of these programs, the stoves are to be produced by artisans in their established workshops and the market mechanism is relied on for dissemination. This is a sound approach which has worked in the case of the "jiko" charcoal stove in Kenya, and the results of these programs should be closely monitored. Consumer response to the models put on the market must be carefully gauged and the programs must have the capacity and flexibility to modify the design of the current models and/or present a variety of models to meet consumer preferences.

18. With respect to peat, ONATOUR, with USAID assistance, has proven mechanized production methods in the highland bogs; production from this project is estimated at about 11,000 tonnes for 1983. Having estimated reserves at 36 million dry tonnes of usable, good quality fuel peat in its survey of 40% of the total Akanyaru area in Burundi, the Finnish firm EKONO (financed by FINIDA, the UNDO, and IDA) will conduct a production test in 1984. As for the Nyamuswaga bog, USAID is financing a survey and hydrological study with a view towards drainage, while a Swedish group is seeking funds to set up a pilot plant for in situ methanization of the peat. On the market side, the army is still a major consumer. In spite of ONATOUR's marketing efforts in Bujumbura, including free distribution of a peat cooking stove with the purchase of peat, peat has not gained acceptance for household cooking because it

---

3/ Report No. 011/84 Burundi Energy Assessment Status Report, January 1984.

behaves differently as a fuel than charcoal, which people are accustomed to cooking with, and because there is no price incentive to substitute it for charcoal. However, ONATOUR has made some headway in spelling peat to institutions and small industries (e.g. bakeries, hospitals).

19. In the petroleum sector, gross domestic consumption of products in 1982 rose to an estimated 40,100 toe, up 6.6% p.a. from 35,300 toe in 1980, while the oil import bill for 1982 amounted to US$30.2 million, an increase of 10.6% p.a. from US$24.7 million in 1980. In early 1983, petroleum products cost over US$100 per bbl c.i.f. Bujumbura. In mid-May 1983, the Ministry of Commerce and Industry (MCI) established a new price structure, still based on the price of products from the Mombasa refinery, but in which the cost of petroleum products c.i.f. Bujumbura dropped to about US$85 per bbl. About 30% of the reduction was due to a lower price for the products ex-refinery in Mombasa, but close to 60% of it was due to a reduction in the allowance for transport costs by the MCI. The results of an ongoing Duke University seismic program on Lake Tanganyika and of the interpretation of gravity and aeromagnetic surveys funded by a Project Preparation Facility to the proposed World Bank Third Technical Assistance Project and by the Energy Sector Management Assistance Programme (ESMAP) suggest that oil could have accumulated in producible quantities under Lake Tanganyika and/or the Ruzizi plain. ESMAP financed consultants will assist the Government in defining an exploration promotion strategy to attract private oil companies, one of which (AMOCO) has just made an exploration offer.

20. Total electricity consumption grew at an average of about 11% p.a., from 40.2 GWh in 1980 to 49.2 GWh in 1982. On the generation side, the Mugere run-of-the-river station, which is connected to the Bujumbura system, started operations in May 1982. The installed capacity is 8 MW, and contrary to expectation as many as 6 MW were available during the 1982 dry season. The Mugere station should provide an output of over 35 GWh p.a., which would meet more than half of Bujumbura's projected demand for 1983, thereby reducing dependence on power imported from Ruzizi I. The contract for civil works for the 18 MW Rwegura hydro station was signed in April 1983. Rwegura is being developed to reduce Burundi's dependence on imported electricity and is to be in operation by 1987. Burundi, Rwanda, and Zaire have decided to participate in the Ruzizi II hydroelectric project (two 13.3 MW generating units), to be cofinanced by IDA, the European Development Fund, and the Government of Italy. The project was approved by the IDA Board in December 1983 and work on construction will begin around mid-1984. The plant should come into service at the end of 1987. A reduced scheme of 80 MW has been decided on for the Rusumo Falls plant on the Kagera River, and invitations are being prepared for consultants to submit feasibility study proposals. In addition to these projects, eight isolated minihydro plants, all under 300kW, are under construction or being planned for sites near rural clinics and schools. To make use of the power from the new plants, an IDA project has been proposed which would increase transmission and distribution capacity by the construction of: (a) a 110 kV line from Ruzizi II either to Rwegura, for transmission of power to Bujumbura via

existing facilities, or directly to Bujumbura; (b) 30 kV lines connecting Citiboke, Bubanza, Rugombo, and Muzinda to the national grid; and (c) electrification of low income districts in Bujumbura. Financed by the European Development Fund, Lahmeyer International has just completed its preliminary version of an assessment of Burundi's hydro potential and of its existing power system, demand projections, and a master plan which is to serve as a basis for power system development. Power supply and demand projections for Burundi need to be reevaluated in light of Rwegura, Ruzizi II, and production from the Mugere station, and a detailed study need to be made of extending the network to mark further use of the power which is to be available.

21. With respect to renewable energy, Iceland's National Energy Authority carried out a reconnaissance of 14 geothermal sites in 1982, concluding that the Ruzizi plain holds the most promise for geothermal development, the temperatures there being adequate for industrial and domestic use, though not high enough for power generation.

This page blank

COSTA RICA: ENERGY BALANCE, 1981
(thousand tonnes of oil equivalent)

	Fuelwood	Charcoal	Agricultural Wastes	Alcohol	Coal & Coke	Crude Oil	Petroleum Products: LPG	Gasoline	Kerosene-Jet Fuel	Diesel	Gasoil	Fuel Oil	Non-Energy Products	Total	Electricity	Total
Primary Supply																
Production	455.9	-	131.8	1.0	-	-	-	-	-	-	-	-	-	-	199.0	787.7
Imports	-	-	-	-	0.3	481.5	17.5	25.8	2.5	142.0	-	-	4.0	191.8	-	673.6
Stock Changes	-	-	-	0.2	-	2.2	(0.3)	11.2	1.9	21.0	(1.2)	6.4	(1.9)	37.1	-	39.5
Closure	-	-	-	(0.4)	-	39.9	0.4	(0.8)	(2.6)	11.3	-	12.2	2.0	22.5	-	62.0
Total	455.9	-	131.8	0.8	0.3	523.6	17.6	36.2	1.8	174.3	(1.2)	18.6	4.1	251.4	199.0	1562.8
Transformation and Losses																
Oil Refining	-	-	-	-	-	(523.6)	7.4	88.5	28.0	146.6	1.4	208.1	11.5	491.5	-	(32.1)
Charcoal Production	(24.1)	9.1	-	-	-	-	-	-	-	-	-	-	-	-	-	(15.0)
Thermal Power Generation	-	-	(3.5)	-	-	-	-	-	-	(8.2)	-	(0.1)	-	(8.3)	202.5	(8.3)
Transmission/Distribution Losses	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(20.3)	(20.3)
Exports	-	-	-	-	-	-	-	(4.0)	-	-	-	(50.0)	-	(54.0)	-	(54.0)
Net Supply/Demand	431.8	9.1	128.3	0.8	0.3	-	25.0	120.7	29.8	312.7	0.2	176.6	15.6	680.6	182.2	1433.1
Demand																
Industry & Agriculture	16.2	-	128.3	-	0.3	-	4.4	-	4.4	47.5	0.2	153.8	-	210.3	64.9	420.0
Transport	-	-	-	0.8	-	-	-	120.7	16.9	263.8	-	-	-	401.4	1.0	403.2
Households & Commerce	415.6	9.1	-	-	-	-	19.5	-	8.5	-	-	-	-	28.0	113.0	565.7
Other	-	-	-	-	-	-	1.1	-	-	1.4	-	22.8	15.6	40.9	3.3	44.2

toe = 10 mn kcal
kwh = 860 kcal

COSTA RICA 1/

1. While the energy sector contributed only about six percent of value added and one percent of total employment, it needs to be carefully reviewed in the light of current resource constraints because of the large share of energy in both the import bill and the investment program. Thus, in balance of payments terms, the value of imports of crude oil and oil products rose from 12.3% of export earnings in 1977 (the last "normal" year) to a high of 22.9% in 1980, gradually decreasing to 19.8% in 1981 and an estimated 14.9% in 1982. The share of national investment devoted to ICE (the major Government-owned power company) has varied between 5% in 1975 and 16% in 1982, or $570 million over the 1975-1982 period. The corresponding share of RECOPE (the Government-owned oil company) rose from 0.5% in 1976 to 13.6% in 1981, totalling about $190 million over the 1975-1982 period. This rapid relative increase was accelerated by the fact that national investment, after growing by 80% between 1975 and 1980, dropped in 1982 to 37% of its 1980 level.

2. Until 1980, the driving force behind the increasing share of investment devoted to the energy sector was the rapid increase in the consumption of energy, given an expanding economy, growing industrialization, low internal energy prices and increased mobility and access to modern services by the population. Thus, the major issue facing the management of the energy sector today is how to adjust the flow of energy sector investments in light of current economic constraints while still meeting the energy requirements of the future. On the demand side, this can be done through policies that promote the rational use of energy, i.e., by encouraging investment and behavioral decisions that affect energy use to be consistent with the real economic cost of energy and the current state of energy use technology. On the supply side, this requires that investments be concentrated on the development, transformation and distribution of those energy resources which demonstrate the greatest potential for meeting the diverse energy needs of the country at lowest cost. On the pricing side, the achievement of these objectives requires that energy prices reflect their economic costs. Finally, the balancing of the diverse interests of the sector requires a strengthening of the planning system to allow it to formulate sectoral priorities and design the requisite policies and investment programs with those long-term objectives in mind. As will be discussed later, the energy sector in Costa Rica already has made some progress towards rationalizing energy use, optimizing investments, and strengthening energy management institutions, and is in the process of considering further steps to complete the process.

1/ Adapted from Report No. 4655-CR, January 1984.

Economic Context

After a period of rapid growth during the sixties and early seventies, the economy of Costa Rica began to deteriorate in 1978 as evidenced by the fall in GDP from US$1,630 per capita in 1979 to US$1,370 in 1983. The deterioration was caused by plummeting coffee prices, weakening demand for manufactured goods in the Central American Common Market (CACM) and a rapid increase in oil prices and interest rates on external debt. Faced with these trends, the Government attempted to compensate through deficit spending and increased borrowing abroad. However, as the terms of trade grew increasingly unfavorable, 1/ the debt burden continued to rise (the debt service ratio jumped from an average of 9% in 1976-77 to 45% in 1981 and 52% in 1982) and net international reserves turned negative, the Government was forced to suspend interest and principal payments on its commercial debt in August 1981. The serious shortage of foreign exchange led to a dramatic adjustment in the economy: the GDP declined by 4.6% in 1981 and a further 9% in 1982; imports fell from $1.5 billion in 1980 to $1.2 billion in 1981 and $0.9 billion in 1982. It is estimated that industry has recently been operating at 40% to 50% of capacity.

Immediately upon taking office in May 1982, the new Government took emergency measures to stabilize the economy and provide the basis for a sustained recovery. High priority has been given to (i) reducing the public sector deficit, (ii) establishing a realistic exchange rate and pricing policies, and (iii) promoting exports. The Government's stabilization and recovery program has formed the basis for a one-year Standby Arrangement with the IMF, approved in December 1982, under which a series of targets, policies and measures were agreed upon. In particular, under the terms of the IMF Arrangement, the overall deficit of the non-financial public sector is to be reduced to 4.4% of GDP in 1983, compared to 14% achieved in 1981 and 9.5% in 1982. The adjustments required for implementing this stabilization and recovery program represent a major challenge for the Government and the economy.

1/ The cost of a ton of crude (c.i.f.) in terms of kilograms of coffee (f.o.b.) increased from 26 in 1977 to 86 in 1980, 130 in 1981, falling back to 99 in 1982.

Principal Issues and Recommendations

Energy Pricing

3. For the immediate future, the main issue in energy pricing relates to the continuing need for power tariff adjustments to safeguard ICE's (and the other power companies') financial viability. ICE's financial condition began to deteriorate in 1980 as a result of the financial upheaval associated with accelerating rates of inflation, devaluation, reduced electricity sales growth, heavy reliance on short-term foreign commercial debt, and delays in tariff adjustments. To catch up on these developments, the Government granted ICE a 70 percent tariff increase in June 1982, and monthly increases of 10-13 percent between November 1982 and April 1983. These increases would have been sufficient for ICE to earn its target 10 percent rate of return in 1983 and meet its debt service obligations as they had been renegotiated by the Government. However, in June 1983, in the face of strong popular opposition to the tariff increases, the Government reduced residential tariffs to their December 1982 levels. This loss in revenue forced ICE to stretch out the implementation of its investment program, and to seek further financing to help meet its debt payments. Even if this financing were to become available, additional tariff increases are needed to maintain ICE's rate of return at the convenanted level of nine percent. Both the Government and the ICE understand the need for further tariff increases but are proceeding with circumspection. ICE already has applied for a nine percent increase to be effective January 1984. Further increases will be needed in the following years (1985-87) just to achieve the convenanted rate of return. Additional increases, related to future wage and salary adjustments, may be expected. To clarify these tariff increase requirements, it is recommended that ICE work out a long-term financial restructuring plan in view of its current inability to meet its very high debt service requirements through tariffs alone. This would put it in a better position to meet its commitments and proceed with the implementation of its investment program albeit at a slower pace. Once the corresponding revenue requirements have been estimated, it is important for the necessary tariff increases to be implemented in a gradual but continuing manner, not only to avoid the need for drastic catch-up increases in the future, but also to safeguard the orderly development of the power industry.

4. For the longer term, the price of electricity and other forms of energy needs to cover not only the cash flow requirements of the sector's enterprises, but also reflect their true economic costs. To ensure that future price changes reflect economic costs, it is recommended that the Government expedite its plans to formulate (through the DSE) and implement (through the National Electricity Service - SNE) a comprehensive energy pricing policy that would take into account the opportunity cost of energy and the country's long-term development needs. As the first steps in this direction, it is recommended that the Government give the highest priority to ICE's updating of its study on

the long run marginal cost of electricity and RECOPE's undertaking of a comprehensive study of petroleum product supply options which would result in a detailed evaluation of the cost of petroleum products to the economy. In addition, SNE needs to consider the advantages of setting RECOPE's refinery gate prices on the basis of the relative market value of products from major export refineries in the Caribbean.

Electric Power Investments

5. The major question regarding the power investment program is the extent to which major generation projects might have to be deferred because of the recent slowdown in demand growth. In this context, the $112 million Ventanas-Garita project (now about 25% complete) might be two years premature, and its continued implementation would have to be justified on the basis of expected revenues from sales to neighboring countries. Thus, an additional review is needed of this project in the context of the country's overall development priorities, financial constraints and the Government's policy not to make power generation investments solely justified on export sales. The scheduling of subsequent projects (Miravalles, Palomo and Angostura) will have to be carefully reviewed and possibly deferred in late 1984 (when, under the current schedule, a decision to begin implementation will have to be made) depending on the state of electricity demand and ICE's financial situation at the time.

6. The development of geothermal resources deserves high priority because of its attractiveness as a firm source of baseload electricity. To assess this resource on a national scale, it is recommended that ICE carry out the proposed national reconnaissance survey, but the study should be carefully designed so as to lead rapidly and economically to identification of the most promising areas. To increase the efficiency of implementing the $110 million Miravalles Geothermal Project (Unit 1), it is recommended that ICE develop a written set of plans, options and contingencies for the siting, drilling and testing of new wells. In order to obtain a good understanding of the economics of various approaches to address the scaling phenomenon (which was discovered in earlier well tests), it is recommended that ICE (and the Government) accept the costs associated with additional testing and drilling in search of better production conditions rather than stay with a more conservative strategy that may reduce risks but could also impose higher costs in the long term.

Development of the Petroleum Industry

7. The main issue in petroleum development is the extent to which the Government should be involved in petroleum exploration, given the capital-intensive nature and geological risks associated with such activities. The mission supports the Government's new strategy of trying to attract foreign investors to carry out petroleum exploration activities. Thus, the Government in preparing the new Hydrocarbons Law is taking into account the Bank's recommendations on the factors that need

to be considered for the strategy to be successful. In addition, it is recommended that the highest priority be given to RECOPE's program to evaluate the hydrocarbon potential of the Campo Diablo area where some definite oil shows are present.

8. A second major issue in the petroleum sector is the absence of a corporate development plan in RECOPE, which makes it impossible to evaluate its investment program. RECOPE is currently responding to this need and has begun to prepare a corporate development plan using appropriate economic and technical criteria so that the Government will be able to place its investments within the framework of the public investment program. Also, in view of the economic costs of maintaining the refinery, RECOPE is in the process of broadening its refinery policy to a petroleum product supply policy, under which petroleum products would be obtained at the lowest cost. To improve this policy, it is recommended that RECOPE carry out a comprehensive study of Costa Rica's petroleum product supply alternatives.

9. In relation to the excessive demurrage charges incurred in the importation of crude oil, the mission supports the ongoing effort between the Central Bank and RECOPE to work out an arrangement whereby such unnecessary expenses can be avoided in the future.

Coal Resources

10. The justification of Costa Rica's coal resources program should be questioned, given its doubtful economic prospects and the tight financial condition of the Government. As this justification is not apparent, it is recommended that the Government reconsider the priority it has given to the national coal program.

Fuelwood and Charcoal

11. The main question regarding the use of fuelwood and charcoal in Costa Rica is the extent to which the existing delicate balance between fuelwood supply and demand may be threatened by the alarming rate of deforestation (which is principally due to the demand for pasture land) and a possible shift by household and industrial users towards increased fuelwood and charcoal use. A survey of energy use in households and a study to understand the structure of the fuelwood market, should contribute to a better understanding of this problem. In the meantime, to create a buffer against a deterioration of fuelwood supplies it is recommended that the Government encourage the planting of trees on private lands through the provision of technical assistance and the establishment of tree nurseries selling seedlings at cost. In addition, it is recommended that the Government give adequate financial support to the Forestry Directorate's current program to strengthen itself and demonstrate the viability of large-scale production forestry by managing natural tropical forests. Moreover, to take advantage of the significant amount of forest biomass that is being destroyed through illegal land clearing, it is recommended that the Government assist in establishing an industry to exploit it for charcoal making using portable kilns.

Energy Use in Industry

12. From the Government's perspective, the main issue with respect to energy in industry is the extent to which the rationalization of energy use should be encouraged through measures other than pricing. Considering that many of the most obvious and lowest cost energy conservation opportunities already are being implemented by the major energy users, it is recommended that the Center for Assistance on Energy to Industry be established at no cost to the Government.

Energy Use in Transport

13. The major energy issue in the transport sector is the extent to which it can curb its voracious appetite for petroleum products through substitution and conservation. In the mission's view, the potential for an economic substitution of electricity for diesel in either railways or urban transport is not encouraging, and thus it is recommended that the Government redefine the objective of its transport pre-investment program to that of finding the least-cost solution to any transport need regardless of its implications for energy substitution. To increase the efficiency of energy use, it is recommended that the Ministry of Transport establish a preventive maintenance program for public buses, along with the requisite facilities, complemented by regular training for mechanics, drivers, and their supervisors.

Planning Institutions

14. The main issue facing the recently established Energy Planning System, which has at its center the new Directorate of Energy, is its ability to prepare a strategy for the sector and coordinate the preparation of a balanced sectoral investment program. While this ability has not been put to the test yet, it is recommended that the Government approve the legal framework that would establish the Directorate of Energy (which has been functioning under an interim arrangement). In view of the importance of energy to the economy, it is recommended that the Energy Planning System be broadened to include the National Electricity Service and major user groups, such as industry and transportation, and sectors that are indirectly involved in energy production, such as agriculture and forestry. To improve the effectiveness of the Directorate of Energy it is recommended that it focus on its priority activities and transfer the technical assistance projects that fall outside its priority functions to other Costa Rican institutions.

Technical Assistance Priorities

15. Insofar as the recommendations discussed above involve the performance of studies, surveys and pilot demonstrations, they also offer an opportunity for technical assistance. Fortunately, many of these technical assistance opportunities already are being discussed with potential donors. The Directorate of Energy serves a central

coordinating role in energy planning and technical and financial assistance and, together with other appropriate sectoral institutions, is the main point of contact for specific technical assistance projects. Priority technical assistance projects for which funding has not yet seen secured are as follows:

a. The demand for electric power: a study of the behavior of major user groups, their relation to economic and demographic variables, and construction of a statistical model for the performance of demand forecasts and simulation.

b. The optimization of power sector investments: design and construction of a generation and transmission expansion planning model that is custom-fitted to the characteristics of the Costa Rican system.

c. A study of fiscal policy in relation to petroleum fuels: an analysis of the demand management and income distribution considerations that need to be taken into account in the design of a taxation package for petroleum fuels, with the objective of maximizing tax revenue and minimizing economic distortions that could jeopardize the economic development process.

d. An economic evaluation of the San Jose Accord: an analysis of the costs and benefits of Costa Rica's current petroleum supply agreement, and comparison with alternative supply arrangements.

e. Energy conservation in the bus company (Transmesa): establishment of a preventive maintenance program for public buses, including training for mechanics, drivers and their supervisors, along with the provision of requisite testing equipment for diesel pumps and injectors.

f. The development of a national strategy for developing the energy potential of the country's forest biomass.

g. The design and implementation of a common planning and operational methodology for the participants in the regional interconnected power system.

ETHIOPIA: ENERGY BALANCE, 1982
(thousand tonnes of oil equivalent)

	Fuel-wood	Char-coal	Dung	Straw	Bagasse	Crude Oil	Petroleum Products: LPG	Motor Gasoline	Aviation Gasoline	Jet Fuel	Kerosene	Diesel	Fuel Oil	Other	Total	Electricity	Total
Primary Supply																	
Production	3403.3		2539.2	1803.6	58.6											187.3	7992.0
Imports						773.3		9.9	9.0	52.2	11.2	93.5			175.8		949.1
Primary Exports																	
Stock Changes						(44.9)		4.2	(3.2)	(27.5)		(0.7)	8.9		(18.3)		(63.2)
Total	3403.3		2539.2	1803.6	58.6	738.4		14.1	5.8	24.7	11.2	92.8	8.9		157.5	187.3	8877.9
Transformation and Losses																	
Oil Refining						(702.8)	5.4	108.3		57.5	0.3	212.9	303.2	15.2			0.0
Charcoal Production	(101.8)	101.8															0.0
Thermal Power Generation					(11.7)							(48.8)	(20.1)			267.9	0.0
Conversion Losses	(343.8)				(17.6)	(25.6)										(195.5)	582.5
Transmission & Distribution Losses																(8.5)	8.5
Non-Energy Use														15.2			15.2
Secondary Supply	2957.7	101.8	2539.2	1803.6	29.3		5.4	122.4	5.8	82.2	11.5	256.9	292.0	0.0	776.2	63.5	8271.3
Secondary Exports													213.5		213.5		213.5
Bunkers										30.1		2.9	9.1		42.1		42.1
Net Supply/Demand	2957.7	101.8	2539.2	1803.6	29.3		5.4	122.4	5.8	52.1	11.5	254.0	69.4		520.6	63.5	8015.7
Demand																	
Industry		0.8			29.3		0.2				0.2	34.3	67.2		101.9	35.0	167.0
Transport								122.4	5.8	52.1		168.8			349.1		349.1
Agriculture												31.0			31.0	1.1	32.1
Households	2957.7	101.0	2539.2	1803.6			5.0				11.2	1.6			17.8	16.3	7435.6
Commercial							0.2				0.1	18.3	2.2		20.8	11.1	31.9

toe = 10.2 mn kcal
kWh = 3180 kcal (supply)
= 860 kcal (demand)

ETHIOPIA 1/

1. Ethiopia's rural character is clearly reflected in the patterns of energy consumption. Of an annual per capita energy consumption of about 245 kg of oil equivalent, 93% is in the form of firewood, charcoal, crop residues and dung, and per capita consumption of petroleum products (17 kgoe) is very low even by regional standards. The GOE intends to create a surge of economic recovery and growth through the vehicle of a ten-year plan involving some US$16 billion in investments geared to achieve an average of 7.5% p.a. GDP growth between 1983/84 and 1992/93. There is no doubting the sincerity and fervor with which this objective is being addressed, though it will require greatly increased energy sector investment to further social and economic development, together with more effective energy planning and management. This is because Ethiopia has still to systematically develop its wealth of hydropower resources, a locally significant gas resource and a variety of other energy resources with economic potential to meet the growing needs of household and commercial consumers. Growth in GDP is more likely to range between 3% and 4% a year through 1992, which should call for a desirable minimum level of energy sector investment (including energy and agroforestry) of US$1.6 billion for the 1983/84-1992/93 period, implying a major increase in the proportion of public sector investment devoted to energy. With the implementation of the optimal energy strategy devised by the mission, biomass fuels decrease marginally and electricity and petroleum fuels increase their relative share of total energy use by 49 and 75%, respectively.

Household Energy

2. The most important issue in the energy sector, and arguably in the future of Ethiopia, is the supply of household fuels, the related massive deforestation, and the resultant and insidious depletion of agricultural resources on which so much economic activity depends (nearly 50% of GDP, 80% of employment and 90% of exports). The increasing scarcity and cost of household fuels, particularly firewood, threatens the ability of the country even to maintain already low incomes and the quality of life of the people, particularly in the rural areas. The Ethiopian landscape has changed dramatically over this century. The estimated cover of closed canopy forests has declined from roughly 40% around the turn of the century to around 3% now, and an estimated 200,000 ha and one billion tonnes of topsoil are lost each year as land is cleared, or forests thinned, to supply new areas for crops, animals and people, and to meet the growing needs for the major fuel, firewood. The cost of

---

1/ Adapted from Report No. 4741-ET, July 1984.

Economic Context

The land area of Ethiopia is 1.22 million square kilometers, making it the tenth largest country in Africa. In 1981, its population was estimated to be 32 million, 85% of which is classified as rural. Population growth is about 2.8% overall, although urbanization is proceeding at about 6.5% per year. With a GDP of US$4,430 million and a per capita income of about US$140 in 1981/82, Ethiopia is among the five poorest nations in the world. The mainstay of the country's economy is agriculture, which accounts for about 50% of GDP, followed by industry, 15%, and transportation 5%. Agriculture also accounts for about 85% of employment and 90% of exports. Coffee contributes 60% of total exports, supplemented by hides and other animal products from Africa's largest livestock population. Manufacturing contributes only 10% of GDP, being limited mainly to food processing, beverages, leather, textiles, cement and petroleum refining.

In describing recent economic performance it is useful to divide the post-revolutionary era into three periods. The period from 1974 to 1977 was marked by political upheaval, armed conflicts and little economic growth. In the second period, beginning in 1978, the economy recovered as security improved. The gross domestic product grew at 5.2% and 5.5% in real terms during FY78/79 and FY79/80, respectively. Growth came mostly from agriculture which benefited from good weather, and from industry after the resumption of industrial activity in and around Asmera and a rapid expansion in capacity utilization in the Addis Ababa region. Improved security also permitted the resumption of normal transport and commercial services. However, this impressive performance was short-lived. During FY80/81 and FY81/82, real GDP growth slowed to 3.0% and 1.5% respectively, mainly due to persistent drought, to the exhaustion of utilized capacity in industry, and severe investment constraints. Following a sharp increase in imports and a significant decline in coffee prices, Ethiopia's terms of trade declined by about 23% over this period. Efforts to raise non-coffee export earnings were unsuccessful for many reasons, including the continuing world economic recession. In FY81/82, Ethiopia's merchandise imports reached a level more than twice the value of merchandise exports, and the current account deficit widened substantially to more than 7% of GDP.

firewood in the capital of Addis Ababa soared from US$9 to US$90 per tonne between 1973 and 1983 and now claims up to 20% of household income. To compensate for the worsening firewood scarcity, growing amounts of natural fertilizers in dung and crop residues are being diverted to household fireplaces, reducing crop yields by more than one million tonnes of grain a year. If no more than the present level of replanting is undertaken, in 20 to 30 years all but the least accessible pockets of forest will have gone, large parts of the north will be uninhabitable, and much of the center will be like Eritrea and Tigrai today: subject to persistent drought, crop failure, famine and outmigration. To arrest these trends and meet the estimated need for woodfuel within the next 30 years, some 6 million ha would have to be planted: in effect to reforest 5% of the Ethiopian landscape. Both the land reforms and the community organizations are in place to implement the required program and mobilizing sufficient financial resources should be possible. Nevertheless, life-styles will have to change dramatically as tree planting and management will have to be incorporated into the very fabric of rural life. Intervention on the scale envisaged will require unprecedented political commitment. Energy and agroforestry will have to be placed among the nation's top priorities for there to be any chance of success. Although in the short-term the problem will be further aggravated due to long lead times for forest development and high population growth, there are good prospects of lessening the rate of deforestation, provided there is a major increase in the mobilization of resources to meet the problem.

High Cost of Petroleum

3. Besides the household energy crisis, the other major energy-related macroeconomic problem is the massive and worsening impact on Ethiopia's trade balance and foreign exchange availability of the cost of petroleum imports (net imports of US$185 million in 1982/83, equivalent to about half of foreign exchange earnings). Unless major demand management efforts are made, the increased demand, particularly from the transport and industrial sectors, will add to the burden through the resulting imports and will continue to constrain economic growth. Measures to alleviate the cost of petroleum imports include serious reconsideration of the future pattern of industrial development; improved technology selection; possible petroleum product pipeline and improvement in the structure and efficiency of the transport fleet; a variety of substitution measures (e.g., ethanol for gasoline and possibly natural gas for diesel in transportation, and biomass and natural gas for fuel oil in heat and steam-raising); and improved energy management in industrial and commercial enterprises.

Overall Energy Strategy

4. The major themes of Ethiopia's energy strategy for the coming decade should be as follows:

(a) To expand the supply of household energy through a greatly increased allocation of financial and trained human resources, and to this end, to pay particular attention to, and take concerted action on:

- reforestation, including improved forest management;
- expanded development and utilization of substitute fuels, like briquetted agricultural residues;
- improvement in efficiency of cooking through the use of stoves with improved fuel economy and the use of aluminum pots and mtads.

(b) The development, execution and prudent financing of a least cost power supply program commensurate with a reasonable level and structure of industrial development and expanded supply to residential and commercial consumers, taking into account the country's limited investment resources, the need for improved power system planning, the potential complimentary role that could be played by natural gas and suitably scaled hydropower developments in the long-term, and the desirability of financing a reasonable proportion of new investment through revised tariffs for increased cash generation.

(c) A major program of demand management, including important changes in the pricing of electricity and some petroleum fuels, rationalization of future industrial structure, selected substitution options (biomass, ethanol, solar heating and possibly natural gas), a petroleum product pipeline and improved transport fleets, industrial energy management and oil refining facilities.

(d) Expanded exploration efforts and eventual exploitation of domestic hydrocarbon resources, with immediate attention to the possible utilization and development of natural gas, and hopefully, but in the longer-term, petroleum.

(e) Expanded participation by the private sector in selected areas, particularly in petroleum exploration, solar water heating, and in the supply of biomass fuels (firewood, charcoal, agricultural residues, briquettes) to households.

Key Issues and Options

Expanding Woodfuel Supply

5. Afforestation. On a large scale, this is the only realistic option for resolving the household energy supply problem in the longer-term. Peri-urban plantations must be established to make urban areas self-sufficient, and rural woodlots and agroforestry on a massive scale are essential to allowing a sustainable energy supply to meet demand in rural areas. The mission estimates the need for forestry of all kinds to be 3.3 million ha planted by 1992, but considers this to be beyond the capabilities of the country in this period due largely to the institutional constraints of manpower and management resources, and the massive organizational and logistical efforts involved. An ambitious but potentially achievable program of afforestation would be to plant by 1992:

(a) 960,000 ha of rural energy-forestry with special emphasis on agroforestry, costing B403 million (US$195 million); and

(b) 195,000 ha of peri-urban forestry costing B343 million (US$166 million).

A further ongoing commitment of B1.2 billion (US$0.6 billion) is required during 1993-97 to meet the 2002 demand. A balance between supply and demand could be achieved between 2010 and 2020 depending on the long-term population growth and the future of alternative fuels. The mission has reviewed options for the supply and management of household energy separately for the northern and the southern regions. The northern region comprises Eritrea, Tigrai, Gondar and Wollo provinces and the southern region the remainder. With full implementation of the short-term measures proposed, only a moderate shortfall need occur in the south by 1992 between absolute need for peri-urban forestry and the achievable planting rate. The shortfall in the north would be about 150,000 ha for peri-urban forestry and almost 1 million ha in rural afforestation by 1992. In short, even with the major effort here proposed, deterioration in northern agro-ecosystems and in household energy supply will increase dramatically this decade before being slowly reversed in the next.

6. Specific priority measures to be undertaken within the achievable aforestation program include:

(a) establishment of training and research and development facilities in agroforestry right down to the peasant farmer level;

(b) establishment of a national forestry management information system to optimize species, provenances, and plantation design and management for each ecological zone; and

(c) a national forest and tree resource inventory to be conducted as a matter of urgency.

In the context of peri-urban forestry, there should be:

(a) increased application of fertilizer in the new Addis Ababa plantations to boost yield and reduce rotation length;

(b) replanting of the 10,000 ha of dead and dying portions of the existing Addis Ababa plantations by 1992; and

(c) planting of at least 10-15% of the area of state farms with boundary woodlots and shelter-belts.

7. Additional Household Fuels. By greatly accelerating reforestation, recovering existing surpluses of woody fuels 2/ from forests and from agriculture, and by more efficient cooking, a near balance can be achieved between supply and demand for household fuels in urban areas in the south and establish the basis for the north's improvement within the decade. During the next decade, when woodfuel supplies from the proposed expanded forestry program are minimal, it should be possible to economically supply the equivalent of about 1.7 million tonnes of wood a year by 1992 to towns in the southern region in the form of charcoal from forest clearing and logging operations, and crop residue briquettes from state farms and cash crops. This would be equivalent to about half of urban household energy demand in the south. The crop residues concerned are strictly those centralized and annually burnt off on Ethiopian State Farms, not those dispersed throughout subsistence agriculture which have much higher value as animal feed and soil conditioners. Furthermore, while the residue harvesting and briquetting equipment to take advantage of this nearly unique State farm energy resource is fully commercial, the scale of the operation proposed here is quite unprecedented and successful implementation depends greatly on good management, careful planning and consumer acceptance of these now briquetted fuels. Northern region towns will not have access to these resources, therefore it is recommended that at least 40,000 tonnes of kerosene be directed each year to northern cities including Asmara and Mekele. In the southern region, LPG and electricity from hydropower can contribute significantly to household cooking energy supply within five years. Oil-fired electricity is not economical for cooking in the north and should be strongly discouraged in favor of kerosene in the short-term. There appear to be good prospects for improving the efficiency of existing charcoal stoves and electric injera cookers, and for introducing new portable metal woodstoves for urban use, warranting immediate trial and development work for each. Huge improvements in cooking efficiency occur from using aluminum pots, thus population-wide acceptance of cooking with aluminum instead of clay pots should be evaluated immediately.

2/ Woody fuels include firewood, charcoal, and crop residues such as straw, stover, coffee skins, and bagasse.

8. Priority supply measures include:

(a) expanding the production of charcoal at Bubeka and other forest clearing sites to 114,000 tonnes per year by 1987;

(b) introducing integrated forest management at selected logging and clear-felling sites with complete conversion to charcoal from all forest residues;

(c) programming exhaustive recovery for firewood and charcoal of all savannah forest timber cleared in state farm development;

(d) beginning commercial recovery of coffee skin residues in the form of briquettes during 1984, leading to production of 150,000 tonnes per year by 1992;

(e) beginning pilot production of fuel briquettes from cereal straw and stover, and cotton residue in 1984/85, following an immediate review of the optimum residue harvesting practices, leading to fully commercial production from all sources by 1986/87;

(f) integrating recovery of sawmill wastes as sawdust briquettes and charcoal in the refurbishment of rural sawmills; and

(g) improving the efficiency of charcoal production with the use of improved kiln design, including portable metal kilns.

The combined capital cost to develop these resources, if fully implemented, is B113 million (US$55 million) and the yield is the equivalent of the annual yield from 163,000 ha of new peri-urban forests.

9. Economics of Rural Afforestation. The main economic justification for the proposed national afforestation program beyond the direct value of household fuel supply is the benefit to agriculture of allowing high value organic fertilizers--dung and crop residues--to be used in crop production rather than as fuels. The value of grain production foregone each year by using cow dung as a cooking fuel is about one billion B (US$500 million); and this can only be reduced substantially by increasing the supply of woodfuel, given the extremely high cost and foreign exchange requirements of chemical fertilizers. Economic rates of return for rural afforestation investments are estimated to range between 25% and 80%, depending on the local circumstances, making this the highest value investment in the energy sector. Typical economic returns for peri-urban plantations are estimated to be 20-25%.

10. Implementation. The implementation of the energy forestry program requires an expansion of the charter and of the manpower, infrastructure and administrative resources of the existing extension service of the Ministry of Agriculture, as well as an early clarification of the required interface and cooperation with the Forestry and Wildlife Community Development Authority (FAWCDA). The mission also recommends the

establishment of a stove marketing organization to implement the improved cooking efficiency program.

Power Subsector

11. With due attention to demand management, major investments in new generation systems other than the 150MW Malka Wakana hydropower plant now under construction can be delayed until about 1988, allowing a much lower cost power system development plan to be identified and implemented than is presently being contemplated. The rate of demand growth on the main interconnected system (ICS) of the Ethiopian Electric Light and Power Authority (EELPA) has been greatly overestimated in recently prepared forecasts, hence the impending investment of US$29 million to rehabilitate the Abu Samuel plant (6MW) and add a fourth unit to the Finchaa hydropower station (34MW) are not warranted prior to the commissioning of the Malka Wakana proposed for mid-1987. Demand management, including conservation measures, can cover a 12-18 month delay in the Malka Wakana project, though the shortfall in capacity occasioned by longer delays can be met only by access to new generating plant, not including those now under consideration. Key elements in the future demand for electricity include boiler and cocker electrification programs now under implementation, and the level and structure of tariffs which are now distorted and unreasonably low. While there is a good case for electric cooking for a small section of the urban population, there is no longer any justification for the electric boiler program, which has been implemented so late that none of the originally perceived benefits now apply, given that the extended period of hydro-based power surplus will come to an end by about 1986. The annual incremental economic cost of operating electric boilers as compared with the existing oil-fired boilers would be about US$8 million by 1986. On the supply side, planning and evaluation must be expanded to include several very large multistage hydropower projects and natural gas from the Ogaden Desert, both of which diminish the status of potentially more expensive and still prospective geothermal power resources. In the north, the smaller interconnected supply system of the Eritrea Regional Electric Supply Authority (ERESA), which for the foreseeable future will rely solely on petroleum-fired generators, must in the short-term install more efficient generating plant and review locally available power resources, e.g., geothermal, and place heavy emphasis on demand management, as the proposed interconnection with the main EELPA ICS is not expected to become economic until the mid-1990s.

12. Specific measures arising from the above include:

(a) A genuine least-cost development program for the EELPA ICS should be developed based on the revised demand forecast presented here and choosing between numerous major hydropower systems and natural gas;

(b) Boiler electrification should not be extended beyond those already installed or committed and then should only be used dur-

ing periods of surplus hydropower with the fuel oil or biomass fired boilers (and in the longer-term, natural gas-fired boilers) retained as the primary means of industrial steam raising. Accordingly, EELPA should cease to supply power on concessional terms to electric boilers from 1985 (the time at which present contracts expire), charging thereafter a full economic price;

(c) A strategy must be devised for future power supply which would protect EELPA from supply constraints in the event of a delay in the commissioning of Malka Wakana but which would not preclude a low cost long-term generation expansion plan. The early expansion of the Tis Abai power station combined possibly with the Finchaa-Bahar Dar 230kV transmission link, and interconnection with the Sudanese grid should be considered in this regard;

(d) The economic viability of geothermal power should be evaluated in the context of the least cost power system development for the EELPA ICS. Emphasis should be given to exploration for geothermal power in the northern part of the country covering also the ERESA system;

(e) Fuel oil-fired diesel engine generation should entirely displace diesel generation and fuel oil-fired steam turbo-alternators for supply to the ERESA ICS in the medium term. In the mid to late 1990s, there is the prospect of either natural gas for power production based on the current prospect of natural gas discovery in the Red Sea or of geothermal power as noted in (d) above.

Petroleum Supply and Transportation

13. The most important problem facing Ethiopia in this area is the burgeoning cost of oil imports. In this respect there are a range of options for supplying refined products and transporting them from the coast to the central highlands market, and there is a good prospect for developing natural gas. In addition, petroleum exploration is being renewed with exploration promotion assistance from the World Bank and from the Soviet Union, which has financed four wells in the Ogaden desert region some 800 km east of Addis Ababa. The petroleum exploration and promotion facility financed by the recent IDA credit must be complemented with rationalized petroleum sector management and lead to a strong effort to engage private sector participation in further petroleum exploration and development. Preliminary mission estimates indicate that the most expensive option for supplying petroleum products over the next 12-15 years is to continue operating the refinery at Asseb in its present form. The competing lower cost options are either to close down the refinery and import all refined product requirements, or invest at least US$70 million in conservation, debottlenecking and secondary conversion facilities, resulting in greatly improved fuel efficiency in the refinery, as

well as a product mix much closer to the pattern of domestic consumption. While the rate of return on new investment appears attractive, the early production of natural gas for local use could well reduce the economic benefits now foreseen by reducing the market for liquid fuels and greatly altering the required product mix. Nevertheless, further engineering and economic study of refinery expansion/modernization is recommended. Regarding the inland transport of petroleum fuels, the mission finds a proposed 850 km, US$270 million product pipeline from Asseb to Addis Ababa more economic than high-volume efficient truck transportation. However, if there is any prospect of replacing diesel with compressed or liquified natural gas in road transportation in the early- to mid-1990s, the cost of the competing alternative of restructured road transport will be significantly reduced. The refined product pipeline therefore must be subjected to more detailed study in the context of broader transport sector issues for its economic viability is closely related to the future growth of liquid petroleum consumption. In line with the finding that natural gas is a potential competitor in the power market, the mission recommends prompt drilling of at least one additional well to better define the volume of gas in place in parallel with a preliminary gas utilization study already funded under the aforementioned IDA credit.

14. Specific measures arising from the above include:

(a) a detailed refinery engineering study to establish the costs of the proposed refinery modifications and the maintenance costs for the refinery over the life of the new equipment;

(b) detailed study of the product pipeline option with, in the short term, gradual replacement of 24 tonne tanker trucks with 35-40 tonne trucks, road quality permitting, due to the significant improvement in fuel economy entailed; and

(c) the use of either the joint Ethiopia-Soviet exploration program or an additional program to drill at least one additional well on the Calub structure to better define the existing gas resource in the Ogaden.

In addition, there is need for immediate modification to the refinery's LPG process train, and to refinery operation, to ensure the recovery of a further 8,000 tonnes of LPG now flared, and the production of 54,000 tonnes of kerosene a year. To increase the availability of kerosene for household use and avoid its use as an industrial fuel, kerosene blending in fuel oil to lower viscosity should be minimized and eventually discontinued as industrial combustion systems and fuel handling facilities are upgraded, including heated storage tanks and tanker vessels, to cope with high viscosity fuel oil.

Petroleum Demand Management

15. In addition to the measures mentioned above, the mission recommends that low cost options to improve the economy of petroleum use be implemented quickly, primarily in industry and transportation, which account for 20% and 67% of petroleum consumption, respectively. In industry, key measures should include:

(a) improved combustion control, water treatment, and new heat recovery systems throughout the manufacturing sector, particularly in such energy-intensive industries as cement, textiles, glass and iron-casting;

(b) industrial-scale solar water heating systems in tanneries and in hotels, hospitals and hostels; and

(c) converting cement kilns to being partly fueled with crop residues.

In the transport sector there is a serious undercapacity problem which has nearly eliminated routine maintenance, contributing to highly inefficient vehicle operation and fuel consumption rates. The measures proposed by the mission for energy savings in the transport sector will not be fully effective without first investing some B50 million (US$25m) in new and larger trucks and additional servicing facilities. The specific measures to be adopted include:

(a) aquisition of diesel pump testing equipment and the servicing facilities for the bus and truck fleet;

(b) turbo-charged engines and radial tires for the truck and tanker fleet operated on the Addis Ababa-Asseb route; and

(c) the implementation of a detailed management information system for the transport fleet and revised policies for truck and bus procurement due to the wide variation in fuel economy, maintenance requirements, and longevity experienced between different makes and models and the substantial economy of large (35-40 tonne) over smaller trucks, particularly for major bulk commodities such as petroleum products.

Other Energy Sources

16. In comparison to the need for expanded fuelwood production, conventional power, and petroleum supply, most other energy sources are of relatively minor importance and should not absorb valuable skilled staff time, administrative, or financial resources out of proportion to their potential to contribute economically to future energy supplies. This is especially true of biogas, producer-gas power generation, solar electricity and wind energy. The exceptions are the recovery of agricultural residues from state farms and major cash crops, production of

ethanol from molasses, solar water heating and, possibly, geothermal and coal resources. Pilot production of various crop residue fuel briquettes should begin immediately, as should consideration of relocating the geothermal exploration effort to the north. Other priority actions in this subsector include:

(a) an immediate review of the potential to create surplus bagasse by upgrading the process energy efficiency of the existing Metahara, Wonji-Shoa sugar mills, and the future Finchaa sugar mill;

(b) proceeding with the production of about 29 million liters a year of ethanol as proposed, providing adequate arrangements are made for product storage and blending, vehicle fuel system compatibility and pricing;

(c) undertaking a national review to determine the economic potential for solar water heating and the viability of local collector production facilities; and

(d) accelerating and broadening the scope of the coal resource inventory now in progress.

Energy Pricing

17. The most serious energy pricing issues concern electricity tariffs and petroleum pricing. Petroleum products are generally underpriced against the full economic cost of supply when the shadow price of foreign exchange is taken into account. Net of taxes, only gasoline is priced well above the border price, although with its highly regulated market and mainly non-productive consumption, this is of little consequence. The mission recommends that:

(a) the price of diesel be increased by about 7% to encourage efficiency in use and to raise revenue; and

(b) no subsidy be applied to kerosene and LPG, because at their full economic cost they are clearly competitive with the market price of firewood and charcoal and tend to be used relatively more by higher income households.

18. Electricity prices have been kept artificially low in all power systems and huge cross-subsidies occur both within and between the EELPA ICS and the oil-fired ERESA ICS. The declining block tariff structure now in place in which the price per unit declines as consumption increases is now inappropriate due to its promotional nature in the face of supply constraints and the heavy cost burden placed on small consumers. Tariffs will have to be adjusted both for financial and economic reasons, as the GOE is now rightly insisting that EELPA meet a certain proportion of its future investment requirements from its own revenues. Tariffs in the ERESA ICS and the EELPA SCS systems are as little as one-fifth of the true costs of supply. The mission recommends that:

(a) tariffs be raised to reflect the full economic costs of supply and to make a reasonable contribution to the cost of new investment;

(b) uniform national tariffs be removed in favor of very substantial differences in prices, reflecting as far as practical the real variation in costs between supply systems;

(c) the near-term price of electricity in the ERESA ICS and SCS, and the EELPA SCS, at least meet the variable costs of production which are 35-40 ec/kWh (US17-20¢kWh); and

(d) time of day charges be applied over an otherwise flat tariff structure in all systems.

19. While the Government is attempting to intervene in the woodfuel and charcoal markets to bring prices down, its current impact is minor. The issue is really whether Government should be involved at all in the woodfuel market at the wholesale/retail level when it could concentrate on moderating price levels by adopting policies to enhance supplies from the forests and other sources. There appears to be no economic distortion at official government prices for firewood and charcoal, but prices in the private market are well above long-run economic production costs, reflecting the growing scarcity in good quality woody fuels.

Manpower Training and Development

20. The availability of skilled manpower and its effective deployment and management is regarded as the main barrier to implementing the national program of afforestation here proposed. A total of about 2,330 new skilled staff, ranging from university graduates to short-course certificate holders, will have to be trained at a cost of about US$6.5 million during this decade, and a significant start must be made in 1984. Community and agroforestry will be prime foci of this training program, which should better utilize the existing agricultural training facilities. Training in the power and petroleum sectors needs to be reviewed and redirected. The mission finds a substantial mismatch between the type of skill training in progress and the future skill requirements of the power sector. Plans affecting the EELPA training institute also could burden it with responsibilities for more general education, duplicating the work of existing educational institutions. Consequently, there is a need in the power subsector for:

(a) a detailed manpower assessment and development plan and, in parallel;

(b) a review of the role and responsibilities of the EELPA manpower training unit and the EELPA training institute.

Specific measures proposed in the petroleum subsector over and above those included in the petroleum Exploration Promotion Project include:

(a) further and marked increases in incentives to work and undertake further training at the Asseb refinery;

(b) revitalized efforts to recruit staff for the in-house training unit and to establish a fully equipped training workshop;

Institutional Arrangements

21. The GOE recognized at an early stage that the pressing problems of energy sector development called for a coordinated approach and established the Ethiopian National Energy Committee (ENEC) within the MME as early as 1979 to assist in policy making and setting priorities. At present, the arrangements for truly integrated energy policy analysis and investment planning in the energy sector are quite inadequate, however. Difficulties arise through the low status accorded ENEC by the major implementing agencies which is related, in turn, to ENEC's position of minimal influence over energy policy formation and investment. Furthermore, there are insufficient qualified energy staff in the Central Planning Supreme Council. The result is that key decisions on project priorities, pricing and other policies, studies, and so on, are taken through different channels in an uncoordinated fashion. The need for a strong and independent secretariat to review energy plans and policies is confirmed, though it must be much better equipped for the task and associated more directly with decision making at the highest level. Nevertheless, its role should be analytical and advisory only: the implementing status and management integrity of the energy parastatals must be preserved. The mission emphasizes the need for establishing clear principles and operational objectives to govern the interaction between an energy secretariat and the implementating agencies and consuming sectors as the first stage in rehabilitating an energy policy and planning capability. The energy secretariat need not be part of the Ministry of Mines and Energy and could conceivably be more effective in the Ethiopian government structure if it had more direct links with the Cabinet (Council of Ministers) or, provided the CPSC retains a strong influence on policies and priorities, attached to that body. Its location in the structure, and whether or not it is advised by a group of independent individuals, is secondary to the need for it to be comprised of highly skilled analysts with considerable status who appreciate the interrelationships between the various energy supply and consuming subsectors of the economy and who are permitted to review all major energy sector decisions prior to commitment.

22. There are two additional issues of institutional management which deserve early attention: the role of FAWCDA in woodfuels (firewood and charcoal) marketing and the charter of the EPC. FAWCDA should not attempt to compete with the vast network of wholesale and retail trade already established by small-holder entrepreneurs. Its role is more to increase supply and to assist with quality control. The mission recommends:

(a) maximizing the involvement of the private sector in biomass fuel distribution and marketing and, wherever possible, in production; and

(b) a review of the utility of a possible wholesale marketing and reprocessing facility for biomass fuels in Addis Ababa.

So far, the EPC has confined its role to petroleum refining although it is now clear that the benefits of investment in the existing or new refinery facilities can be quickly negated if oil is discovered or natural gas reserves are developed. Also, petroleum exploration efforts to date have been somewhat fragmented. The need for close coordination and rational investment in this sector leads the mission to recommend that:

(a) the EPC assume responsibility for all investigations into the commercial production of existing and prospective petroleum resources, including natural gas; and

(b) its manpower and resources be upgraded by recruiting and training lawyers, financial analysts and additional managers to adequately fulfill this new integrating role in petroleum supply and resource management.

Future Energy Demand

23. The growth in energy demand depends largely on the level of investment possible in the more energy intensive sectors of the economy, particularly industry and transport, and the degree to which fuel economy and substitution measures here proposed are implemented. With the World Bank's forecast of a maximum yearly GDP growth rate of 4% for the decade, with the implementation of fuel substitution and conservation measures proposed by the mission, and through close review of the committed program of industrialization, the mission foresees an overall growth in petroleum demand of about 7% a year if there is an early economic recovery and sustained GDP growth of 4% throughout the decade. Demand for fuel oil and kerosene will grow fastest, with diesel growing at less than 6% a year in the most likely scenario. It is not anticipated that natural gas will be in production before 1994. Growth in public power supply of 8.5% per year is expected and the demand for traditional biomass fuels will parallel population growth although, with the mix of supply, will change rapidly towards crop residues and dung away from firewood and charcoal as deforestation is intensified. It is likely that there will be an additional 2.5 million tonnes of organic residues a year diverted from agriculture to household cooking by the end of the decade. With the recommended expansion of reforestation and forest management as well as some degree of substitution by briquetting crop residues, more efficient charcoal production, and greater supply of petroleum fuels and electricity to households for cooking, this trend of using unprocessed residuals and dung and the rate of deforestation could be reversed by some time in the 1990s.

Energy Sector Investment

24. The proportion which energy sector investment makes of total national investment must be greatly increased from recent levels if significant economic development is to ensue. The mission estimates that of the B15-20 billion (US$7-10 billion) that could conceivably be available for public sector investment in the 1983/84-1992/93 period, about B3.6 billion (US$1.7 billion) should be allocated to the energy sector. Power development will consume more than one-half and forestry and household energy investment generally about one-quarter of the required funds, with the remainder primarily for petroleum exploration, refining and distribution. However, it is the capacity to implement projects and to disburse funds as well as the availability of funds that are key constraints to afforestation during the next ten years. The highest priorities for investment are outlined in tabular form at the end of this chapter. It must be reiterated that several major investments are to be made during the ten years from 1983/84-1993/94 which will not yield substantial benefits until five to ten years later, such as in the development of prospective power resources, or for fuelwood plantations in drier regions. The investment program proposed is balanced between economic options for alleviating rapidly worsening deforestation and for reducing the cost of imported oil in the short-term, and greatly expanding the sustainable supply of cheaper indigenous fuels in the longer term.

Summary of Priority Actions

25. The foregoing describes the state of the energy economy in Ethiopia, the key issues and the subsector-by-subsector options, and the more important recommendations. The key recommendations for action are summarized under four general categories of activities below (investments, policy changes, institutional improvements, and studies).

Investment Planning

26. A realistic and detailed energy sector investment plan is required, selecting projects and programs to be funded on the basis of their relative contribution to energy supply and their relative economic return. The most urgent need is for investment planning in energy forestry and household fuel supply which demands close cooperation among the various primary production ministries (State Farms, Agriculture, Coffee and Tea Development), FAWCDA and the Ministry of Mines and Energy. Investment planning by EELPA also must be quickly rationalized and upgraded in the light of new prospective power resources and changing demands for electricity. During the next five years, while the government's own planning capability is being enhanced, there may be need to resort to external assistance to provide the required expertise.

HIGH PRIORITY INVESTMENTS FOR 1982-92

Sector and Item	Objective	Estimated Capital Cost (US$ million 1983)
Household Fuels		
Rural Forestry	. equivalent of 960,000 ha of plantations in woodlots and agroforestry	175
Peri-urban Forestry	. upgrading existing and establishing 195,000 ha of new plantations	212
New biomass fuels and cooking efficiency	. briquetting 750,000 tonne crop residue and carbonizing 900,000 tonne wood annually by 1992, and implementing improved stove programs	73
Power Sector		
New power generation	. to supply 30-40MW in 1988-89 and 200-300MW by 1994	360
Displacing diesel generation	. replacing diesel generation in the ERESA ICS and both SCS systems with cheaper hydropower and fuel oil.	45
Transmission projects	. connection of SCS diesel generation new industrial loads and new hydropower or gas generation with existing EELPA ICS	180
Petroleum Sector		
Oil and gas inventory and utilization study	. continued oil and gas drilling reconnaissance work, and exploration promotion	30
Natural gas resource	. drilling to better define the Calub resource, and gas utilization studies	8
Gas pipeline, and field development	. investment in development of Calub resource in the Ogaden desert and transmission to markets	300 (before 1993) of 600 total

Policy Changes

27. Pricing policies for petroleum and power must be reviewed as soon as possible because in both subsectors levying correct economic prices is the key to demand management and desired interfuel substitution measures. There is also an urgent need to reconsider the role of government and encourage private sector participation in the production, delivery, and marketing of biomass fuels if woodfuel supply targets are to be met. Hence, a major review of the most profitable and efficient organization of this sector should be undertaken immediately by independent management consultants.

Institutional Improvements

28. There are five immediate focal points for quickly strengthening and broadening the energy policy and planning capability:

(a) upgrading ENEC and/or taking action on the institutional arrangements of the energy sector to ensure effective coordination of energy policy planning; defining a constructive and workable relationship between the energy policymaking body and implementing agencies (EELPA, EPC, FAWCDA, etc.);

(b) developing EELPA's competence in power system planning;

(c) defining the respective roles of FAWCDA and the MOA in delivering the rural forestry program;

(d) broadening the role of the EPC into petroleum production, expanding its skill base accordingly, and streamlining petroleum exploration under one agency; and

(e) establishing a coordinated approach to manpower training to meet the growing deficiency of appropriately skilled staff in the EPC, EELPA, FAWCDA, MOA and ENEC.

Studies

29. Of the very many pre-feasibility, pre-investment and basic policy and strategy studies recommended in this assessment, the most urgent studies by subsector include the following.

(a) Petroleum: (i) refinery engineering, including LPG recovery; (ii) preliminary natural gas production and utilization study; (iii) fuel oil conservation in industry, defining detailed engineering and costs; (iv) prefeasibility studies on solar heating and crop residue-fired cement kilns; and (v) diesel conservation in transportation, defining diesel pump facility requirements, costs of increased servicing and fleet capacity, and improved structure of the truck fleet.

(b) Electricity: (i) defining a strategy for covering supply constraints though 1990; (ii) major hydropower options inventory; (iii) undertaking mini-hydropower and fuel oil displacement of diesel generation prefeasibility studies (all as inputs to a least cost development study for the EELPA ICS). An urgent review is required of electricity conservation in the ERESA ICS system, including energy audits of major power consuming industries, plus a review of domestic solar water heating potential in the ERESA ICS and elsewhere in Ethiopia.

(c) Household Energy: In forestry, special studies are needed on species selection and provenance screening and strategies for agroforestry in each major agro-ecosystem, and the design and cost of a national fuelwood resource inventory for ongoing monitoring. Studies to facilitate short-term supplies of household fuels include (i) the least-cost method of corn stover and cotton stalk harvesting and briquetting; (ii) the logistics, technology packages and investment planning for carbonizing forest residue; and (iii) an urgent review of potential and investment requirements to generate surplus bagasse in the sugar industry. A special review is required of the least-cost method of meeting the cooking fuel requirements including possible improved stove prospects for Asmara, Mekele and other northern towns during the next decade.

The combination of these initiatives and the implementation of the investment program and the policies arising should result in:

(a) measurably enhanced supply and lowered cost of household fuels within the decade;

(b) a rational and efficient use of expensive imported petroleum fuels and electricity; and

(c) a marked reduction in the balance of payments pressure for the supply of modern energy forms.

FIJI: ENERGY BALANCE, 1982
(thousand tonnes of oil equivalent)

	Fuel-wood	Bagasse	Total Non-Commercial	Coal	Petroleum	Electri-city	Total Commercial	Total
Supply								
Primary Production	72.9	243.5	316.4	-	-	-	-	316.4
Imports	-	-	-	12.0	397.0	-	309.0	409.0
Exports	-	-	-	-	(148.9)	-	(148.9)	(148.9)
Power Generation	-	-	-	-	(66.4)	66.4	-	-
Sector Use/Losses	-	-	-	-	-	(20.5)	(20.5)	(20.5)
Net Supply/Demand	72.9	243.5	316.4	12.0	181.7	45.9	239.6	556.0
Demand								
Industry and Commerce	14.2	243.5	257.7	12.0	24.2	32.7	68.9	326.6
Household	56.6	-	56.6	-	22.5	9.4	31.9	88.5
Transport	-	-	-	0	133.9	-	133.9	133.9
Others	2.1	-	2.1	-	1.1	3.8	4.9	7.0

toe = 10.0 mn kcal
kWh = 2500 kcal

FIJI 1/

1. Fiji's performance in the energy sector has been remarkably good during the past ten years despite its complete reliance on imports for the supply of petroleum products. The main issues for the future are essentially related to institutional and, to some extent, pricing arrangements to ensure, first, that an appropriate mix of the variety of available indigenous energy resources is used, second, that energy supplies are available to rural and urban areas on each of the two main islands of Viti Levu (with 75% of the population) and Vanua Levu (15%), as well as over 300 other islands, and, third, that current efforts to encourage efficient use of energy are continued.

2. With the completion of the Monasavu hydro project, there will be sufficient power capacity to meet Viti Levu's needs (95% of the national total) until the early part of 1990. Total petroleum demand will decline by 6.8% p.a. up to 1985 and thereafter will increase at about 1.9% p.a. It is expected to be the same in 2000 as in 1981. As the country's source of power for electricity shifts from oil to hydropower, the petroleum product demand mix will change, with greater emphasis on light products, expecially those needed by the transport sector. In this report the mission has used two scenarios from 1983: a base GDP/growth scenario (BGS) of 3.5% p.a. which the mission believes is realistic and an optimistic growth scenario (OGS) of 5.0% p.a. which the Government hopes to achieve. Under both scenarios, total petroleum demand is not expected to increase significantly and growth in power demand will approximate the real GDP growth rate. Total energy demand under the optimistic growth scenario would increase at 2.1% p.a. and under base growth scenario at 1.8% p.a. 2/ In neither case is per capita energy use expected to increase significantly.

Power Sector

3. Due to the recent slowdown in the economy and increases in power tariffs, power demand growth during 1981-1983 is averaging about 2-3% p.a. Power demand in the future is expected to grow at 3.5% - 5.8% p.a. Maximum demand in 1990 would be 60 MW (BGS) to 66 MW (OGS) while in 2000 it would be 82 MW (BGS) to 103 MW (OGS). The Fiji Electricity Authority (FEA) has recently revised its forecasts downward and these now match the mission's high growth scenario projections. The mission's

---

1/ Adapted from Report No. 4462-FIJ, June 1983.

2/ The forecast energy demand assumes that the major growth will come from non-energy intensive sectors. No major construction projects needing large energy inputs like Monasavu are envisaged during the forecast period.

Economic Context

Fiji comprises a group of more than 300 islands in the South Pacific, covering a land area of 18,371 sq. km. About 90% of the 658,000 (mid-1982 estimate) population lives on two main islands, Viti Levu (75%) and Vanua Levu (15%). About 60% of the labor force is employed in agriculture, forestry and fishing. These together contribute about 25% of GDP. The other major contributors to GDP are the services (16%) and manufacturing (12%) sectors. Although per capita GDP is relatively high (about F$1,057 in 1982), the economy is mainly dependent on sugar exports and tourism and is vulnerable to external trade fluctuations. After experiencing negative growth in 1980 and a recovery in 1981, in 1982 the growth in GDP has again reversed to -2.0%. This reversal was due to a decline in manufacturing, construction, and distribution activities (services sector including tourism). Due to prolonged drought, growth prospects for 1983 are also dismal, with a projected 0.3% decline in GDP.

projections indicate that the current generation and transmission facilities on Viti Levu are sufficient to meet the demand up to 1991 under the OGS and up to 1995 under the BGS. In 1985 there will be about 90 GWh of surplus energy. In the long-term, there are four possible hydro-power projects on Viti Levu for which provisions were made during the construction of the Monasavu hydropower development and Vaturu water supply schemes. These projects can be brought on stream fairly quickly with relatively small investment to meet the small increments in power demand beyond 1991 and 1995. Two additional hydropower projects are also under investigation. The total hydropower potential on Viti Levu is estimated at 300 MW. The mission commends the foresight and preparation work of the FEA and concludes that there is no urgency for undertaking further work, such as a long-term power master plan for Viti Levu.

4. For Vanua Levu, it is possible to replace diesel based power generation in Labasa and meet current maximum demand of 2 MW by a combination of a samll run-of-river hydro plant (providing energy mainly during the wet season), and a bagasse-based power supply from the Fiji Sugar Corporation (FSC) along with wood-based power generation from the Malau sawmill (in the dry season).

5. Rural Electrification. About 25% of households in the rural areas and 50% in the urban and peri-urban areas are connected to electricity supply. Currently there are two rural electrification programs, one under FEA and the other under the Public Works Department (PWD). PWD provides power to isolated rural communities, and FEA extends its grid to rural communities located in its vicinity.

6. Rough estimates show that some 80,000 houses would have to be connected to completely electrify Fiji, at a capital cost of about US$80 million. Although the additional load will not be large (10 to 15 MW), the magnitude of the financial needs and the logistics of supplying electricity to three times the number of current customers make it an ambitious plan which will require a major planning effort. The mission supports the Government's decision to transfer the bulk of rural electrification activities to FEA to ensure a consistent policy with regard to technical standards, capital contributions by consumers and maintenance. ADB has agreed to provide technical assistance to develop a country-wide rural electrification plan which should be based on appropriate economic justification. The study will include an evaluation of the number of villages to be electrified each year, estimates of costs, financing and technical standards, and establish a priority list for the electrification program based on economic calculations.

Liquid Fuels

7. Petroleum Exploration. Since 1978, when new exploration licenses were awarded, exploration has not proceeded at a satisfactory pace. Although considerable seismic work has been done, only seven wells up to a depth of 3,000 meters have been drilled and these have not found a promising source or reservoir rocks. In view of potential structures and traps which still remain untested, including deeper sedimentary layers (between 3,000-5,000 meters) at one of the wells, continued efforts to encourage exploration drilling are justified. To promote such a program, the Government will need to disseminate technical information to attract new concessionaires and hold promotional meetings. The mission recommends a technical assistance program for this purpose.

8. As far as the petroleum law is concerned, the mission bleives there is sufficient flexibility to permit several contract approaches. Existing contracts are straightforward concession agreements. Since the income tax abatement clause does not serve as a significant incentive, a production-sharing type of contract might be worth considering. This type of contract is widely acceptable to oil companies because it allows for rapid investment recovery and is relatively simple to administer. It would also allow Fiji substantial control and participation.

9. Petroleum Supplies. Fiji currently imports about 320,000 tonnes p.a. of petroleum. The products are brought in by three oil companies, and about 75% of supplies originate from Australia. LPG is imported by a non-established (non-major) petroleum trader. Product costs (excluding LPG) are calculated on the basis of a Singapore import parity. A recently completed study by consultants indicates that as Australia is much closer to Fiji than Singapore, Fiji is overcharged in freight. The mission visited Australia and Singapore to investigate this matter and concluded that while the freight rates applied to the transport of clean products carry a premium which is higher than that normally used in international trade, the import volumes of each company are too small to enable the country to bargain for favorable rates and therefore lower prices.

10. Under the current situation, the companies guarantee a continuation of supplies, which is advantageous to Fiji. It is true that GOF may be able to procure supplies from independent marketers in the short run at lower spot prices, but this may prove to be only a temporary advantage if, under different market conditions, such supplies were no longer available.

11. However, it is possible both to procure supplies at lower than current costs and ensure the continuity of supplies. To this end the mission recommends that:

(a) as a first step, the storage/marketing and supply/transport functions be separated to allow for different companies to handle these two aspects. Such a separation would increase distribution efficiency and could be implemented without disrupting current distribution arrangements;

(b) the Governments of Fiji, Papua New Guinea and the Solomons should pool their requirements and seek bids from established international majors to supply the combined needs of the three countries. 3/ If possible, other countries in the region should be included in the supply pool; and

(c) the governments also negotiate with prospective suppliers for freight rates whch are in line with international standards, or arrange with independent companies to transport these products.

12. In the mission's view, these arrangements would be compatible with current petroleum supply logistics and would give a prospective supplier the incentive of access to a large market to quote lower than Singapore basing point prices. The mission's investigations confirm that such arrangements will be acceptable to the oil marketing companies. Indeed, Bougainville in PNG was able to procure fuel oil supplies from Gulf Oil at substantially lower than Singapore postings. A local refinery as a source of petroleum supplies is considered uneconomic.

13. Ethanol. In the feasibility study done for the Fiji Government, options based on either new sugar areas or a distillery using cane juice annexed to an existing sugar mill were found uneconomic. 4/ The molasses-based option for a free standing distillery was found to be marginal. The mission's review suggests that the economics of the molasses-based option could be improved if:

3/ The combined demand of these three countries is about 985,000 tonnes p.a. (about 19,000 barrels/day), including the supplies to Bougainville.

4/ The report was prepared jointly by the FSC, British Petroleum South West Pacific (BP) and Colonial Sugar Refiners (CSR) of Australia.

(a) the size of the proposed plant is reduced to meet only the domestic demand for ethanol for blending at 20% with gasoline (10-14 million liters);

(b) the plant is annexed to the Lautoka Sugar Mill to take advantage of installed capital equipment and excess bagasse available during part of the crushing season;

(c) arrangements are made to dispose of the plant effluent into the ocean in an ecologically acceptable manner, that would not affect tourism in the area: 5/

(d) the plant is designed to operate year round, using pine chips from the Fiji Pine Commission (FPC) as a fuel in the off-season; and

(e) the capital costs are revised according to appropriate design and procurement arrangements.

The mission's evaluation shows that the project economics is marginal and highly sensitive to the prices of molasses and ethanol. It is recommended that the Government review the mission's recommendations and if acceptable, partly base its decision on the terms at which potential commercial partners would be prepared to supply capital for the project.

Special Energy Programs

14. GOF has initiated several special energy programs since the establishment of the Department of Energy (DOE) in the Ministry of Energy and Mineral Resources (MEMR). The mission's assessment of some of these programs follows:

Energy Conservation. The main thrust of the energy conservation program is in public organizations, and the initial goal is to reduce the electricity bills of government agencies by 20% (1983/84). In addition to tax incentives, GOF has allocated F$200,000 in the FY1983 budget to implement recommendations of energy audits started in 1982. The mission supports the fuel economy program of the Ministry of Agriculture and Fisheries (MAF) which is designed to replace outboard motors (used by small scale fishermen) with fuel efficient diesel inboard motors.

Gasification. The EEC is providing funding through the EDF for two pilot gasification projects. Both projects are to retrofit diesel engine

---

5/ These are strong feelings in Fiji against the disposal of effluent into the ocean.

generators. FEA plans to retrofit an existing 365 kVA generator with a medium-sized gasifier at its control center at Vuda Point. If tests are successful, the gasifier would be transferred to an outstation such as Savusavu. The scope of a second pilot project has not yet been defined. In the mission's view, FEA's choice of small charcoal gasifiers (20 to 50 kW) rather than small steam engines is a sound one given that FEA's main objective is to retrofit diesel engines of the type used in isolated rural electrification schemes.

Stove Development. The DOE has been successful in adapting and developing wood and charcoal burning stoves for household use. In the mission's view, the next step, which involves dissemination and/or commercialization of the stoves, should be the responsibility of specialized divisions or agencies of the Ministry of Fijian Affairs and Rural Development (MFARD) provided adequate staff is available for this purpose. 6/ DOE should, however, continue to provide the necessary technical backup for this program.

Biogas. The MAF has installed about 11 pilot biogas digestors to handle the waste disposal problem under its piggery dvelopment program. Because of the interest shown by farmers, MAF has approved a proposal to expand the pilot program by installing additional digestors on private piggeries. GOF has recently reduced MAF's initial allocation of F$10,000 (US$10,400) to F$5,000 (US$5,020) in the current budget (equivalent to F$500 (US$502) grant per installation for 10 farmers). In order to maintain the program's momentum, the MAF could use unallocated farm improvement funds (currently F$16,000 (US$16,640)) to supplement GOF's direct budget support.

Solar Energy. Several GOF organizations such as the Department of Posts and Telecommunications, have made significant progress in the use of solar energy technologies. GOF has also introduced tax and investment incentives to promote local manufacturing and assembling of solar systems such as water heaters.

Institutions

15. The role of the DOE within the MEMR needs to be clearly defined. It should be limited to planning and policy areas. MEMR should closely liaise with FEA and the Central Planning Office (CPO) to help identify the growth areas where power will be needed or can be used. This will help coordinate the planning process and remove the inconsistencies in various programs. The MEMR should also play a lead role in energy pricing policy. The mission recommends a technical

---

6/ MFARD has now been split into two ministries.

assistance project to strengthen MEMR's institutional capabilities, particularly in the area of energy economics and petroleum supply arrangements. The government has also indicated a need for short-term technical assistance for preparing a strategy for petroleum supplies and negotiations of supplies contracts in 1984.

Prices

16. Petroleum. Although retail prices fully reflect the cost of imports, disparities between taxes on gasoline (Fc16/liter (US$0.63/US gallon)) and diesel oil (Fc5/liter (US$0.20/US gallon)) continue to distort relative prices of these products. In the mission's view, there is sufficient scope to streamline the product prices and reduce the cost of imports. For this the mission recommends a three-step strategy for regional procurement of petroleum products. The mission also recommends a close working relationship between the MEMR and the Prices and Incomes Board (PIB).

17. Power Tariffs. There have been several tariff increases recently, and FEA has been able to offset major escalations in its operating expenses and comply with most covenants under the IBRD/ADB power loan agreement. Additional tariff increases were planned for January and July of 1982 (10% each). The Government believes that current tariff levels are high and decided to defer these increases . The mission recommends that, after the completion of Monasavu, the tariffs should be reviewed in the second half of 1983 based on long-run marginal costs.

Investments

18. Considering that: (a) the preparation of a power development program is not an immediate priority; (b) the rural electrification program must be defined by the ADB study and the extent of implementation agreed by the Government based on its resources; and (c) there are uncertainties about the oil and gas exploration program, estimates of future total investment in the energy sector are not needed at this time, even though the scope and areas of possible investments are identified under each energy subsector. More important is technical assistance of about US$1.1 million to cover petroleum, power and energy planning/management in the next three years.

THE GAMBIA: ENERGY BALANCE, 1982
(thousand tonnes of oil equivalent)

	Fuelwood	Groundnut Residues	Total Noncommercial	Petroleum	Electricity	Total Commercial	Total
Primary Supply							
Production	125.0	1.6	126.6	..	-	-	126.6
Imports	-	-	-	53.4	-	53.4	53.4
Total	125.0	1.6	126.6	53.4	-	53.4	180.0
Transformation and Losses							
Public Power Generation	-	-	-	(9.2)	9.2	-	-
Conversion Losses	-	-	-		(5.5)	(5.5)	(5.5)
Distribution Losses	-	-	-		(0.8)	(0.8)	(0.8)
Net Supply/Demand	125.0	1.6	126.6	44.2	2.9	47.1	173.7
Demand							
Residential	110.0	-	110.0	0.4	1.1	1.5	111.5
Industry/Commercial	15.0	1.6	16.6	3.3	1.2	4.5	21.1
Agriculture	-	-	-	4.5	-	4.5	4.5
Transport	-	-	-	25.4	-	25.4	25.4
Government/Others	-	-	-	10.6	0.6	11.2	11.2

toe = 10.0 mn kcal
kWh = 2500 kcal (production)
860 kcal (consumption)

THE GAMBIA 1/

1. The Gambia relies entirely on imports to meet its commercial energy needs, including electricity, which is based on diesel systems. The Government's difficulties in servicing the country's growing oil import bill have become acute in recent years because declining groundnut production and low export prices have reduced foreign exchange earnings to critically low levels. The net effect is that oil imports, which absorbed only about 9% of commodity export earnings in 1974/75, now account for over 22% of earnings in a good year. In a bad year such as 1980/81, when the country was particularly hard hit by the poor groundnut harvest, oil imports absorbed about 70% of such earnings. The outlook for improvement is not favorable, as export prices for groundnuts are not expected to improve much over current levels, and the Government may eventually be compelled to introduce some form of rationing for petroleum products to ensure essential supplies to important sectors of the economy. In practical terms, the country's options for reducing petroleum imports are limited by a relatively modest indigenous energy resource endowment. There is some possibility of economically exploitable oil and gas deposits in the Gambia's sedimentary basin but this requires systematic exploration. Hydropower and peat are marginal energy resources, and applications of nonconventional sources (solar, wind) are yet to be fully assessed.

2. The Mission projects that commercial energy demand (excluding fuelwood and other biomass) will grow at about seven percent a year, due mainly to the restoration of adequate diesel power generating capacity in the Banjul area, which has been short of power since an explosion at the Half Die Power Station in 1977. These projections need to be reviewed in 1985 as part of the proposed medium-term power development plan.

Energy Sector Issues

3. The Government's basic energy policy as outlined in the current Development Plan is: (i) to secure adequate energy supplies to meet future requirements of the economy; and (ii) to minimize the cost of energy to the economy by improving the efficiency of energy use in the economy. Immediate problem areas in the energy sector are rooted in institutional weaknesses which have developed from inadequate staffing of energy institutions that control day-to-day operations in subsectors such as power, petroleum and forestry, and the lack of a well articulated energy policy or strategy with which to guide planning and other efforts by these institutions and the Ministry of Economic Planning and Indus-

---

1/ Adapted from Report No. 4743-GM, November 1983.

Economic Context

The Gambian economy is based on non-energy intensive agriculture and groundnut production. The modern sector, which comprises commerce, public works, tourism and small industries, is growing in importance due to the Gambia's role as an entrepot serving neighboring Sahelian countries. The economy has suffered from a persisting drought which has seriously cut agricultural output. Groundnut production reached a record low of 45,000 tonnes in the 1980/81 growing season. The Government currently is proceeding with the Second Development Plan which assumes a five percent yearly growth in GDP over the period 1980 to 1986. This level of growth reflects the Government's projection that groundnut production will rebound to previous levels of about 135,000 tonnes a year.

trial Development (MEPID). The Government is fully aware of the seriousness of these problems and has requested technical and financial assistance from external sources to tackle them. The response to this request among foreign agencies has been good, and progress is being made on some of the more pressing operational problems of the Gambia Utilities Corporation (GUC), the Department of Forests (DOF), and the Geological Unit of the Ministry of Local Government and Lands (for petroleum exploration).

Banjul Power System

4. The Banjul area has been short of power since late 1977, when an explosion destroyed part of the Half Die Power Station in Banjul. The GUC is in the process of restoring adequate capacity for the area by expanding installed capacity at the new Kotu Power Station which took over base load operations in July 1982. The Government and GUC have secured external financing from the Japanese Government and KfW (West Germany) for two diesel power units (one 5.0 MW and one 3.8 MW). Both units are to be installed by the end of 1985, at which time GUC expects to have enough capacity to meet the short-term load requirements in the area. However, because GUC is holding up action on some 2600 applications for new connections, further capacity will be needed shortly after 1985. GUC plans to commission a medium-term power development study to determine system capacity requirements (generation, transmission and distribution) beyond 1985. In the Mission's view, this study is needed to clarify the scope and timing of additional investments in the Banjul system. KfW and the German Technical Assistance Agency (GTZ) have indicated interest in sponsoring the study.

Provincial Power Systems

5. GUC operates isolated small diesel power generating systems in the administrative headquarters for the provinces. Because of GUC's operational and financial weaknesses, these provincial systems, with a total installed capacity of 5.2 MW, have been neglected and their current total available capacity is only 2.6 MW. The Mission endorses GUC's request for asssistance to carry out an emergency overhaul and rehabilitation program for the provincial systems. A few of the units have broken down recently and several more are likely to break down permanently unless such a program is begun immediately. The Government is waiting for a response to its request for technical assistance from the bilateral program with the U.K. Government.

Petroleum Supplies

6. The Government relies on private oil companies (Shell, BP and Texaco) to furnish the country's petroleum supplies. Current difficulties in maintaining this arrangement reflect (i) a breakdown of the West African Replenishment Program (WARP), which was a pooling system for supplying petroleum to the region, and (ii) foreign exchange shortages which have undermined the ability of private oil companies to maintain their lines of credit to the Gambia. In March, 1983, the Government introduced a temporary arrangement which allows the oil companies to procure products from Senegal. This arrangement has led to significant price increases because of: (i) higher procurement and handling charges through Senegal; and (ii) payment of Senegalese taxes on petroleum products (although duties have been waived). The Government would like to establish a more permanent arrangement which could both reduce costs and assure relative security of supply. The Mission recommends that the Government commission a study to evaluate the relative costs of the current arrangement and alternatives before deciding on a permanent arrangement. In the Mission's view, an arrangement similar to the recently established Special Oil Purchasing Facility could form one basis for supplying the entire country's petroleum needs. The Facility was established by the Government, with financing from the Islamic Development Bank, to procure GUC's diesel oil requirements directly from Algeria. The Mission also recommends the development of a contingency allocation program to replace the existing ad hoc system for distributing and retailing products during supply interruptions and shortages. A more uniform and rational set of criteria could be established through joint consultations between the Government and representatives of the private oil companies.

Petroleum Storage Facilities

7. Despite the recent installation of a sophisticated fire protection system at the Shell operated depot, there is still some concern in the Government about the safety of its location in Banjul city center. The Government has identified a site for a new storage depot on land reclaimed for the Banjul Port Expansion Program but it is not clear

what portion of the investment required for this new depot will need to be financed by the Government. The Mission recommends that the Government carefully review the costs and benefits of such a relocation before deciding on its next move.

Energy Efficiency and Savings

8. The Mission reviewed a number of options for improving the efficiency of energy use, and reducing energy costs through fuel substitution. The Mission identified a sizeable unexploited potential for saving diesel oil and electricity by retrofitting existing water heating systems in the commercial/industrial sector. Specifically, about 720,000 liters of diesel oil a year and some electricity could be saved by installing solar water heating systems at seven major hotels and the Banjul Brewery. Both the Government and potential users have expressed interest in pursuing this option. The Mission recommends a comprehensive technical assistance program to prepare detailed designs, tender documents for procurement and installation of equipment, and to supervise and monitor the initial operation of these systems. Equipment for the proposed Solar Retrofit Program could be financed through the foreign currency line-of-credit of the Gambia Commercial and Development Bank (GCDB). GCDB will, however, need external financing to replenish its foreign currency reserves.

Energy Pricing

9. The Government's policy is not to subsidize petroleum and, in fact, retail prices are well above the c.i.f. import levels due to high Government duties. Retail prices are adjusted on a semiannual basis after consultation with the private oil marketing companies. The differential between retail prices for petroleum products in Senegal and the Gambia has been almost completely eliminated in the past two years. Despite regular increases that have more than doubled electricity tariffs in 1976, GUC is still facing financial difficulties. GUC has, however, been able to improve its liquidity position by adopting cost-cutting measures and by receiving strong Government support to pursue outstanding bills. Although GUC had requested another 20% increase to be effective in September 1983, the Government is reluctant for social reasons to approve further increases until GUC exhausts other avenues for reducing costs. As the operating losses for provincial stations are also a major contributor to GUC's high costs, the Mission has also recommended that the scope of the proposed study of provincial electricity systems to be funded by the Islamic Development Bank be expanded to include a detailed assessment of the costs to GUC of operating and maintaining such isolated systems. Fuelwood prices are not controlled by the Government. At current prices, fuelwood remains the cheapest energy source for cooking in the Gambia.

Development of Indigenous Energy Resources

Fuelwood

10. The first phase of the Gambia-German Forestry Project (GGFP) is almost complete, and a second phase which is estimated to cost DM 5.0 million (US$2.0 million) is to start in November, 1983. The USAID sponsored Forestry Project also has been completed. Because of the high costs of establishing fuelwood plantations, future support from USAID may be for only communal woodlot schemes. The Mission endorses the GGFP recommendation that greater emphasis be placed on managing the country's natural woodlands to sustain the production of fuelwood and other forest products. This approach will be developed during the second phase of the GGFP. In the Mission's view, the Department of Forests (DOF) needs strengthening at the professional level to effectively carry out the proposed approach. At least five more persons need to be trained to the Bachelor's and/or Master's level before DOF can adequately manage its field operations staff under a proposed five-zone system. In the Mission's view, the efforts of the GGFP need to be supplemented by technical assistance: (i) to do a comparative analysis of the financial aspects, including evaluation of economic costs and benefits of alternative schemes for producing fuelwood in relation to the different markets in the Gambia; and (ii) to evaluate the appropriateness of existing license fees and royalties.

Oil and Gas

11. The Gambia is collaborating with Senegal and Guinea-Bissau in a joint study of the region's sedimentary basin. Progress is being made by the Government's consultants, Atlantic Resources Limited of Portugal, who have completed the first stage of retrieving, reevaluating and reprocessing available geological and geophysical data on the basin. The Government is also being assisted by the PetroCanada International Assistance Corporation (PIAC) who also has completed a 600 km marine seismic survey in part of the basin. The data will also be used for the regional basin study.

Hydropower

12. There is no hydropower potential in the Gambia because of the very flat nature of the country's landscape. The maximum elevation of the country is only 30 meters. The Gambia will have access to future hydropower developments upstream on the river because of its membership on the Joint Commission for the Development of the Gambia River (OMVG). The prospects for obtaining hydropower supplies through this arrangement before the 1990s are remote.

Peat

13. Recent discoveries of mangrove peat occurrences along sections of the Casamance River in Senegal have raised some interest in the

possibility of similar occurrences along the Gambia River. However, there is the likelihood that the fuel quality of any mangrove peat deposits found along the Gambia River will be as poor as that of the deposits in western Senegal which were found to have a high ash and salt content. In the Mission's view, a limited reconnaissance survey would appear to be the next step for the Government.

Institutional Framework for Energy Planning

14. Further to the recommendations contained in the final report on the Energy Survey and Master Plan Study (EMPS) on the Gambia (financed by the United Nations Sudano-Sahelian Office), the Government established a National Energy Commission (NEC) comprising public and private officials to advise the Cabinet on energy matters. The Energy Unit, first established within the Ministry of Economic Planning and Industrial Development (MEPID) to monitor and review the EMPS, is to function as the permanent secretariat to the NEC. The Energy Unit currently is staffed on a part-time basis with a Principal Planner and an expatriate technical adviser to the MEPID. The Government has allocated resources for MEPID to recruit an economist to work full-time in the Energy Unit. The economist will be supervised by the Principal Planner of MEPID and continue to receive support from other MEPID staff as required. A resident expatriate energy economist/planner also will be needed for about 18-24 months to assist in establishing the unit, defining its work program vis-à-vis NEC's priorities. In the Mission's view, the need for the expatriate energy economist/planner is critical during the formative years of the Energy Unit and NEC because the counterpart economist is likely to have little energy sector experience.

Implications for External Assistance

15. The most pressing requirement for external financial assistance is for the emergency overhaul and rehabilitation of the eleven provincial, diesel-based power generating systems. About US$1.0 million in spare parts is urgently required to prevent the possible permanent breakdown of some units. A substantial part of the investment required to reestablish adequate electric power generating capacity for the Banjul system has recently been secured from bilateral assistance programs with Japan and West Germany. However, because of the large suppressed demand for electricity services in the Banjul area, additional capacity will be required soon after 1985. The Solar Retrofit Program will require external financing of about US$0.6 million for solar water heating equipment.

16. The main focus of external technical assistance for energy development in the Gambia should be institution building in the operational entities (GUC, DOF, Geological Unit), and planning/investment programming

tasks to be carried out by the Energy Unit of MEPID and the NEC. These are summarized below:

SUMMARY OF TECHNICAL ASSISTANCE REQUIREMENTS

Sector	Estimated Cost	Source
	(US$ '000)	
Power		
Rehabilitation of Provincial Systems	100	UK-ODA
Rural Electrification Program Review	not determined	ISDB
Medium Term Power Plan for Banjul System	not determined	KfW/GTZ
Institution Building		
Resident Energy Economist/Planner (18-24 months)	240	none identified
GUC Diesel Mechanics Training Program	not determined	none identified
Professional Forestry Training	not detrmined	none identified
Petroleum Supplies Specialist	50	none identified
Forestry Economist	12	none identified
Energy Development		
Solar Retrofit Program	150	none identified
Pilot Mangrove Harvesting Program	20	none identified

Estimated at US$10,000 per man-month of specialist consulting.

HAITI: ENERGY BALANCE, 1979
(thousand tons of oil equivalent)

	Wood	Charcoal	Bagasse	LPG	Gasoline	Kerosene-Jet Fuel	Diesel	Fuel Oil	Electricity	Total
Primary Supply										
Production	980.0	-	104.5	-	-	-	-	-	47.9	1132.4
Imports	-	-	-	2.2	53.7	25.3	86.6	62.0	-	229.8
Losses		-	40.3	-	-	-	-	-		40.3
Total	980.0	-	64.2	2.2	53.7	25.3	86.6	62.0	47.9	1321.9
Transformation and Losses										
Public Thermal Power Generation	-	-	-	-	-	-	(18.5)	(3.8)	16.5	(5.8)
Conversion Losses	-	-	-	-	-	-	-	-	(42.8)	(42.8)
Charcoal Production	(168.6)	61.1	-	-	-	-	-	-	-	(107.5)
Energy Sector Use	-	-	-	-	-	-	-	-	(0.2)	(0.2)
Transmission & Distribution Losses	-	-	-	-	-	-	-	-	(5.9)	(5.9)
Net Supply/Demand	811.4	61.1	64.2	2.2	53.7	25.3	68.1	58.2	15.5	1159.7
Demand										
Industry	202.0	-	64.2	-	6.1	-	22.1	58.2	7.8	360.4
Transport	-	-	-	-	-	-	-	-	-	-
Road	-	-	-	-	43.2	-	46.0	-	-	89.2
Air	-	-	-	-	4.4	19.1	-	-	-	23.5
Commerce & Service	203.0	30.5	-	1.1	-	3.1	-	-	1.7	239.4
Households	406.4	30.6	-	1.1	-	3.1	-	-	6.0	447.2

toe = 10 mn kcal
kWh = 2570 kcal (production)
860 kcal (consumption)

HAITI 1/

1. Haiti has an adverse energy position. The main characteristics are: (i) the weak natural energy base of the country, aggravated by the rapid depletion of its forest resources; (ii) the growing energy intensiveness of the modern sector of the economy and the high dependence of this sector on imported petroleum; (iii) the subcritical size of its energy systems, which constrains the choice of least cost solutions; and (iv) the weakness of the country's institutional structure and the scarcity of technical and economic capability to handle the problems.

2. It is therefore essential that the country develop effective and carefully balanced programs in supply development, demand management, institutional building, sector organization and pricing, and this report assesses these aspects of the energy sector. Haiti will continue to need external support and although in recent years bilateral and multilateral agencies have done a great deal in clarifying crucial issues and in project identification and formulation, there is a need for coordinated project implementation to enhance the effectiveness of these efforts and avoid duplication.

Energy Balance

3. Primary energy requirements rose by about 5.6% per year during the past decade, or 1.6 times the rate of economic growth. Per capita consumption (about 270 kg of oil equivalent in 1979) puts Haiti among the least energy-intensive economies of the world. The demand structure reflects the relatively small size of the modern urban sector. Although the demand for commercial fuels has grown at high rates during the 1970s (10% per year for oil, 16% for electricity and 15% for charcoal), these fuels supplied less than 25% of the final consumer needs in 1979. This is so because a significant portion of the industrial, artisanal and commercial sectors use bagasse and wood as the main energy source and because commercial energy is too expensive a commodity for the rural population, which depends entirely on fuelwood for its energy needs and derives an income from the production and sale of charcoal. Another indication of the market's segmentation is given by the fact that 93% of oil and electricity available for final consumption is used by industry and transport, although these sectors' share in total final energy demand is only 41%.

4. Domestic energy resources provide 83% of total primary energy requirements. Wood is by far the most important source, followed by bagasse and hydropower. The energy deficit of about 17% is met by imported petroleum products. Although still modest in volumetric terms

---

1/ Adapted from Report No. 3672-HA, June 1982.

Economic Context

Haiti is a small, open economy, with a markedly dual structure: a large agricultural sector, characterized by low productivity and dense population, and a modern, urban sector of rapid growth during the 1970's, which has a high import content. Although there has been moderate growth of the economy during the decade of about 3.6% per year, income per capita in Haiti (US$260) remains the lowest in the Western Hemisphere and three-quarters of its population live in dire poverty, with incomes per capita below US$100.

Agricultural production has been stagnant and as a result its share in GDP has decreased from 49% in 1970 to about 39% in 1979. Future productivity of the sector is threatened by a severe soil erosion problem. The pressure on land and the indiscriminate felling of trees for energy has reduced the land's protective forest covers and in many areas the land has lost its ability to retain moisture and regulate water runoff. The result is progressive desertification and periodic agricultural crisis caused by floods and droughts.

The manufacturing and construction sectors are not large enough to compensate for the poor performance in agriculture or to provide productive employment for migrants from rural areas. Most dynamic in recent years has been the assembly industry, which benefits from low-cost labor, but whose expansion depends on market conditions in the USA and Europe. The industrial sector generated 24% of GDP in 1979 and had an average growth rate in recent years of 5.6% per year; the share of the tertiary sector was 37% in GDP, and its growth rate was 3.6% per annum.

The poor performance of agriculture, the high import content of the modern sector and the progressive deterioration of the terms of trade have caused a growing deficit in the trade balance, which is only compensated in part by the inflow of foreign transfers in the form of public grants and private remittances from Haitians abroad. Medium term projections indicate that the deficit in the trade balance is likely to increase from US$ 128 million in 1980 to US$300 million by 1985. The Bank has already suggested a shift in economic policy toward agricultural and other raw material production to create the base for a backward linkage of the industrial sector and continued foreign assistance to supplement the low level of domestic savings.

(4.8 thousand barrels per day in 1979), the cost of these imports has become a severe burden to the economy. The oil import bill was US$32 million in 1979 and is estimated at US$61 million in 1980, equal to 23 and 29%, respectively, of the country's export earnings. If past trends continue, the energy deficit would increase to 22% of total supplies by 1985 and if the gap were to be supplied by imported petroleum, the volume of these imports would reach 9 thousand barrels per day and their cost, in constant 1980 prices, would absorb at least 45% of Haiti's projected export revenue.

5. The efficiency with which energy is transformed and used in Haiti merits special scrutiny in view of the growing constraints on domestic energy supplies and the economic burden of foreign energy imports. About 12% of primary gross supply of energy is consumed and lost in conversion processes. The most important loss occurs in charcoal production, although only 17% of wood was converted into charcoal in 1979. With progressing urbanization and exploitation of farther removed forests, the share of conversion will increase and result in accelerated depletion of the resource base. To limit this trend, urgent measures are required to establish plantations near urban centers, thus reducing the incentive for producing charcoal and to adopt better conversion methods. With respect to bagasse, the table shows that almost 40% of this fuel is lost because of inefficient handling and burning in sugarcane processing plants; similarly, it becomes evident that the losses in power transmission and distribution exceeded in 1979 the amount of electric power thermally generated.

6. On the other hand, fuelwood is used with very low efficiency by the final consumer. In this report, a 7% to 15% efficiency range was assumed, which is less than half of the estimated average efficiency with which fuels are used in Haiti. This indicates that considerable savings in fuelwood consumption could be achieved through the dissemination of more efficient stoves.

Development Projects

7. To realize a more sustainable energy position over the longer term, Haiti should follow a two-pronged approach. First, through appropriate demand management and stimulation of higher energy efficiency, increases in energy consumption should be curtailed in a manner which does not impair economic growth. Second, to the extent consistent with efficient resource allocation, indigenous energy resources should be developed. Since Haiti will not be able to support more than a limited number of projects during the next five years due to the shortage of trained people, it is important to distinguish between those which will have an immediate impact on the two crucial issues of Haiti's energy problem: depleting forest resources and increasing cost of oil imports, and those which are important for consideration in the longer-term.

Short Term Projects

Indigenous Resource Development

8. Forest Resources. There is a general acknowledgement that the rapid disappearance of Haiti's forest cover involves an environmental problem of the first order that threatens the long-term productive capacity of the nation. Athough statistical information is inadequate, several studies have provided conclusive evidence of the growing imbalance between the natural growth rate of wood in existing forest areas and the domestic consumption of wood. The estimate contained in this report indicates a relationship of 1:2. Current reforestation programs are insufficient to introduce a significant change in this situation. The depletion of this resource is further aggravated by the continuing and uncontrolled expansion of agriculture into forest areas. To overcome the problem and assure a continued supply of fuelwood and charcoal, Haiti must proceed with a determined reforestation policy, including protection of remaining forests and new plantations. However, there is a justified concern that energy plantations would compete with land required for agriculture. The issue must be resolved through the definition of a land use policy and through the formulation of a strong agricultural extension program to increase the productivity of land. As a first step, a national inventory and mapping program should be completed, showing current land cover and use. It is recommended that this survey be started on a priority basis on areas suitable for fuelwood plantation development and later be expanded to cover the entire country. Further, the following actions are recommended:

(a) Identification and eventual establishment of forest plantations of fast growing species which will supply a significant portion of the nation's needs for charcoal and fuelwood. Fully implemented the program would cover between 100,000 and 300,000 ha and should be located near the major consuming centers. An immediate goal should be the establishment of a 10,000 ha plantation near Port-au-Prince, with the objective of meeting about one-third of the capital's charcoal demand by 1990.

(b) Immediate action to sharply reduce erosion and sedimentation at Peligre and thus to protect Haiti's hydroelectric resources. Requirements include the control of grazing and cultivation, the planting of grasses on steep slopes, and reforestation of the Artibonite headwaters, in conjunction with orderly agricultural development.

(c) Identification of several blocks of partially forested land suitable for wood production which could be improved by immediate institution of basic forest management practices including fire control and elimination of illegal felling and cattle grazing. After a short period, stand improvement and planting could be initiated in these areas, with the double objective of

energy production and industrial utilization of wood. The pine forest of La Selle should be considered for demonstration of these policies. The long-term objective should be to establish such forest management on approximately 100,000 ha. The Northwest Region should be included in the program.

(d) Establishment of plantation programs to identify suitable tree species and to demonstrate results for wood production and erosion control. Provisional estimates of trial plantation sizes are:

Location	Hectare
Central Plateau	200
North-West (dry sites)	100
North, or North-East (mountain sites)	100
North, or North-East (plain)	100
Cul-de-Sac	100
Southern Regions	200

9. Expansion of Power Generating Capacity. For planting-up purposes, electricity sales in the Port-au-Prince market have been projected by the public utility to grow at 13.1% per year during the period 1980-1986, on the basis of assumed economic growth of 4%. This compares with an actual average rate during the past decade of 16.4% in electric sales and 3.6% in GDP. Even if GDP does not grow at 4 percent, because of some industrial projects not materializing, the projections appear reasonable because demand growth is determined more by the supply capacity of the utility than by the characteristics of the market, as no more than 34% of the population in Port-au-Prince has access to electricity. The projections imply that generation requirements will double during the period and that maximum demand will increase from 54 MW in 1980 to 106 MW in 1986. For the decade as a whole, increase in generating capacity is estimated at 140 MW.

10. The analysis of alternative primary energy sources available for power generation indicates that the development of the hydropotential is the least cost solution for expanding generation in the interconnected system. As indicated in the table below, generation based on domestic lignite may not be competitive with imported coal, even if sufficient reserves can be proved to justify the installation of a steam power plant.

COST ESTIMATE FOR POWER GENERATION ALTERNATIVES

Type of Plant	Size	Investment Cost	Unit Cost Estimate		
			Fuel	Capital	Total
	(MW)	(US$/kW, 1981)	(¢/kWh)	(¢/kWh)	(¢/kWh)
Hydro Plants	5-32	2,200 or less	-	4.9	4.9
Diesel Units					
Bunker C fueled	7-14	800	6.2	1.9	8.1
Steam Plants					
Imported Coal-fired	30.0	1,500	3.0	3.5	6.5
Domestic Lignite-Fired					
Low Reserve Estimate	15.0	3,000	4.3	7.3	11.6
High Reserve Estimate	30.0	1,700	4.3	3.9	8.2

11. Haiti's undeveloped hydropotential is estimated at about 120 MW. The largest portion is located on the Artibonite river, downstream from the existing Peligre dam, and on an upstream tributary, the Guayamouc river. Some 100 MW, with an average aggregated generating potential of 600 GWh per year, could be developed and connected to the national grid. In addition, there are a number of mini and micro sites, some of which could be developed to supply isolated networks.

12. Electricite d'Haiti envisages the development of the hydropotential on the Artibonite and Guayamouc rivers during the 1980's. As a first step, its investment program for 1981-1986 establishes total expenditures at about US$250 million, allocated to the following projects:

(a) Feasibility studies for the proposed hydropower plants and construction of the largest of the four possible sites on the Artibonite (La Chapelle) and of one dam on the Guayamouc river, which not only is the least cost option for power generation but also will significantly reduce the inflow of erosion material into the Peligre Lake.

(b) A 35 MW increase in the thermal generating capacity to meet the incremental demand of the interconnected system until the hydro plants are commissioned. These plants will be diesel units, Bunker C fueled.

(c) Renovation of the distribution system, and enforcement of measures against thefts to reduce losses in the system from 28% in 1979 at least to 19% in 1986.

13. In addition, the following actions are recommended:

(a) Further investigation on the feasibility of developing the remaining potential on the Artibonite-Guayamouc basin, taking into account the cost of thermal capacity that has to be in-

stalled as back-up for the hydro system and comparing these costs with the coal alternative.

(b) Continue the feasibility study for the construction of a dam on the Artibonite river, upstream from Peligre, to further reduce the siltation problem of this reservoir and generate electricity. EdH should also obtain additional information on the hydrology of other upstream river basins to determine whether dams could be built in this area in the future.

(c) Initiate studies on the alternatives available for long-term expansion of the generation capacity of the system. In the 1990s, the system is likely to require a yearly increment in capacity of 15-20 MW. This would allow the commissioning of commercial size steam power plants, fueled with imported coal or imported heavy oil. The cost of these alternatives will have to be assessed in the light of relative price evolution and transport costs of these fuels.

(d) The subsidy to the isolated electric systems of the interior must be carefully monitored. A realistic cost-benefit analysis should preceed any future expansion. The development of mini-hydroplants should be encouraged whenever possible, to reduce the consumption of diesel oil in these systems.

(e) Rural electrification on a large scale should not be considered at this time, with the exception of the lower Artibonite valley, where pumping water for irrigation will achieve a significant increase in agricultural productivity.

14. Hydrocarbon Exploration. Past exploration efforts have not been successful. Two companies are engaged at present in exploration, following a long list of previous contractors which in total have drilled 11 wells over a total prospective area of 20,000 km^2. Expert opinion is that prospects appear to exist at depths of more than 5,000 meters in the Artibonite and Cul-de-Sac basins and in the Les Cayes area in the southern peninsula. To accelerate exploration, the Government should request technical and financial assistance from international agencies to identify exploration projects that can attract private interest. The preparatory work for the promotion of new exploration includes:

(a) Synthesis of all geological information available from past and present exploratory activity, to better define the geological structure and help to identify drillable prospects. An exchange of information with the Dominican Republic would shed additional light on the deeper geological structure of the island, as oil has been found in the Enriquillo Graben and deep drilling is progressing.

(b) Review of the present hydrocarbon legislation and Service Contracts to bring them into line with modern petroleum

operation. Model contracts and appropriate tax regimes should be adapted to local conditions. Further, the service contract with the current contractors should be submitted to legal scrutiny as the company appears to have withdrawn from further activities in Haiti.

Demand Management

15. In view of the very limited resource endowment, the most immediate options available to Haiti are pricing policies and other measures to increase the efficiency of energy use, and substitute imports of high cost petroleum products by imports of cheaper and heavier oils and coal.

16. Pricing Policies. Pricing policies and fiscal incentives must be appropriate to the general objectives of supply development and demand management. Because of Haiti's highly skewed distribution of income, conflict between prices and purchasing power of the poor population can arise, which must be resolved.

17. Petroleum. All oil product prices are based on border values and there are no direct subsidies. In recent years, the Government has progressively reduced its taxes on all products but gasoline to shield domestic consumers from the increase in world market prices. The taxes on gasoline were retained for conservation reasons. However, this effect has been partially eroded by substituting diesel for gasoline vehicles. Although diesel vehicles are more efficient in terms of volumetric fuel consumption, their investment cost is higher. Under current international price relationships the diesel option is economic for intensive uses - such as public transport and freight, - but it is an expensive means of providing for private transport needs.

18. To avoid further distortion of the market, the Haitian Government decided in late 1981 to progressively increase taxes on transport diesel to realign over the medium term domestic relative prices for gasoline and diesel to world market ratios. Control will have to be exercised to avoid the use of the lower priced industrial diesel oil or kerosene for transport purposes.

19. Complementary measures to enhance conservation in the private transport sector should be envisaged, such as:

(a) Discourage the import of vehicles for private use.

(b) Eliminate all tax exemptions granted to official entities on import duties and excise tax for vehicles and fuels.

(c) Increase the annual licensing fee on automobiles, imposing a higher levy on privately-owned diesel vehicles, until the gasoline/diesel price ratio has been fully realigned.

20. Electricity. For appropriate electricity pricing, the tariff should reflect the incremental opportunity cost of expanding the service and generate adequate funds for financing the expansion of the system. In January 1977, the public utility adopted a new tariff structure based on the principle of marginal pricing. Some months later, it was modified to allow social pricing below a certain level of consumption for low income families and small industrial users. A fuel adjustment clause was implemented at the same time. EdH's average revenue rose from US¢ 6.5 per kWh in 1978 to an estimated US¢ 11.2 in 1981, i.e. an increase of about 20% per annum. The adequacy of the tariff structure is to be reviewed in early 1982. It is recommended that in this process consideration be given to the level of cross subsidization among categories of consumers and between Port-au-Prince and the provinces, and that marginal costs be assessed in the light of the new investments.

21. The present financial situation of the electric utility is comfortable although the rates of return were only 4.4% and 5.5% in 1979 and 1980, lower than the respective 7% and 7.5% rates of return established as targets by the government and the electric corporation in consultation with IDA. Internal cash generation has provided 54% of the total construction expenditures of EdH in the last fiscal year. Financial forecasts show that for EdH to earn 8% on its revalued assets during 1981-1986, its average revenue per kWh need to be raised by about 10% per year. The corresponding revenues would enable EdH to contribute internally about 35% toward its investment program during that period.

22. Fuelwood. For consumers/harvesters wood appears to be a free good, but a zero price does not reflect the economic cost of depletion of the forest resources. The only tax in the production of charcoal is a levy of about US$1.65 per ton, imposed when cutting green trees. This is too low to finance effective forest management or to encourage the establishment of plantations. There is no doubt that the cost of wood plantations will result in a much higher price for wood. Therefore, the price of charcoal will have to be increased through higher taxation. Compensatory measures will have to be found to allow the poorest segments of the population in deforested areas to continue purchasing their required needs.

Demand Management Projects

23. Reduction of losses and thefts in power distribution. In 1979, these losses exceeded the amount of electricity generated in thermal units. Thefts represent a high portion of the 28% of energy lost. Investment in the renovation of the distribution system of Port-au-Prince is therefore well justified and the law against illegal connections must be fully enforced.

24. Energy audits in large industrial establishments are required to assess immediately attainable energy savings, by increasing the efficiency of energy use in existing equipment; these audits should cover steam generation and distribution equipment, electricity use in machinery and lighting, etc.

25. Technology changes. The cement factory has proposed an expansion of its productive capacity, conversion of its manufacturing process to the dry technology, and replacement of residual oil for imported coal as the main energy source. The dry technology reduces energy input per unit of output by almost 50% and the substitution for coal could lead to important foreign exchange savings. Given the significant impact of this project on Haiti's energy balance, the project should be evaluated as soon as possible.

26. There are a number of industrial groups that have a good growth potential. These should be evaluated to assess retrofitting possibilities and installation of new efficient equipment.

27. Mass transport system. Major measures in this area would be to increase the number of buses in the Port-au-Prince area and introduce interurban services, implement traffic regulations to reduce congestion in flow and curtail the import of vehicles for private use.

28. Efficient Stoves. The introduction of an efficient stove design appropriate to local conditions could reduce the energy intake for cooking by as much as half of the required in the traditional 3-stone fireplace. A preliminary analysis indicates that even if the dissemination is fully subsidized and only a 5% increase in fuel efficiency is achieved, the program would have a positive return relative to the cost of new wood plantations. A survey should also be carried out on the type of equipment most commonly used by the commercial and artisenal sectors, to assess the technical modifications required to improve their efficiency.

Institutional Development

29. Haiti's energy situation will continue to deteriorate unless the Government recognizes the urgency of the issues and commits itself to decisive action on the above recommendations. It is felt that the implementation of the energy program is constrained more by shortcomings in the decision making/implementation process than by the availability of resources. In other words, there is a possibility for Haiti to obtain larger amounts of financial and technical foreign assistance, but, at the present, the country lacks the ability to effectively and productively utilize the additional resources that could be made available to it. To improve this situation, the Government must agree on and define its energy objectives. It should decide upon a strategy and on the programs to carry out that strategy. An implementation schedule should be set, and the agency responsible for each program should be designated. Finally, these agencies should be given the necessary legal authority and a minimum of financial support to execute their responsibilities.

30. To assist the Government in the planning and implementation process, the mission recommends the creation of an Advisory Committee, which would be made up of the heads of the agencies in charge of energy programs, of technical public and private experts, and representatives of

interested international aid agencies. Furthermore, it is suggested that an Energy Statistical Unit be established to provide the quantitative framework for the decision-making process.

31. The technical and managerial capability of the individual agencies must be strengthened, particularly the Forestry Service and the Division of Energy Resources. At a first step, it is suggested that an Economic Evaluation Unit be set-up to help select those projects with the highest socio-economic returns and to advise the technical departments of the Ministries on organizational schemes for project development. Whenever possible, the private sector should be encouraged to participate in project execution and operation. Special attention should be given to the utilization of communal and cooperative organizations in rural areas. In addition, the individual services should contract a few high level outside experts and managers to allow immediate execution of priority projects and provide for on-the-job training of present staff.

Longer Term Projects

Indigenous Resource Development

32. Agricultural Waste Products and Solar Water Heating. Haiti's large agricultural sector offers opportunities for converting agro-industrial waste products into usable forms of energy. It is suggested to direct efforts towards the identification of specific localized projects. This requires assessment of the volumes and geographic location of potential materials, such as those derived from coffee, cotton, sugar cane, vetiver, and solid urban waste; evaluation of energy end-uses, choice of most appropriate technology and economic and financial analysis.

33. Large consumers of hot water should be made aware of the economic advantages of solar water heating systems. They have proven to be competitive in many countries in applications that range from hot water for households, hotels and hospitals, to pre-heating of low-medium temperature process water in industries. These systems can be installed in new buildings or retrofitted into existing ones. They can be used alone or in combination with electric or fossil-fueled heaters. It is suggested that the Government should evaluate potential savings of commercial energy that can be achieved through the diffusion of this technology and provide the private sector with the required technical assistance.

34. Lignite: Maissade and Camp Perrin. Lignite is found near the town of Maissade in the Central Plateau and in two locations in the Southwest peninsula. Maissade is by far the most important field, although the quality of its lignite (high ash and sulphur content) makes it suitable only for industrial use. Camp Perrin is a very small field, but its lignite has the right quality for use as cooking fuel.

35. The structure of Maissade has been determined by two geological surveys which indicate the existence of several small deposits in which lignite seams with a thickness of 1-2.5 meters are buried at depth of up to 20 meters. Only one of these deposits has been evaluated; proven reserves are 750 thousand tons and the ratio of lignite to overburden is 1:10.5. A preliminary cost estimate for capital intensive open cast mining of this deposit indicates that lignite could be recovered at about US$36/ton. Taking into account its calorific value (2,500 kcal/kg), Maissade lignite would only be competitive with coal should the landed price of this product exceed US$100/ton. 2/ (The current landed cost for imported coal is estimated at US$ 70/ton.) The intensive exploitation of the deposit for power generation can therefore not be justified under present economic conditions.

36. However, further exploration is necessary to determine the extension of the deposits, the depth of the seams, their thickness and the quality of the coal. 3/ This involves the following action: (a) topographic mapping of the area; (b) synthesis of the results from the previous exploratory campaigns; (c) intensive exploration of deposits already detected and further extensive exploration of the rest of the field. A detailed feasibility study of the mining project should be made once the new information has been compiled. It should include the evaluation of alternative industrial uses for the lignite.

37. The survey on Camp Perrin indicated that the deposit could contain at best some 100,000 tons. The Ministry of Mines and Natural Resources intends to assess whether this lignite could be mined as a cottage industry to provide a fuel for household cooking. Despite the probable size of the deposit, it could provide for the household requirements of the cities of the region.

38. Other Renewable Resources. Several public institutions in Haiti are engaged in research on renewable energy technologies. In view of the scarcity of technical and managerial resources, it is suggested that the range of programs be narrowed, by selecting those that might have the highest impact on the rural sector, reducing deforestation and increasing the productivity of agriculture, such as solar crop dryers and cookers, wind water-pumping, and mini-hydroplants. The strategy should include research and development to adapt these technologies to local conditions, build-up of domestic capability in repair, maintenance and construction of hardware, extension of their use and training.

2/ Based on relative calorific values of coal and lignite. This figure does not include the capital cost differential between lignite fueled and coal fueled power plants.

3/ The German aid agency has in principle agreed to finance the second phase exploration of Maissade.

Demand Management

39. Higher efficiency in Bagasse use. Only one industrial plant cogenerates steam and electricity from bagasse to satisfy the energy requirements in its sugar cane processing facility. There are two other industrial plants in operation that use bagasse to generate heat, but which purchase diesel oil for power generation. It is therefore recommended that the industry be studied to determine whether it is feasible to increase electric generation from bagasse and supply a surplus to the national grid. It would require investment in power generation equipment and in bagasse handling facilities.

40. Residential and Commercial Sectors. A national educational campaign informing the public on the energy problem and indicating saving opportunities would be helpful in obtaining the cooperation of the population in the demand management program.

41. The prevailing method of producing charcoal in Haiti is in traditional earth mounds. There are no obvious gains to be expected from introducing modern charcoal making processes, because few areas have the wood concentrations to warrant substantial investment in new equipment. More efficient methods, including the recovery of pyrolytic oils, should be considered in future energy plantations, and in areas where forest management programs have been established.

Investment Requirements and Foreign Assistance

42. The public energy investment requirements for the next five years were conservatively estimated at about US$300 million, 82% of which (US$248 million) correspond to the power development program; 11% (US$33.4 million) to forestry projects; 2.0% (US$6.2 million) to other resource assessment and development; and 5% (US$15.5 million) to demand management and institutional building.

43. Public finances already depend heavily on foreign resources and a significant portion of domestic resources are earmarked as counterpart funds. The increased investment effort involves important decisions in scarce resource allocation and, therefore, coordination of objectives between Government and foreign aid institutions becomes crucial.

INDONESIA: COMMERCIAL ENERGY BALANCE, FY 1979/80
(million barrels of oil equivalent)

	Coal				Petroleum			
	Steam Coal	Anthracite	Crude Oil	Condensate	Products	Natural Gas	Electricity	Total
Primary Supply								
Production	0.925	0.361	555.051	22.126		182.320	4.084	764.867
Crude Exports			-376.630					-376.630
Condensates Exports				-15.976				-15.976
Crude Imports			31.438					31.438
Stock Change	-0.108	-.006	-14.102					-14.216
Flared Gas and Losses						-40.750		-40.750
Total	0.817	0.355	195.757	6.150		141.570	4.084	348.733
Transformation								
Refineries			-190.707	-4.320	190.406	-1.420		-6.041
LNP Plant					63.158	-75.480		-12.322
NGP Plants					4.400	-5.500		-1.100
Own Use Gas Fields (fuel, gas lift, pressure maintenance)						-35.790		-35.790
Own Use Coal Mines	-0.250							-0.250
Public Thermal Power Generation					-10.342		8.699	-1.643
Balancing Item			-5.050	-1.830	-7.170		-3.031	-17.081
Secondary Supply	0.567	0.355	0	0	240.452	23.380	9.752	274.506
International Product Trade								
Imports					16.239			16.239
Exports of Petroleum Products and Coal	-0.073	-0.204			-61.623			-61.900
LNG Exports					-63.158			-63.158
Bunkers and uplift					-4.065			-4.065
Net Supply/Demand	0.494	0.151			127.845	23.380	9.752	161.622
Demand								
Feedstock Natural Gas						14.880		14.880
Industry	0.389	0.151			41.804	8.500	3.511	54.355
Transportation	0.105				51.866			51.971
Households, Commercial, Government					34.175		6.202	40.377
Others, Including Agriculture							0.039	0.039

boe = 1.46 mn kcal
kWh = 860 kcal

INDONESIA 1/

1. Indonesia is a country rich in energy resources and, as is well known, a member of the Organization of Petroleum Exporting Countries. Nonetheless, it is likely to face severe energy problems in the near future comparable to those faced in most oil-importing developing countries. The problems arise because only one of its energy resources, oil, has been substantially developed, and because oil plays such a vital role in the country's social and economic development. Oil products meet 80% of the country's commercial energy needs. Net oil exports are financing practically all non-oil imports, and oil revenues account for 70% of the Government's total revenues. Since oil has been relatively cheap to develop, investment in energy has taken only 2% of the Gross Domestic Product which is low compared with other countries at about the same level of GDP. Moreover, most of this investment has been carried out by foreign private industry (with its associated technical and administrative inputs) under production pricing contracts with the Government.

2. As in most oil-exporting countries, there has, in addition, been a "cheap oil" policy for domestic energy consumption. This has been implemented largely by providing heavy subsidies on oil products, especially kerosene, diesel and fuel oil. Together with a GDP growth rate of 7.5%, this policy has led to a very high growth of demand for oil products. Growth of domestic demand for oil is now outpacing increases in oil production and oil exports are showing a declining trend. If unchecked, this will continue to erode the surplus of oil available for export and, even allowing for the expected increases in domestic production and world oil prices, will not only rapidly reduce the contribution of oil to financing non-oil imports and Government revenues but could also, within two decades, lead to Indonesia becoming a subsjtantial oil importer. Further, the subsidies on internally used oil products, already accounting for 20% of the Government's budget, will increase the burden. Thus, in a few years, the social and economic development objectives of the Government could be seriously jeopardized.

3. Whereas the problem of most oil-importing developing countries is to reduce oil imports, Indonesia's problem is how to ensure a continuation of petroleum export earnings. Although the problems differ the remedies in both cases are remarkably similar in that a major part of the solution lies in expanding oil production and in developing other indigenous energy sources in order to substitute for the oil products used in the country. In the past, a substantial part of the investment in the energy sector was devoted to meeting the needs of the export market which accounted for nearly 62% of the total energy produced. Over

---

1/ Adapted from Report No. 3543-INS, November 1981.

the next two decades, domestic energy needs will assume increasing importance and a substantial part of anticipated investment in the energy sector will be to meet these needs. While net energy exports can be maintained at present levels (about 480 million BOE) during the current decade, with a decline in oil exports being compensated by increased exports of LNG, they will almost certainly decline over the followingt decade. Indonesia is in the early stages of its industrial development and will require increasing amounts of energy for meeting domestic needs. It will also continue to require the foreign exchange earnings that energy exports provide. Thus, the growth of the energy sector is the key to future economic development. This, in itself, implies that the level of investment in Indonesia's energy sector will have to be increased substantially -- fourfold in the next decade in real terms and a further doubling in the following decade. Since much of this increase will have to be carried out by the public sector, this further implies that major decisions on national investment allocations will have to be made.

4. Indonesia has many kinds of energy sources -- oil, gas, hydro power sites, coal, geothermal resources and a large biomass potential, but except for oil and gas, the exploitation of energy resources is in a relatively early stage of exploration and development. The country has a multitude of options available for energy development because of this diversified energy base. Indeed, it is the possibility of substitution among primary energy sources, and among individual energy products, that makes the task of the energy planners in optimizing and achieving a balanced growth of the different energy subsectors a challenging one. Some of the interfuel substitutions can occur rapidly as, for example, a switch from kerosene to LPG in cooking. Other changes will occur more slowly as in the case of power generation where lead times are long. There are also other policy choices to be made regarding pricing strategies, for example, on the general level of energy prices, on the relative prices of different fuels to stimulate interfuel substition, on prices to encourage production of specific indigenous resources, and on prices to stimulate more efficient use of energy. There is also the need for conservation. For instance, nearly 17% of the energy produced is lost either in transformation or due to flaring; the value of gas flared in FY80 alone is estimated at US$1.0 billion. These and other policy options need to be continuously evaluated and appropriate institutional arrangements for national energy planning as well as planning in the energy subsectors is essential.

5. In short, to alleviate its energy problem over the medium to long term, Indonesia must soon embark on a series of important measures. The mission recognizes that with the country currently exporting substantial quantities of oil and not facing immediate balance of payments problems it may be difficult to convince some decision-makers and the population at large of the need for these measures. However, as it will be several years before the necessary investments produce the various fuels in sufficient quantities, there is already an urgency to formulate and to begtin to implement a national energy plan. The mission therefore strongly endorses the recent establishment of an

interministerial group (BAKOREN) for developing an energy policy, and an Energy Planning Unit for preparing energy plans for the short, medium, and long term. Furthermore, the mission is impressed by the GOI's commitment, and expressed in its recent statement of overall energy policy, to developing and implementing plans to transform the country from an oil-based economy to one in which all energy resources are optimally used in order to support Indonesia's future economic and social development.

Energy Demand

6. Current per capita energy consumption is fairly low, although it has grown rapidly over the last decade. It is estimated that the per capita consumption of total (commercial and non-commercial) energy is only about 2.2 BOE, of which nearly 50% is from traditional fuels, namely fuelwood and agricultural wastes, and the rest from commercial energy sources. Oil and gas account for 98% of commercial energy consumption; the other 2% comes from coal, hydropower and other resources.

7. Per capita consumption of electricity is also low at 76 kWh (1980). Nearly 50% of the generation is in captive power plants, most of it in the industrial sector, and the other 50% is generated by the national power corporation, PLN. Of the 57,000 villages in the country, only about 3,000 are electrified, reflecting the total lack of access to electricity in most areas of the country.

8. The elasticity of commercial energy to GDP is high and was 1.59 for the period 1970-78. It is likely that this will not fall significantly over the short and medium term, reflecting the growth in population of about 2.3%, the increased substitution of traditional fuels by commercial fuels in the household sector and the growing share of the industrial, transport and service sectors in the economy. Commercial energy consumption is likely to increase at an annual rate of about 12% up to 1990 and may increase at 10% subsequently. If so, the probable levels of future demand for commercial energy could be about 500 million BOE in 1990 and 1,300 million BOE in 2000, compared to a figure of 162 million BOE in 1980. These tentative estimates are based on current consumption trends and therefore are firmer for 1990. The estimate for 2000 is speculative, and, in fact, may never materialize, because long before demand rises to such a level, Indonesia would have become a net energy importer and consequently may not be able to support a high economic growth rate. Because of this, the mission presented an alternative scenario for 2000 which might be feasible if new policies for energy demand management and interfuel substitution are successfully implemented and if necessary organizational and institutional changes in the energy sector are made. Both scenarios underscore the need for action to improve energy supplies in the medium term through a rapid increase of investment in the sector. The impact of demand illustrates the need to improve the data on energy consumption and to introduce

formal demand analysis and projections. Indeed, this should be a priority task of the recently formed Energy Planning Unit.

Primary Energy Resource Development

9. Indonesia appears to have substantial reserves of oil and gas in, vast sedimentary basins yet to be explored, significant deposits of coal with inferred reserves in the billion of tonnes, and vast geothermal and hydroelectric potential. In addition, it has a large biomass resource as nearly 64% of the land area is covered with forests. However, while substantial compared to current levels of consumption, the energy resource base is relatively small on a per capita basis and when compared to likely demand by the end of the century. Moreover, most of the energy resources are located away from the main population centers.

10. Before major decisions are made on the best way of moving away from the massive dependence on oil for commercial energy, it is essential that much more work be done to prove up the reserves of gas and coal and to firm-up the potential of geothermal and hydro. Nevertheless, there are already some indications of the likely pattern of non-oil primary energy resource development.

Natural Gas

11. Though generally located away from the most populated areas, natural gas can play a major role in meeting domestic energy demand not only as a substitute for oil products, but also as a fuel for power generation. Most of Indonesia's natural gas reserves (85%) are not associated with oil production, and exploitation for uses other than export has been constrained by low producer prices and poor inter-institutional arrangements. The mission urges that these policies be changed as they have led to the wasteful flaring of 30% of the gas associated with oil production. In particular, the mission recommends amendments to the petroleum production-sharing contracts to encourage the use of gas which is now flared. With these changes the mission considers that a doubling of production to 353 million BOE is possible by 1990. Inadequate attention has been paid to natural gas liquids (NGL), which could increase from 32 to 80 million BOE by 1985 and there is a clear need for an evaluation of the relative benefits of using these as a domestic extender for gasoline or as a "spike" for exported crude oil. Furthermore, LPG, which is currently produced in the refineries and largely exported, and production of which could increase fourfold by 1988 with the increase in investment in LNG trains, should be used to replace kerosene in domestic uses because the future world price of LPG is likely to fall relatively to that of kerosene.

Coal

12. Coal has been discovered over large areas in Sumatra and Kalimantan, but more intensive geological surveys and delineation work is necessary to upgrade thye current figure of only 300 million tonnes for proven recoverable reserves out of estimated reserves of over 10 billion tonnes. Very little investment has gone into coal exploration and, given the magnitude of the reserves likely to be established and the increasing role that coal is expected to play in industry and power generation, there is a need to accelerate these programs. While the mission supports the Government's policy of attracting private industry into coal exploration and development, it recommends a reduction in the time period allowed to potential developers either to make their development commitments or to relinquish their concessions. It is suggested that the Government consider financing the pre-development activities itself and then put the areas up for bids in order to speed up coal development. Even if this is done, however, the mission believes that there is likely to be a shortfall in the domestic coal supply in relation to the future demand for coal from industry and the electric power subsector.

13. The mission also recommends that the work on proposals to develop coal liquefaction and gasification projects be deferred as coal in the required quantities is not likely to be available. Indeed, the mission considers that not even preliminary studies on these proposals should currently be undertaken as they will result in the diversion of scarce technical and administrative manpower away from essential tasks in conventional energy development.

Geothermal

14. Geothermal potential is estimated at 10,000 MW but of this only about 1,460 MW has been identified on a firm basis so far. Although a Volcanological Institute has been set up in Bandung and some expertise has been built up in geothermal prospecting and evaluation at this Institute and in the national oil company, PERTAMINA, adequate progress has not been made in prospect identification and delineation due to inadequate funding and restrictive operating procedures. Fortunately, over 50% of the potential is in Java, where it is needed most, but substantial drilling and exploratory work still has to be carried out to firm-up the potential and estimate development costs. The mission also recommends the establishment of a public sector agency under the control of the Directorate-General of Power to encourage geothermal development, to oversee private sector geothermal contracts, and to explore for and develop the geothermal resources which do not attract private industry. The mission considers that if these steps are taken, 400 MW of geothermal power could be on stream by 1990.

Hydro Power

15. The hydroelectric potential of Indonesia is estimated at 31,000 MW. However, only some 2,500 MW is available on Java, and most of this

has been, or is being, developed. In the rest of the country, development of hydro potential has received low priority due to the lack of adequately investigated projects, the long lead time required for construction of hydro projects and the lack of a long term (15 to 20 years) plan for power development. A separate hydro survey unit is being established within the electric utility, PLN, to carry out a study on Indonesia's river basins, to evaluate the hydroelectric potential on a firmer basis and to build-up a "shelf" of projects. Once this is completed it will be possible to assess the potential contribution of hydro stations for both urban and rural electrification programs outside of Java.

Biomass

16. None of the measures recommended above should detract from the continuing need to explore for, and develop, new sources of oil, both onshore and offshore, or to ensure that the country's substantial biomass resources (especially wood) are used in the most appropriate way. It appears that recent oil production sharing contract terms have re-established the former pace of oil exploration activity and should encourage further secondary recovery activities. However, it is unlikely that annual oil production will increase beyond about 700 million barrels unless massive new reserves are discovered. In the areas outside Java/Bali, work is needed on the potential use of logging and other agricultural residues for use as fuels and, especially, on the means of transporting these wastes.

Inter-fuel Options

17. The energy supply options open to Indonesia were analyzed by the mission largely on the basis of the substitution possibilities of oil products within the major energy consuming sectors. The key sectors are the household sector (kerosene), the electric power sector (fuel oil and diesel), the transport sector (gasoline, diesel and fuel oil), and the industrial sector (kerosene, diesel and fuel oil).

Households

18. Energy consumption in the household sector is basically for cooking and lighting. For cooking, fuelwood, kerosene and negligible quantities of LPG are used and for lighting, kerosene and electricity. Current household use of kerosene is estimated at over 40 million barrels per annum and is expected to rise rapidly as incomes rise. It is largely for this reason that the financial (and economic) subsidies on petroleum products have been growing so rapidly.

19. Preparations should therefore be made, as a matter of urgency, for the introduction of alternative fuels in the household sector. For cooking, a study of LPG potential, including marketing and pricing, for

replacing kerosene in urban areas and gradual market penetration throughout the whole of Java/Bali should be undertaken. This study should also review the technical and economic merits of substituting kerosene by methanol for cooking purposes as is being considered elsewhere. Whatever fuelwood is available from private backyards should continue to be used since this does not lead to deforestation and it has little or no economic cost. Charcoal is too expensive for use as a basic cooking fuel. For lighting, while LPG can be used in the short to medium term to replace kerosene, the promotion of electrification of households and specifically in Java/Bali, the longer term development of a national power grid should be given consideration. Outside Java/Bali, while kerosene would remain the major energy resource for lighting, use of LPG to replace kerosene should be considered as a longer term option.

Industry

20. The industrial sector has three distinct categories of energy requirement: feedstock, motive power and heat. The largest use of hydrocarbon energy in the industrial sector is as feedstock: petroleum products in refineries and petrochemicals, and natural gas in fertilizers, methanol and petrochemicals production. Many of the existing plants now being designed and there are substantial opportunities to increase energy efficiency by retrofitting. In the case of motive power, a vigorous effort is required by the Government to ensure that reliable power is supplied by the national agency for power (PLN) and that the small diesel-based private generating plants on Java/Bali are retired. For heat requirements several alternative forms of energy are available: oil products, primarily fuel oil, diesel and kerosene, gas, coal and fuelwood. The most obvious way of reducing the use of oil products in industry is the increased use of natural gas, although as long as domestic gas prices are far below the opportunity cost (as feedback for LNG) there is little incentive to promote production. As the pricing discrepancies are remedied over time, increased attention should be given to the development of a natural gas based industrial sector. This can only occur if gas transmission popelines are developed to meet the needs of the large industrial plants, industrial estates and power stations. A corollary of this is that attention should be given to locating industries within reasonable proximity of the energy resources used, especially natural gas. In some cases (such as cement plants) the use of non-oil fuels (such as coal) could be made mandatory. Attention should alsoa be paid to developing the cogeneration potential of lumber mills and large industrial plants on the other islands. Special emphasis should be placed on reducing the diversion of kerosene into industrial use and one of the ways this can be achieved is by segregating kerosene marketing from the marketing of other liquid fuels. In this regard, the Government might consider as one option taxes on bulk transport and distribution of kerosene, together with distribution of kerosene only in 10 or 20 liter cans for household purposes; this technique has worked well in other countries.

Transport

21. With the exception of negligible quantities of electricity used in the railway subsector, consumption of energy in the transport sector is wholly confined to petroleum products, principally gasoline and diesel, and some fuel oil in inter-island shipping. Indeed, the transport sector is the largest consumer of oil products and is likely to continue to account for 30% of all commercial energy consumption. The only possible alternatives to oil products are NGL, LPG and alcohol. With increasing production of natural gas, there will be corresponding increases in the amounts of NGL, and, as noted above there is a need to assess the economic viability of using NGL as a substitute for, or extender of, gasoline. LPG is a potential substitute for diesel as well as for gasoline, but since it requires a spark-ignition engine it can only be considered as a replacement for diesel as part of a program for replacing or adding to bus fleets with new engines. It is unlikely, given the premium on land and the relatively high cost of producing ethanol, that alcohol from biomass will prove to be a viable option as an extender of either gasoline or diesel on a large scale in the near future. The mission considers that there is no need to replace the fuel oil used in inter-island shipping and some industries, largely because this is probably the most effective way of utilizing this product which is inevitably produced by the refineries and for which it is therefore technically desirable to maintain a reasonable level of demand. On a broader front, the longer term potential for energy demand management in transport, including widespread railway electrification and urban public transport systems, as well as changes in transport modes particularly on Java/Bali, needs to be analyzed. The automobile industry can be encouraged to concentrate more on the production of fuel efficient vehicles.

22. The strategy for the development of the power sector is consistent with the GOI's energy policy to diversify from oil-based generation and use geothermal, natural gas, coal and hydro resources. Much emphasis is being placed on the development of domestic coal as a fuel for power generation, but, as already mentioned, unless a vigorous exploration effort is initiated, coal may not become the expected backbone of the electric power sector. Indeed, the uncertainties associated with coal development are such that multi-fuel-fired plants (coal/gas/oil) should be planned whenever possible. In line with this, feasibility studies should also be done on the alternatives of gas pipelines, coal transport, and electricity transmission from mine-head plants to load centers not only on Java and the other major islands but also between islands, especially Sumatra and Java. Geothermal and hydro developments have already been mentioned; in the short run the rapid development of geothermal resources on Java/Bali for base load appears to be essential, while for peak load service hydroelectric power stations swhould be planned after the necessary resource identification effort.

23. BATAN, the national agency for atomic energy, had originally considered commissioning a number of nuclear power stations, but given

the potential for gas, coal, geothermal and hydro in the medium-term and the lower cost of power from these sources, the mission agrees that it would be prudent to defer commitment to a large program until more information is available on competing energy resources. Plans can, however, be made for the installation of a single commercial-size nuclear power plant in order for the country to gain experience in nuclear technology and have this option available for the longer term.

24. For smaller power plants, especially on the other islands, greater efforts at supplementing diesel-based generators will be required. Both wood-based thermal (including gasification) and mini-hydro generators could be developed; these would equally provide a basis for possible future connections to grid systems. On Java, where there is already an emerging grid, the mission recommends that consideration be given to using this grid system to serve the rural areas in the longer term.

Rural Sector Energy Use

25. The mission recommends that the special energy needs of the rural areas be met in different ways on different islands. In particular, since it is increasingly difficult to distinguish between the urban and rural areas on the densely-populated islands of Java and Bali, provision of energy to rural areas on these islands should be an integral part of the supply system to urban areas. This is possible because there is already widespread commercialization of energy on Java/Bali, even for traditional fuels such as wood, although the availability of these traditional fuels appears to be diminishing rapidly. Thus, the recommendations made above on the fuel options for households, industry, transport and electric power are appropriate for the rural areas of java and Bali. For rural, small-scale industry on these islands (75% of total small-scale industry), the provision of energy is especially important because, although it accounts for only a small proportion of manufacturing activity it represents a substantial proportion of employment. It is estimated that nearly 1.2 million small-scale enterprises are scattered throughout the rural areas of Indonesia, providing up to 80% of total employment in the manufacturing sector, but contributing only 12% of gross output and 14% of total value added to manufacturing. The productivity of these enterprises could be improved greatly by providing them with easy access to electricity.

26. Very little commercial energy is being used in agriculture today, but this is likely to change in the coming years as animate power is replaced by mechanical power in many farming operations for increasing agricultural yields. While this has not been taken into consideration in the mission's tentative energy demand forecasts, it should certainly be a factor in the forecasting work of the Energy Planning Unit.

27. On the other islands rural energy needs for household cooking and industry can be largely met by fuelwood, or, possibly, by charcoal and/or gas produced from wood or rice husks. Where kerosene is currently

used for lighting it may well continue to be the most economic option unless the transport and distribution of LPG as a substitute proves to be competitive. It is especially important on the other islands to establish a strong organization for planning and implementing rural energy programs. To this end, the mission recommends that a Rural Energy Policy Coordinating Task Force be established within the Energy Planning Unit.

Pricing and Subsidies

28. The mission considers that current petroleum product pricing is a major constraint to the Government's stated policy of replacing oil by other indigenous energy resources. This pricing policy is characterized by massive financial (and economic) subsidies on almost all petroleum products which, in addition to the fiscal strain on the Government's budget, is providing a clear disincentive to potential producers of non-oil resources and is encouraging the rapidly growing use of petroleum products (sometimes wastefully) rather than other fuels. The oil products subsidies are dominated by one product, kerosene, accounting for about 50% of the economic subsidy. As kerosene can be substituted for diesel in the transport sector and for fuel oil in the industry sector, these two fuels are also subsidized. Indeed, if it were politically feasible to remove the subsidy on kerosene, many of the other problems relating to energy product pricing would automatically be solved.

29. The rationale for the subsidy on kerosene has been that it replaces the fuelwood used for cooking and this prevents deforestation and helps the poorer households. This objective is of relevance only on Java/Bali, the kerosene subsidy seems to have been effective in replacing the use of fuelwood except for the prevalence of backyard woodlots which is the most economic way of providing cooking fuel, even in comparison with subsidized kerosene. The removal of the kerosene subsidy, if accompanied by measures to further stimulate backyard woodlots and alternate fuels would be desirable, especially as the benefit of the preswent subsidy has gone more to the affluent households than to the poorer households. There is also evidence that kerosene is being diverted to industrial use, including the cement industry, as the price differential between kerosene and fuel oil makes it profitable to do this.

30. The mission supports the Government's stated policy of eventually withdrawing subsidies while recognizing the difficulties inherent in this process. The mission analysis of energy pricing therefore took into consideration not only the opportunity costs of different energy forms but also the possibility of lower market prices for some products, particularly LPG which is a direct substitute for kerosene. If the segregation of kerosene marketing, as suggested earlier, is achieved, there would be little need for subsidies on other liquid fuels except those designed to help the poor, or promote specific

regions or industries. In such cases, subsidies should be rearranged so as to ensure that they reach those for whom they are designed.

31. With respect to natural gas, the mission recommends that in all areas where non-associated gas exists, the producer price should be put at its opportunity cost as LNG feedstock to stimulate the production of gas for indigenous use. The government may in some cases consider that a lower producer price may provide sufficient incentive and therefore tax the difference between the price and the opportunity cost. To promote the use of gas, subsidies on the retail price of gas may be required until the subsidies on competing fuels, especially fuel oil and coal, are removed, but efforts should be made to shift the subsidies "downstream" whenever possible (e.g., to the retail price of fertilizer in the case of gas and the prices of inter-island shipping in the case of fuel oil). Where gas is associated with oil production, and especially where the gas is currently flared, use of the gas can be encouraged by using a pricing formula based on its marginal cost of production, transmission and distribution in petroleum production-sharing contracts.

32. With respect to coal, the principle of pricing on the basis of the opportunity cost of importing an equivalent fuel has been accepted by the government and the mission supports this principle.

33. The mission also supports the recent adoption by PLN of electricity tariffs reflecting long-run marginal costs, although regular revisions are essential as these costs change. Further changes are also required in the tariff structure, especially important are increases in the tariffs for medium and high voltage users. Moreover, the policy of uniform tariffs across the country should be reconsidered once the long-run marginal costs of electricity supplied outside Java can be estimated.

34. Energy prices and subsidies have to be viewed in the context of a need for demand management and efficient interfuel choices in the long term. It has to be ensured that the present pricing policies do not distort future consumption and demand patterns and become counter-productive to energy policies. As Indonesia diversifies its energy base, and as opportunities for interfuel substitution become more and more possible, it is essential that comprehensive pricing policies be evolved and that they cover all of the energy subsectors.

Institutions

35. The GOI has already recognized the need for developing and implementing a national energy policy to support Indonesia's economic and social development. As a first step, an Energy Planning Unit has been established in the Office of the Director General of Power. The GOI has also established an interministerial group, BAKOREN, headed by the Minister of Mines and Energy for developing an energy policy and ensuring its implementation. There is a need to strengthen the planning unit and

also to place it in the Office of the Minister of Energy and Mines so that it can effectively coordinate with all the Directorates dealing with energy.

36. Among the many studies recommended by the mission, some should be carried out urgently to provide policy options to BAKOREN. These include:

(a) Developing (on the basis of planned GDP growth and its sectoral distribution) energy demand forecasts and a series of alternative plans over 5, 10 and 15 year periods for meeting this demand;

(b) the feasibility of using LPG to meet the cooking and lighting needs of the household sector;

(c) alternative transport for energy, including coal shipments, electricity transmission from mine-head plants and natural gas pipelines to planned and projected thermal power stations, especially between Sumatra and West Java.

(d) the economics of the complete electrification of Java/Bali as a longer term substitute for kerosene in lighting taking into account the income elasticity of kerosene in this case;

(e) the feasibility of wood gasification plants on the other islands to run stationary engines for power generation to meet isolated loads; and

(f) a marketing strategy for kerosene, especially segregation of its distribution system from other petroleum products.

These studies are in addition to studies already proposed for (a) utilization of flared gas; (b) city gas distribution systems; and (c) LPG marketing. For the medium-term, studies to assess the potential of geothermal and hydro are required, while a similar effort is required for coal in addition to the preparation of a rational coal policy.

37. The success of such an ambitious energy program will depend on the strength of the relevant national agencies or institutions. These are Pertamina in the case of oil and gas, PLN in the case of electricity, PN Batubara in the case of coal, and BATAN for nuclear power. The mission considers that geothermal development may proceed at a faster pace if a separate agency is formed for it. Most of the institutions in the energy sector still require strengthening, particularly PN Batubara. In view of the wide diversity of its operations, some structural changes may be desirable in the case of Pertamina.

38. The major constraint for an ambitious energy program, however, is not the institutions themselves, as the higher echelons of management of these institutions are indeed very competent, but the availability of

a cadre of trained geologists, engineers and scientists for all these energy subsectors. These people are simply not available in sufficient numbers, and steps should be taken to assess the trained manpower needs of the various energy organizations and to increase the enrollment at the universities/technical institutes accordingly. In the short term, it may be necessary to increase the scope of technical assistance schemes in all areas where such shortages are felt.

Investment

39. The energy requirements of Indonesia will rise rapidly over the next two decades and will require a major increase in investment in all the energy subsectors, most importantly in the power subsector. Public sector investments are expected to rise from a current level of about US$1.25 billion to over US$10 billion by the turn of the century in 1980 prices. As a percentage of GDP, these investments in the energy sector are expected to rise from 2.1% in 1980 to 3.9% in the year 2000. On a cumulative basis, they could amount to about US$38 billion in the current decade alone. The oil and gas sector alone would account for nearly 50% of these investments, and the power sector for nearly 45%. While the mission recognizes that investment in the oil and gas sector should continue to have the highest priority, because oil and gas are expected to meet most of the demand for commercial energy over the next two decades, a crucial part of the investment program is the US$350 million required for surveys and the delineation of coal, hydro and geothermal resources.

KENYA: COMMERCIAL ENERGY BALANCE, 1979
(thousand tonnes of oil equivalent)

	Coal	Crude Oil	Petroleum Products: LPG	Motor Gasoline	Aviation Gasoline	Kerosene-Jet Fuel	Gasoil	Heavy Diesel	Fuel Oil	Electricity	Total
Primary Supply											
Production	-	-	-	-	-	-	-	-	-	322	322
Imports	40	2,739	-	69	12	179	20	10	-	40	3,109
Total	40	2,739	-	69	12	179	20	10	-	362	3,431
Transformation and Losses											
Oil Refining		(2,739)	21	368	-	431	437	112	1,215		(155)
Thermal Power Generation	-	-	-	-	-	-	(4)	-	(91)	17	78
Conversion Losses										(241)	(241)
Transmission/Distribution Losses	-	-	-	-	-	-	-	-	-	(21)	(21)
Secondary Supply	40	-	21	437	12	610	453	122	1,124	117	2,936
Exports	-	-	1	134	7	492	109		774	-	1,517
Net Supply/Demand	40	-	20	303	5	118	344		472	117	1,419
Demand											
Residential	-	-	12	-	-	66	-		-	25	103
Commercial	-	-	5	-	-	2	19		11	32	69
Industrial	40	-	3	-	-	16	34		382	57	532
Transport	-	-	-	292	5	32	191		49	-	569
Agriculture	-	-	-	11	-	2	100		30	3	146

toe = 10.3 mn kcal
kWh = 2583 kcal (production)
= 860 kcal (consumption)

KENYA 1/

1. Kenya's known commercial energy resources are basically hydro and geothermal. While these resources are adequate for providing most of the country's need for electricity during this decade, Kenya is essentially totally dependent on imports for oil and other commercial fuels. Moreover, forest resources are being 'mined' to meet the large and growing demand for woodfuels, which, for the most part, are not sold commercially. Commercial energy use in Kenya amounted to 1.9 million toe in 1979, with petroleum, hydroelectricity and coal accounting for 79%, 19% and 2% respectively. The use of non-commercial energy, largely fuelwood and charcoal, was 4.7 million toe.

2. Kenya faces two major energy problems. First, the cost of imported energy is becoming an increasingly heavy burden on the balance of payments, accounting for 36% of exports in 1980 compared with 16% in 1978. And second, deforestation, though still not as serious a problem as in some other African countries, is worsening because woodfuels are being consumed at about four times the annual rate of incremental production.

3. A number of measures must be taken to deal with these problems. First, reducing the net cost of petroleum products to the country by encouraging a more economic mix of petroleum product imports and exports. Second, replacing the remaining thermal power generation through further development of indigenous hydroelectric and geothermal resources and, in the longer-term, possibly developing regional power projects. Third, encouraging large users of petroleum products to convert to coal (which must be imported but at a lower cost to the economy). Fourth, ensuring that energy in all sectors is used in the most efficient way. Fifth, strengthening efforts to discover indigenous petroleum resources and use, where feasible, renewable energy sources such as solar. And sixth, improving reforestation programs and developing programs for improving the efficiency of wood and charcoal-burning cookstoves and charcoal conversion techniques. In addition to these actions, the Government must develop an overall long-term strategy for the energy sector, a goal which can be accomplished only after completion of a number of studies which are underway or are recommended in this report.

4. Before 1973, demand for petroleum products grew at 10%/year, giving a GDP elasticity for petroleum of 1.54. Since 1973, as real GDP growth declined to an average of 4.7%/year, petroleum demand growth has dropped to 4.1%, giving an elasticity of 0.87. An important influence on this lower elasticity was the government's policy of allowing domestic

---

1/ Adapted from Report No.3800-KE, May 1982.

Economic Context

Kenya is a middle-income country with a GDP of US$420 per capita in 1980. Agriculture remains the principal source of income in rural areas where over 80% of the population of about 15 million lives and works. The country's first decade as an independent nation witnessed rapid growth, with GDP increasing, in real terms, at an annual rate of 6.5% between 1964-73. Since 1973, however, major fluctuations in the prices of both exports and imports have resulted in significant variations in the growth of GDP. For example, in 1974, the year following the first petroleum shock, GDP growth dropped to 2.6%, while in 1977, following the increase in coffee prices, the rate jumped to 8.6%, declining again to 3.8% in 1980 with the end of the coffee boom and the second petroleum shock.

prices of petroleum products to move upwards in line with international prices.

5. Meanwhile, the GDP elasticity for electricity increased from 1.57 in the period 1969-73, when demand grew 2/ at 10.2% annually, to 1.72 in the period 1973-80, when demand grew at 8.1% annually. This is partly because the growth of electricity consumption was from a low base, and partly because electricity tariffs have not increased as fast as petroleum prices; this in turn was largely due to the declining share of petroleum-based electricity generation in total power generation (from about 33% in 1970 to around 11% in 1979 3/) and partly because of continued imports from Uganda, equivalent to up to 1/5 of total electricity supply, at relatively cheap rates.

6. During this decade, and especially during the period to 1985, it is unlikely that there will be major changes in the relationship between GDP growth and the growth of petroleum product and electricity demand. For petroleum products, the recent elasticity (0.87) has been low by international standards, and as the initial impact of the price rises wears off it will require substantial efforts in energy conservation and fuel substitution to reduce it further; for electricity, demand forecasts (which may not fully reflect further rapid urbanization and

---

2/ Sales from the interconnected power system.

3/ Although this increased to 21% of total generation in the dry year of 1980, the trend has been for a decreasing share of oil-fired generation.

some planned industrial developments) suggest only a marginal reduction in the GDP elasticity.

7. Energy imports and exports play an important role in Kenya's external trade and balance-of-payments. Petroleum is imported mainly as crude oil and is refined at the Mombasa refinery (jointly owned by the government and the private oil companies), which has a capacity of some 95,000 bbls/day. About 40% of the refinery's production is then exported, either inland to nearby land-locked countries or off-shore.

8. Kenya's geographic position has meant that relatively high prices could be charged for petroleum products delivered to the land-locked countries and international airlines; this has helped cushion to some extent the impact of world oil price increases on its balance-of-payments and petroleum trade account. Up to 1973 Kenya's 'energy trade' was roughly in equilibrium, with exports of refined products roughly covering almost the entire cost of imported crude oil, coal and electricity. Since 1973, exports to the landlocked countries and international airlines have accounted for a progressively smaller share of refinery throughput and the effect on the net oil import bill has declined accordingly, especially since 1977. In 1980, net energy imports reached 36% or non-enery exports. In the future, this trend is likely to continue as the landlocked countries increase their efforts to obtain petroleum products from other sources in order to provide some competition for Kenya. As such, except in years when export earnings from coffee are high, net energy imports are likely to increase as a proportion of non-energy exports in the future unless the Government takes urgent remedial action as recommended in this report.

Energy Demand Patterns

9. The transport sector is the largest commercial energy consumer, accounting for 40% of domestic demand; the second largest is industry, at 38%. These are followed by residential/commercial energy demand (12% of the total) and agriculture (10%). Since transport has been growing rapidly and since there have been moves to replace heavy diesel and fuel oil used in power generation and industry by hydro, geothermal and coal, the mix of petroleum products in domestic demand has changed significantly: the share of demand of heavy diesel and fuel oil declined from 37% in 1969 to 26% in 1980, while the share of gasoline and gasoil increased from 37% to 44% and the share of jet fuel increased from 19% to 23%.

10. The industrial sector accounts for 37% of the domestic demand for petroleum products, with 88% of its demand being for fuel oil for use in boilers, etc. It also accounts for all Kenya's demand for coal, which is imported from Swaziland and primarily used in the cement sector. About half of Kenya's demand for electricity comes from industry. The main commercial fuels used in the residential/commercial sectors are

kerosene (40%) and electricity (32%), the former largely for cooking and lighting, the latter primarily for lighting and appliances in high income households, while in the agricultural sector over two thirds of demand for commercial fuel is for gasoil for tractors and farm machinery.

11. Electricity is provided mainly from hydroelectric plants with additional supply from oil-fired steam turbines, gas turbines, diesel generators, and purchases from the Uganda Electricity Board. In particularly dry years, such as 1980, the hydro shortfall is made up by increased output from the thermal plant (at Mombasa) and by higher imports from Uganda. Major load centres are Nairobi and Mombasa, but the market in Western Kenya has been growing at a faster rate. Although total electricity sales were 1468 GWh, or 92 kWh per capita in 1980, only 6% of the population is connected to electricity, mainly in the urban areas where 13% of the population lives.

12. Excluded from the commercial energy balance are fuelwood and charcoal, which most households use for cooking. Total annual consumption of wood for energy purposes is estimated at about 25 million tonnes, or annual per capita consumption of about 1.5 cubic metres. This compares with an annual regrowth of trees of about 6 million tonnes. While fuelwood is still generally available within reasonable distances of consumers, and they can collect it at minimal cost, several areas are already beginning to show signs of widening deforestation, and commercialization of these woodfuels is beginning to emerge in some urban areas.

Energy Demand Issues

13. The main scope for restraining the growth of energy demand in the coming years is in a few specific activities in the transport, industrial and household sectors. In the transport sector, there are several opportunities for increasing the efficiency of energy use and fuel substitution. The Government has already increased import duties on larger private cars, and this will increase the efficiency of private transport over the long term. The mission suggests that an additional measure which could reduce gasoline and gasoil consumption by 10-15%, especially in Nairobi, is improved traffic management, including no parking zones, one-way streets, etc. A program to introduce diesel-fuelled matatus (small buses serving urban and surrounding areas) is being studied, but the mission warns that this program may not be consistent with the future product mix from the refinery. Indeed, the mission recommends that relatively higher import duties on diesel-fuelled passenger cars than on petrol-driven cars should be considered as well as a realignment of the sales taxes on transport fuels which currently favour use of diesel oil.

14. To reduce fuel consumption in freight movement the Government should encourage the transfer of as much freight as possible from the

highways to the railway. A recent study 4/ estimated that in 1979, 1.75 million tonnes of freight were carried by heavy trucks on roads paralleling the railway. It is the operational delays on the railway rather than costs which lead to this situation and studies to be financed by the Bank will identify problems and formulate measures for improvement as well as review the tariff structure. Kenya Railways also needs to determine its optimal long-term source of motive power (including electrification), and to improve its capacity for carrying containerized goods. Improvements in the switching system are necessary as a first step but longer term options include twinning the line from Mombasa to Nairobi as traffic increases. Diversion of one million tonnes of freight from the roads to the railway, which the mission considers feasible and which could be done without investment in new capacity, 5/ could save an estimated 12 million litres of diesel oil per year, or about 2.5% of the total consumption of this product in 1980.

15. In the industrial sector, the main potential for saving petroleum is in the conversion of cement plants to use imported coal instead of fuel oil. Two cement plants, Bamburi Cement and East African Portland Cement (EAPC), consume 23% of all domestically-used fuel oil, and, despite the surplus of fuel oil which is produced by the Mombasa Refinery and the fact that imported coal is subject to a 20% import duty while the fuel oil is not taxed, there is still a clear cost advantage to the firms in the use of coal 6/ (EAPC is also considering converting its plant from the wet process to the dry process and the mission expects that this will provide further substantial cost savings through lower energy use). 7/ Substitution of fuel oil by coal seems also to be feasible at the pulp and paper mill, and a study to confirm this should be done in the near future. Indeed, the mission recommends that the Ministry of Energy carry out a full survey of all potential coal users, as well as a study of the port, railway and other infrastructure facilities required to handle larger quantities of imported coal. (The Bamburi Cement plant already has capacity to handle the increased volume of coal it would require). The mission understands that a Norwegian-financed study of coal transport was completed in late 1981 but is not sure that all aspects of this recommendation were addressed. The import duty on coal should also be removed completely to ensure that it does not deter further substitution of oil by coal in industry.

4/ Study of Road Use Charges and Axle Load Limits, December 1980, Kamsax International A/S, for Danida.

5/ The Kamsax study includes the details of the types of products (mainly bulk products) which would be involved.

6/ The import duty was reduced from 30% to 20% in July 1981.

7/ The mission considers that the expansion of the EAPC plant using the dry process may obviate the need for a third cement plant.

16. Most of the larger industrial companies, especially those with international ties, have already made efforts to increase the efficiency of energy use. However, recent studies suggest that in small and medium sized industries also energy consumption could be reduced by 20 to 30% per unit of output without large expenditures, while hotels could reduce their consumption of electricity and petroleum products by as much as 50% by promoting simple conservation measures and making greater use of solar water heating. The mission therefore recommends that MOE launch a program to provide technical assistance to medium and small establishments for achieving a reasonable target reduction of energy consumption of, for example, 15% in three years. To assist in determining priorities in this program data on energy inputs per unit of output should be collected in a systematic manner.

17. Solar water heaters appear to offer good potential for reducing electricity consumption in the residential sector, where electric water heating accounts for at least 20% of household electricity consumption. There are some 19,000 residential water heaters in Kenya which are specially metered with an electronic signal interruptor to ensure that consumption is only off-peak and can be interrupted independently of the rest of the supply to these households. There are also an unknown number of residential electric water heaters which are metered at the normal tariff. Solar water heaters which could replace these electric water heaters are assembled in Kenya and cost about KSh 9,500 (US$1,200) installed (40-gallon tank, 3 collectors, thermo-syphon), though without the 15% sales tax and import duties on components which the mission recommends be abolished, the cost would be about KSh 6,600 (US$825). Based on the current standard residential tariff a solar water heater of this size and cost would have an attractive payback period of about 2.5 years. The present differential between normal and off-peak tariffs is very high, and therefore discourages replacement of electric water heaters by solar water heaters. However, EAPL have proposed to reduce this differential from July 1982 as well as increase tariffs to finance the local cost components of the power investment program during the 1980's. The mission recommends that the Government approve the proposed increases in tariffs.

18. It is also recommended that the Government should undertake a comprehensive study of the economic benefits and costs of a solar water heater program. If justified, the Government should establish a program of technical assistance for solar water heaters installations once the capabilities of local manufacturers have been assessed and performance standards for solar collectors have been determined.

19. There are two methods for reducing the growth of fuelwood and charcoal demand if substitution by other fuels is not possible: improving stoves and improving charcoal conversion efficiencies. The stove improvement program requires a large effort through extension services, and in the first instance should be directed towards charcoal stoves in the urban areas. Several agencies and organizations in Kenya are addressing the issue of improved stove efficiencies and these deserve

continued support. About 40% of the 20-25 million tons of wood consumed per year ends up as charcoal, whose use amounts to some 1.4 million tons/year. With such a low conversion efficiency (10 to 14%), any measures to improve it could thus have an important impact on decreasing the level of wood demand. The mission recommends the creation of one or more new institutions, such as a "Charcoal Corporation," or a series of charcoal co-operatives, whose objective would be to introduce modern efficient charcoal producing technology into the rural areas. Such an institution, which could be linked with afforestation programs, could build efficient kilns, purchase wood from those who currently produce charcoal inefficiently, and sell charcoal to existing distributors. Efforts in this area will have little effect in the short term but are essential to ensure that wood resources are used more efficiently in the longer term. The results of the Beijer Institute's Study of the fuelwood cycle can be used as input for this program.

Energy Supply Issues

Petroleum

20. Although exploration for petroleum is being encouraged in Kenya, and, indeed, is crucial to the long-term energy prospects of the country, it is expected that all of this decade's needs will have to be imported. Meeting the demand for light products in Kenya and land-locked countries will require different amounts of crude oil, depending on the type of crude, the refinery configuration and the pattern of demand. The table below gives an example using two basic alternatives. Since the present configuration does not match current or projected demand and since the surplus of residual fuel oil must be exported at a lower price than the price of crude, it is highly likely that investment in secondary refining facilities would have a high rate of return. The mission therefore recommends the Government urgently commission a study of the options for ensuring that Kenya can obtain the petroleum products it is likely to need at the minimum cost, taking into account potential exports and comparing all options with importing refined products directly from abroad.

COMPARISON OF ALTERNATIVE REFINERY YIELDS AND DEMAND PATTERN
(% by weight)

	Gasoline and Distillates	Residual Fuel Oil	Losses, Other
Refinery Output			
Current	48	46	5
With secondary refining	64	28	7
Demand Pattern			
1980	71	23	5
Projected 1985	77	17	5

Electricity

21. The East African Power and Light Company (EAPL) has plans to add 345 MW of generating capacity by 1990, giving total installed capacity of nearly 800 MW. This plan is basically designed to increase the use of indigenous power resources and thereby reduce the use of oil-fired thermal generation by developing geothermal and hydro resources, and by strengthening the transmission lines to Mombasa. These objectives are supported by the mission.

22. EAPL (through the Kenya Power Company) is developing the Olkaria geothermal field. To date, the drilling program has been limited to one portion of the field, though an expanded deep drilling program designed to outline the limits of the field has been proposed. The consultants to KPC are optimistic that this program would identify at least an additional 170 MW of economic potential, and could possibly lead to development of over 500 MW. The mission therefore recommends that high priority be given to this expanded program.

23. Together with the geothermal potential, Kenya's hydro-power resources are adequate to meet most of the increased demand during the 1980s. The Masinga dam project on the Tana River is now onstream and will have 40MW of capacity, though more importantly it will provide necessary storage to impound the run-off from the long rains and allow the existing downstream hydro plants to generate up to an additional 100 GWh by taking advantage of the controlled flow. The Kiambere 140MW hydro project is planned to be on-stream in 1986 and the Turkwel 120MW project, is planned for 1988. The mission considers that it is vital to maintain this hydro-power program sequence since any significant delay would lead to the need for additional thermal capacity at Mombasa. The mission therefore recommends that EAPL ensure that the preparatory engineering studies for Turkwel are completed as a matter of urgency. The mission also urges that the option of importing more electricity from neighboring countries, especially for the longer term, be given greater emphasis.

Ethanol

24. There are currently two ethanol plants under construction which will use molasses as feedstock, and by mid-1982 the ethanol supply will be about 36,000 m^3 annually. A third project using sugar cane juice as feedstock is also under consideration. However, the mission concluded that the Government has not dealt systematically with the economic, technical, organizational, and financial issues relating to the introduction of fuel alcohol in Kenya, including high capital costs, transport costs for molasses, external energy costs (particularly at one plant where there is a lack of bagasse), the profitable molasses export markets, and above all the fact that gasoline landed at Mombasa at US$1.10/US gallon still has a highly competitive price relative to substitutes. Even if the capital investment in the two existing plants

are treated as sunk costs one of them will be a drain on the budget and the other will be only marginally profitable. Moreover, there appears to be no economic or financial justification for construction of the third plant.

25. The mission therefore recommends first, that no further investments be made in the fuel alcohol program, second, that a course of action be developed to maximize cash flow from the Kenya Chemical and Food Corporation (KCFC) plant, and third that a program of technical assistance for the Ministry of Energy should be developed for rationalizing and monitoring the production and use of alcohol.

Woodfuels

26. Forests currently cover almost two million hectares in Kenya, most of which are under public ownership and management, and current yield is low, at about 3 m^3 per hectare. To meet the demand for wood fuels, these forests should yield 20 m^3 per hectare or the area under forests should be increased. In doing this, efforts should continue to be made to find tree species that can thrive in the semi-arid areas of Kenya, where competition with other crops will not be significant, and to promote general rural afforestation -- farm woodlots, etc. It is clear that considerable investment (of the order of $25 million annually) would be required for this program, and a program of this size would require substantial improvement in institutional and management capabilities.

Other Renewable Energy Sources

27. Bagasse is already used as a fuel within the sugar industry and though some potential exists for generating surplus electricity for sale to the grid, this is unlikely to be competitive with geothermal or hydropower. The same is likely to hold in the near future for mini hydro schemes though less is known about these. While not urgent, a survey to determine whether mini hydro could contribute substantially to future rural electrification programs would be useful.

28. Wind energy is already used for pumping water in some areas of Kenya, and the mission considers that its use could be extended. Windmills appear to compare favorably with diesel pumps at 4000 gallons per day (though less favorably at 20,000 gallons per day). The Ministry of Energy and the Meteorology Department are currently updating a study which evaluated wind potential and more metering stations are to be installed. The mission supports these efforts.

29. Because of the large livestock population in Kenya (over 30 million cattle, sheep, and goats), biogas from anaerobic digesters offers a promising source of energy for rural areas. There are currently about 100 digesters in Kenya and the size of the animal population suggests

that up to 200,000 four cubic metres/day digesters could be built. However, factors such as ownership, colonization patterns and cooking habits need to be evaluated before the widespread introduction of digesters is attempted. The Government should first attempt to gain general acceptance for digesters on livestock farms, or in other communities where there is a sufficiently concentrated animal population.

30. To consolidate the various research and demonstration efforts in new and renewable energies, the mission recommends that an energy research institute be established, with support from the Ministry of Energy (MOE) and the University of Nairobi. Its program would include identification of solutions to rural energy problems, adaptation of new technologies to Kenya's situation, and analysis of the impact which alternative development paths would have on energy use and the economy. The mission supports the basic organization which the EEC consultants have recently recommended to the MOE but it does not agree that either a special fund or a separate Development Bank needs to be established for funding renewable energy projects since competent banks of this type already exist. In general, there is a need for greater coordination and a clearer direction of aid for renewable resources, and the mission recommends that the various programs now being implemented by various Ministries should be placed under the responsibility of MOE.

Future Energy Balance and Investments

31. The mission estimates that commercial energy use in 1985 will be about 2.6 million toe, of which imported petroleum would provide 69% (compared with 79% in 1979), assuming that the refinery modification will be completed. Contributions to the replacement of oil would come from coal and renewables, which would provide 7% and 2% of primary energy respectively, and primary electricity (including geothermal) which would provide 22%. Even in such a scenario, however, crude oil imports would be 10% higher than in 1979, thus adding to the balance of payments problem even with optimistic assumptions about oil and non-oil exports and no real rises in the world price of oil. Without real price increases, imports of oil and coal could cost US$770 million (1981$) in 1985 while petroleum product exports could amount to US$430 million giving net energy import costs of about US$340 million.

32. The Table below presents a preliminary comparison of selected energy projects, which are either under construction or being considered, on the basis of total capital cost per unit of oil displaced, and also on foreign exchange benefits. It suggests that the foreign exchange benefits from the hydro and geothermal projects as well as the refinery conversion and cement plant modifications appear to be quite high, while the ethanol projects will actually increase foreign exchange costs to the economy.

Energy Sector Developments, 1981-1983 8/

33. Economic conditions have deteriorated in Kenya since the 1981 energy assessment mission. Whereas net energy imports cost 36% of export earnings in 1980, by 1982 this figure had grown to 57%. GDP growth, reported at 3.8% in 1980, had fallen to about 3% in 1982 and showed little sign of improvement in 1983/84. Foreign exchange reserves have been drawn down consistently since 1980 to the point now where not all of the energy sector investment and aid essential to arrest the declining balance of payments situation can be fully used because necessary stringencies on government expenditure have limited effective counterpart contribution to some projects.

34. Differences of opinion between the Government and oil companies concerning the refinery ownership structure and investment in modifications have delayed refinery upgrading and further aggravated the impact of the high cost of imported energy on economic development. In this situation relatively wide-ranging and quick assistance to the private sector and successful parastatals to implement fuel saving measures is vital, along with skilled advice to the Government on policy measures. There is also a need to determine a firmer, more analytically-based long-term energy investment program (including a least-cost power development strategy) and to determine the appropriate institutional structure for the power sector; as well as to strengthen the new Ministry of Energy and Regional Development in its ability to formulate policies and priorities for energy development.

Energy Planning and Institutions

35. The Ministry of Energy (MOE) has grown substantially since 1981 and has procured the services of a number of expatriate advisors from Energy/Development International and the German GTZ-SEP (Special Energy Project). MOE 9/ now has a greater capability to plan and establish investment programs for the sector than at the time of the assessment. However, there is still some disaggregation of responsibility and planning for woodfuels and agroforestry with an obvious woodfuel component, despite the cooperative agreement with respect to agroforestry between the Ministry of Energy and the Ministry of Agriculture and Livestock Development, and the Ministry of Environment and Natural Resources.

8/ Adapted from Report No. 016/84, Kenya Energy Assessment Status Report, June 1984.

9/ The Ministry of Energy was expanded to include regional development functions and is now, accordingly, the Ministry of Energy and Regional Development (MOERD).

Energy Conservation and Substitution

36. Through the University of Western Ontario and Ontario Hydro, CIDA has provided assistance to the Government of Kenya in assessing the market for and commercial viability of locally producing solar water heaters for industrial and household use. Petrosun International of Canada and Petrosun Kenya have countributed to and participated in this review and fully intend to proceed with a medium scale local manufacturing plan for solar collectors. The GTZ-SEP project is also in the process of establishing local manufacturing facilities for solar collectors, though on a much smaller scale. In addition, an engineer and an analyst funded by the World Solar Power Foundation of London and the World Wildlife Fund are documenting the number and performance of solar installations now in use in Kenya.

37. Since the time of the assessment mission, the matatas diesel bus fleet appears to have grown rapidly though without either Government support or hindrance. Fares are maintained by owner/operators at 1 Ksh below the public bus system, and the matatas mode is more flexible and convenient for commutors. Although the Government does not control the price of matatas, the fact that it is all diesel-powered is recognized by MOE as undesirable.

38. In its 1981 budget speech, the Ministry of Finance announced a 10% reduction of import duties on coal from 30% to 20% of the c.i.f. price, indicating that further reductions, perhaps to the elimination of duty, may be implemented later. Since then, across-the-board increases in duty have lessened the impact of this reduction. The current import duty competes at 22.2% (US$64.6 c.i.f. ex Maputo c.f. US$14.36 duty per tonne).

39. In response to the Assessment Mission's recommendation to convert the East African Portland Cement Company (EAPC) from oil to coal, EAPC has commissioned Norcem Engineering to do a full feasibility study of converting both from fuel oil to coal firing and from wet to dry processing. Exansion of overall production and the logistics of coal handling and transportation between Mombasa and Athi River also have been examined. The study is funded by a grant from NORAD. Savings of about US$1 million in foreign exchange will result although the investment is very marginal financially at the present coal import duty rate. The study indicates that severe constraints on port handling facilities may be faced for coal imports over and above the EAPC requirements.

40. The Assessment Mission also recommended that the Government study opportunities for converting from oil to coal in industries other than cement. In response, GOK has promoted conversions to coal, coal-oil-mixtures, and coal-water mixes in recent draft energy policy and investment strategies and the energy component of the draft five-year development plan. In addition, the Government's eneergy planners have recently completed and industrial survey and have begun an inhouse coal use review to prepare for a major coal conversion study funded through

ESMAP. Besides a detailed coal market analysis, region by region, there is a need to clarify the coal handling capacity at Mombasa before committing to a detailed design phase on coal conversion at any of the several major fuel oil consumers besides EAPC. This would be an essential component of a proposed ESMAP project on interfuel substitution in the industrial sector.

Petroleum

41. The Assessment Mission recommended an expansion of oil and gas exploration building on the initiatives already proposed by the Bank. Since then, the Bank-assisted petroleum exploration promotion project has proceeded successfully through the first round of defining potential and soliciting interest in further exploration. These oil companies have begun to negotiate exploration agreements.

Electric Power

42. Geothermal exploration also has advanced since the assessment. Dry steam has been tapped in the Olkaria field, and, in addition to the Olkaria Geothermal Expansion Project, work has begun on preparing a project to expand geothermal exploration in the wider Olkaria region and the Rift Valley. A long-term investment plan should follow from these projects.

Fuelwood

43. Although there has been no systematic approach to pre-investment work on peri-urban woodfuel plantations, a conceptual beginning has been made by MOE for Mombasa, although it would only satisfy a small portion of the near-term demand. Preliminary design and costing of plantation development for a range of ecosystems near major demand centers have been completed by the Beijer Institute. These provide the basis for detailed comprehensive pre-investment work as a part of a national strategy to meet the centralized urban-industrial market. In addition, the UNIDO staff in the Ministry of Industry have proposed a 270,000 ha fuelwood development on semi-arid land in the coastal belt to service an iron and steel industry. However, the viability of this project has yet to be established. The GOK has requested technical assistance to design investments in peri-urban plantations, to better manage recovery of woodfuels from existing resources, and to examine prospects for improving the efficiency of carbonization.

44. Data on the supply of charcoal remain deficient, but demand data have been provided by the Beijer Institute's 'Fuelwood Cycle' study, now complete. The characteristics of present and alternative charcoal production techniques and supply patterns can be the subject of assistance under the USAID Renewable Energy Project and the extended Dutch forestry-agroforestry projects, priority and funds permitting.

Ethanol

45. The Assessment Mission recommended that investments in ethanol production be terminated until the industry could be reviewed in detail. GOK responded by halting all further new investment in ethanol production facilities. The KCFC plant, costing 1.5 billion KSh to date, has been put into receivership but no liquidation has taken place. The planned Riana plant proposal also has been shelved. The Ministry of Economic Planning and Development has indicated that in due course it would like to define a rationalized ethanol development strategy and program for which technical assistance would be required.

COMPARISON OF PROJECTS IN THE ENERGY SECTOR

Project	Capital Cost	Oil Displaced	Additional Imported Energy Required per Year	Capital Costs per Unit Energy a/	Total Net Foreign Exchange Savings
	(US$,Million)	(Barrels per day)			(US$ m per year)
Bamburi Cement - Coal Conversion & Uprating	16.0	1,050	91,000 tonnes coal	$ 19,600	1.4
East African Portland Cement: Coal Conversion	10.0	1,320	124,000 tonnes coal	$ 7,600	1.9
Ethanol-Approved Projects (Kenya Chemical and Food Co., and Agro-Chemical and Food Co.)	60.5	520	- $114,000	- 1.5	
Ethanol - Proposed Project (Riana - Cane Juice distillery)	76.0	650	- $115,000	- 2.0	
Kiambere - 140 MW Hydro	300.0	3,260 b/	- $2143/kW	13.2	
Geothermal - 30MW, Olkaria	89	1,010 c/	- $2967/kW	4.4	
Refinery Conversion	103.0	20,000 d/	19,250 e/ barrels of fuel oil	$ 5,150	32.3

a/ Per daily barrel of oil displaced except where kW are specified.
b/ Based on 4,000 kWh per tonne of oil equivalent.
c/ Projects amortized at 11% over 10 years except for the power projects which are amortized over 25 years.
d/ Reduction in crude throughput.
e/ Annual foregone exports of fuel oil.

LESOTHO: COMMERCIAL ENERGY BALANCE, 1981
(thousand tonnes of oil equivalent)

	Fuelwood	Coal	Petolruem	Electricity	Total
Primary Supply					
Production	n.a.				
Imports	9.7	49.1	65.4	22.0	146.2
Transformation and Losses					
Thermal Power Generation			(3.1)	1.1	(2.0)
Transmission/ Distribution Losses				(1.5)	(1.5)
Net Supply/Demand	9.7	49.1	62.3	21.6	142.7
Demand					
Retail/Domestic	6.8	39.1	29.4	4.8	80.1
Commercial/Government	2.9	9.7	16.9	12.6	42.1
Industrial		0.3	5.2	4.2	9.7
Agriculture			8.9		8.9
Aviation			1.9		1.9

toe = 10 mn kcal
kWh = 2500 kcal.

LESOTHO 1/

1. Lesotho relies on the Republic of South Africa (RSA) for most of its energy requirements, including power, petroleum, coal and fuelwood. In 1981, energy imports were 150,000 toe and absorbed about 11.7% of the country's foreign exchange earnings, including remittances. As energy imports account only for eight percent of total imports, energy appears to be just a part of the much broader problem of Lesotho's economic dependency on the RSA. In practical terms, the country's options for reducing its energy imports are limited by a relatively poor indigenous resource endowment and a difficult geo-political situation. Hydropower is the major resource but it will be expensive and take many years to develop; its potential will depend on an agreement with the RSA to purchase water. Lesotho is virtually treeless, and although significant progress has been made in reforestation through a Woodlot Project, the pace of replanting has been slow (400 ha/year) because of an absence of skilled manpower. 2/ Lesotho will continue to rely on imports to meet the bulk of its energy needs through the 1990s.

2. The Lesotho economy grew rapidly during the 1970s, with GNP growth averaging nine percent p.a., but the factors which propelled this growth have weakened, and a GNP growth rate of less than three percent p.a. for 1982-83 is expected to be a more realistic reflection of future trends. As the external factors contributing to GNP are uncertain, the Mission has a used three percent GDP growth scenario as a basis, together with historical relationships between GDP and energy consumption, to estimate energy demand through 1990. The Mission projects that the demand for commercial energy (excluding fuelwood) will increase at an average rate of five percent a year until 1990. Most of this demand will be met from imports, further aggravating the country's balance-of-payments position. Although these demand projections need to be improved, this is not critical as no major investment decisions are to be based on them. In the case of hydropower development, a careful demand analysis will be required before making any decisions on projects.

Electric Power Distribution

3. Lesotho meets more than 95% of its electricity needs through imports from the Electricity Supply Commission (ESCOM) of the RSA. The high growth rate in power demand over the past three years, more than 15%

1/ Adapted from Report No. 4676-LSO, January 1984.

2/ During the January 1984 draft review meeting, the Mission was informed that the manpower situation for the woodlot project had improved in 1983 and replanting increased to 1200 ha. In future, the planting rate is expected to increase at 20% p.a.

Economic Context

Lesotho is a small kingdom entirely enclosed by the Republic of South Africa (RSA). About 13% of the country's 1.4 million people (1982 estimate) live in urban centers. About 11% of the working population depends directly on the RSA for employment, and a majority of these migrant laborers work in the RSA mines. The population of Lesotho is projected to grow at about 2.3% a year until the end of the century.

Lesotho is designated by the UN as one of the least developed countries. Its economy is open and mainly dependent on the RSA. In 1982-83, it had an estimated GDP of LSM329.0 million (US$303.6 million) and an estimated GNP of LSM557.3 million (US$514.3 million). The difference between the GDP and GNP is made up largely by remittances from migrant workers which usually constitute over 40% of GNP. The real GDP and GNP growth rates were 8% p.a. and 9% p.a. respectively, during the 1970s, propelled by: increased remittances from migrant workers, an increase in Customs Union payments which already make up 70% of the government's income, the opening up of the Letseng-La-Terai diamond mine for exports in 1977, and the inflow of substantial external assistance.

Despite rapid growth in the 1970s, the basic structure of the economy has not changed much over the past decade. However, excessive soil erosion has reduced arable land by an estimated 7%,and the socioeconomic conditions for more than 90% of the population that still depends on agriculture for their livelihood have worsened, including a reduction in the availability of crop residues for energy. Industrial options are limited because of the shortage of skilled manpower, a small domestic market, and heavy reliance on imported raw materials. Manufacturing output and handicrafts have not yet exceeded 6% of GDP.

The factors which sustained rapid economic growth in the 1970s have weakened over the past few years. For example, the number of Basotho mine workers fell betweem 1977 and 1982 because of RSA's policy of increasing employment opportunities for its own blacks, the mechanization of certain mines, and the closing of marginal mines, the closing of the Letseng-La-Terai diamond mine in 1982 which has depressed export earnings; and the fact that receipts from the Customs Union have increased by only 4.3% a year since 1979/80. Real GDP growth in 1982/83 is estimated to be 3.1%. Expected to drop somewhat in the future, the mission assumed a 3.0% p.a. real GDP growth rate inpreparing energy projections.

p.a., has overloaded the transmission system of the Lesotho Electricity Corporation (LEC). The sub-grid serving Maseru, Roma, Mafeteng, Mohale's Hoek and Quthing needs immediate expansion to handle the projected 1984 winter power demand. The LEC has started a LSM6.6 million (US$6.3 million) expansion program by commissioning work on the construction of a 2 x 40 MVA, 88/33 kV substation at Maseru. However, they have run short of funds and would need LSM3.4 million (US$3.2 million) of external financing to complete the project. In the Mission's view, construction of the Maseru substation is a high priority, and the Government should actively seek external support funds for the project.

4. Rural Electrification. Several rural electrification (RE) schemes are being developed by LEC to supply power to public institutions in isolated areas in the highlands. These RE schemes will use mini hydropower and/or diesel generation; the Mission estimates that both these sources are economically competitive in the highlands. The Electricity Supply Board of Ireland (ESB) had worked out a plan for RE in the lowlands consisting of constructing a basic rural network (BRN) to supply power to 388 public institutions and rural households in about 1,000 villages. Recent experience in the Hololo Valley suggests that power demand in rural households is low. In the Mission's view, the economic justification for large-scale rural electrification has not been established and the Government should consider such a project with caution.

Petroleum Supplies

5. Lesotho imports all of its petroleum products from the RSA. An Inter-State Oil Committee (ISOC) consisting of representatives from the RSA, Lesotho, Botswana and Swaziland (BLS countries) was created in 1979 to monitor the procurement, allocation, pricing and conservation of petroleum. In the Mission's view, it would be difficult for Lesotho to seek to reduce the cost of petroleum imports through alternative supply arrangements because of the geo-political situation and land-locked nature of the country. However, because of supply shortages or emergencies, the current capacity of petroleum storage facilities (six day supply cover) needs to be expanded. In addition, the GOL should also aim at rationalizing the internal marketing and distribution system.

Development of Indigenous Energy Resources

6. The country's potential energy resources include hydropower, and modest volumes of fuelwood and, possibly, hydrocarbons. Fuelwood is currently the only viable domestic alternative to imports from RSA. Large scale hydropower would require agreements on water sales to the RSA. The hydrocarbon potential is uncertain. There may be some difficulty in harnessing new energy sources such as wind and solar because of large seasonal variations in climatic patterns.

Hydropower

7. The main options lie with large hydro sites which have been identified on the Senqu (or Orange) and Senqunyane rivers. The two most advanced options are the Lesotho Highlands Water Project (LHWP) and the Jordane Project. The Mission supports the decision by the EEC to fund a detailed feasibility study on the LHWP and recommends that particular attention be given to: (i) identifying and quantifying the distribution of benefits between RSA and Lesotho; and (ii) examining the viability of a smaller, separate power scheme for Lesotho. 3/

Fuelwood

8. The GOL entered into a joint venture with the UK-ODA and Anglo de Beers (RSA) in 1973 to develop fuelwood supplies through a Woodlot Project. Although implementation of the project has encountered problems with land acquisition, lack of a proven technical package for reforesting under the harsh climatic conditions in Lesotho, and a shortage of local skilled personnel, about 3,600 ha of two eucalyptus species have been planted and are achieving mean annual increments of about 7 m^3/ha/year. Progress has been made in securing land for tree planting and in identifying a suitable technical package for tree planting in the lowlands. In the Mission's view, there is potential for replacing fuelwood imports from the RSA. Local woodlots are currently supplying fuelwood competitively. The Mission supports the initiatives made by the management of the Woodlot Project to extend the project life to 20 years and have a fuelwood marketing study done to determine the production costs and a least cost distribution method. In the Mission's view, the main constraint in the reforestation effort is the lack of foresters and a forestry service to administer several ongoing and proposed projects. There is now an urgent need to establish a Forestry Division within the Ministry of Agriculture and Marketing (MAM) to take over the responsibility of coordinating and administering these projects from the management of the Woodlot Project. The African Development Bank (AfDB) is considering technical assistance for forestry institution building as part of a proposed US$8.3 million Conservation Forestry Project. The Mission recommends that the scope of the institution building component in the proposed AfDB project be expanded to include the establishment of a project implementation unit as a nucleus Forestry Division of MAM.

Hydrocarbons

9. In 1972, the Government entered into an exploration agreement with Westrans Petroleum Inc. of the USA who later did some photogeological mapping in parts of the Lesotho lowlands. These studies indicated

---

3/ Stage I of the Feasibility Study was completed in December 1983. The Study recommends that Lesotho should go ahead with Stage II (to be completed by late 1985).

favorable conditions for geophysical exploration, and Westrans proceeded to do further gravity and magnetic surveys to locate a structure for drilling. Later, in 1974, Westrans drilled a 5,421 foot hole at Mahobong but there were no significant oil or gas shows. Westrans by then had been acquired by ELF Aquitane of France and relinquished the concession. The Government does not believe that this exploration effort by Westrans is sufficient to base any conclusions on Lesotho's hydrocarbon potential. In the Mission's view, GOL's desire to attract further petroleum exploration activity would require that external assistance be provided to the Department of Mines to prepare the necessary maps and a good well log of the Mahobong-1 well, and possibly some assistance to allow the Lesotho National Development Corporation (LNDC) to prepare a clear statement of concession terms, fiscal regulations, and the legislative framework for exploration contained in the Mining Rights Act of 1967.

Institutions

10. The Government of Lesotho has recently established an Energy Planning Unit (EPU) within the Ministry of Water, Energy and Mines (MWEMIN) to be responsible for preparing and implementing an appropriate energy policy and program. The EPU is yet to be adequately staffed. An Undersecretary of the MWEMIN works as the head of EPU part-time, and also takes care of day-to-day matters on an ad-hoc basis without the benefit of techncial or staff support. The Mission recommends that a small staff be recruited for the EPU who could then be assisted and trained by an expatriate Energy Economist to handle the EPU's responsibilities.

Implications for External Assistance

11. Considering that (i) large investments in hydropower options such as the LHWP and the Jordane Project are not required before the 1990s; and (ii) that the large scale development of fuelwood supplies is being tackled as part of an overall forestry/conservation strategy, the Mission estimates that LSM 3.4 million (US$3.2 million) will be the major investment required in the energy sector for expanding the LEC system. The main focus of future external assistance for energy development in Lesotho should be technical assistance for institution building in the Forestry Division, the Energy Planning Unit, hydrocarbon exploration and the LEC.

MALAWI: ENERGY BALANCE 1980
(thousand tonnes of oil equivalent)

	Fuelwood	Other Biomass	Coal	Petroleum Products	Electricity	Total Commercial Energy	Total
Primary Supply							
Production	3029.0	83.4	-	-	96.1	96.1	3208.5
Imports	-	-	31.2	148.7	-	179.9	179.9
Total	3029.0	83.4	31.2	148.7	96.1	276.0	3388.4
Transformation							
Thermal Power Generation			-	-1.3	1.3		
Conversion Losses			-	-	-0.9		
Transmission and Distribution Losses			-	-	-2.8		
Net Supply/Demand	3029.0	83.4	31.2	147.4	29.5	208.1	3320.5
Demand							
Industry	1527.0	83.4	29.6	60.4	21.6	112.6	1723.0
Transport	-	-	-	80.6	-	80.6	80.6
Commercial	9.0	-	1.6	0.1	3.2	4.9	13.9
Residential	1493.0	-	-	6.3	4.7	11.0	1504.0

toe = 10.333 mn kcal
kWh = 2580 kcal (production)
= 860 kcal (consumption)

MALAWI 1/

1. Malawi faces two major energy problems. First, the consumption of fuelwood, which accounts for 90% of the primary energy supply for the country, exceeds the sustainable yield of this resource. Although this has not yet manifested itself in serious deforestation or widespread fuelwood shortages, a continuation of this trend could seriously deplete Malawi's extensive national forest cover. The Government has taken a number of commendable measures aimed at alleviating this problem by increasing the substainable supply of fuelwood. However, the emphasis of the reforestation program needs to be changed to accord more closely with the needs and perceptions of the rural population and, more importantly, these efforts need to be complemented by an equally vigorous program to increase the efficiency with which fuelwood is used, especially in the tobacco industry. Available evidence suggests that such a program could yield substanital fuelwood savings in a relatively short period and consequently it deserves a much higher level of public funding and support than it has received in the past.

2. The second major energy problem facing Malawi is that petroleum imports, which are a small but vital component of total energy supply, have become increasingly costly both because of the rising cost of the imports themselves and the cost of disruption in their transit from the coast of Mozambique. There is no easy solution to this problem because Malawi is dependent on often unstable supply routes for all its imports. Nevertheless, a number of measures can be taken to mitigate the worst effects of this problem. These include the streamlining of existing transport arrangements and encouraging more appropriate provisions for holding petroleum stocks within the country.

3. These and the other main recommendations in the report are listed in the following section for ease of reference. However, it is important to put these recommendations and indeed the whole discussion in the report, it their proper persepective. Malawi's energy problems are far less severe then they could have been given the country's limited energy resource base and its geographical position. The credit for this is mainly due to sound Government policies which have correctly identified the priority areas for action and responded promptly and realistically to recent developments in the international energy situation. The recommendations made in the report are therefore, designed to assist the Government is maintaining its good record in energy policy and management.

1/ Adapted from Report No. 3903-MAL, August 1982.

Economic Context

Malawi is a poor, landlocked country with a population of six million which is almost entirely rural and rapidly growing. Agriculture dominates the economy, accounting for 43% of GDP, 85% of the labor force and almost all of the country's exports. Malawi's main natural resources are a good supply of water, moderately fertile land and a climate which is favourable for crop production. Unlike its neighbours, Malawi does not have substantial mineral resources. Since independence in 1964, the country's economic performance has been impressive. Despite its poor resource base, high population density and the handicap of having to depend on relatively inefficient and unstable access routes to external markets, Malawi managed a growth rate of about 6% a year through 1978. At the same time, significant progress was made in meeting the educational, health and other basic needs of the population.

Since 1978, however, Malawi's economic position has deteriorated sharply. There was virtually no economic growth in 1980 and 1981 and there was a sharp widening of the deficits on both the Government's overall budget and the current account of the balance of payments, both of which have historically been kept at a prudent and manageable level. Potentially more serious is the recent increase in external debt, much of it contracted on severe terms in international commercial markets. Since 1978 the country's terms of trade have fallen by 35% as a result of declining export prices, particularly for tobacco and tea, the main exports, and rapidly rising costs for essential imports, including petroleum. Two years of poor rainfall and the consequent need for maize imports also contributed to the trade balance problem, as did the complete breakdown of normal supply routes through Mozambique during 1979 and the subsequent costs of air freighting essential commodities into the country. The adverse effect of these external forces has been compounded by weaknesses in Government policy. In particular, budgetary controls have been inadequate, inefficiencies in parastatal operations and the system of price and wage controls have hurt both public and private sector corporations, and inadequate incentives for smallholders have inhibited export growth and diversification. The Government recognizes the gravity of these problems and, with the assistance of the Bank and the Fund, it has started a program of economic recovery designed to diversify the export base, encourage efficient import substitution, adjust incentives and income policies, improve the public sector's financial performance, and strengthen the Government's overall economic planning and monitoring capability.

Summary of Recommendations

Fuelwood

4. The work being done by the Tobacco Research Authority on improving the efficiency of fuelwood use in the tobacco industry should be strengthened and expanded and given much higher priority in terms of public funding and support.

5. The reforestation program needs to be reoriented (i) to target the seedling sales to areas where there is already an apparent and recognized fuelwood shortage, (ii) to sell species suitable for building poles rather then fuelwood, (iii) where seedlings are sold for fuelwood production, to introduce species which can be grown on marginal land to reduce competition with agricultural crops, (iv) to place additional emphasis on the managed plantation component of the reforestation program, and (e) to provide extension service on the care and maintenance of seedlings.

6. Fuelwood pricing policy should take into account the effects of higher prices from Government plantations on the rate of withdrawal from customary land. Efforts to raise the price of wood should therefore focus on those segments of the market (industrial, urban) which purchase a large proportion of their wood requirements.

Petroleum

7. Supply. The question of strategic storage reserves has been examined by a consultant study. The mission supports the consultant's recommendation of entering into a small supply contract with the refinery at Ndola and acquiring a small reserve fleet of road tankers to be used in an emergency but the recommendation regarding strategic storage requires further clarification. In addition, the following steps should be taken to streamline the existing supply system:

(a) A formal "alert" mechanism needs to be formulated so that it is triggered whenever the stocks of any particular product fall below a certain pre-specified level. OILCOM could be charged with the responsibility of administering this mechanism.

(b) A standing committee on petroleum supply should be established. This committee, which would include representatives of the oil companies, Malawi Railways and the Government, would meet every time the "alert" mechanism was triggered or if a potential supply problem existed.

8. Pricing. 2/ The Government should re-examine with the oil companies the financial disincentives embedded in the current procedure for holding inland stocks.

9. The "Kerosene Subsidy" should be abolished and the regular taxes on kerosene and other products adjusted to provide the same net effect at a lower administrative cost.

10. The Government should begin to obtain independent information on international price trends and monitor the CIF costs of the various oil companies so that in future anomolies in these costs are addressed without undue delay.

Electricity

11. Supply. To ensure the optimal selection of future power projects there should be a systematic identification and ranking of all the potential major hydro projects and considerations should be given to diversifying away from the Middle Shire river.

12. Government and the electric utility, ESCOM, should begin a survey and identification of the country's small hydro potential for replacing isolated diesel generation.

13. Pricing. The next round of tariff revisions should be based on the results of an undated marginal cost of supply study which should be carried out, with technical assistance if required. ESCOM should also examine whether alternative connection and metering procedures could help to increase household access to electricity by reducing the cost of supply.

Coal

14. The Coal Users Committee should continue its operations as long as all the users are satisfied with this arrangement.

15. The prospects for developing the Ngana coal deposit do not appear encouraging at this time because of high cost and the remote location. Thus, further work on this deposit is not a priority task at this time.

16. The Geological Survey should continue to collect and analyze information on other coal deposits as part of its ongoing work and a laboratory should be established for analyzing the samples collected, although this too is not a task of immediate priority.

2/ The follow-up mission was informed that the Government was acting on these recommendations but the issues had not been fully resolved.

Non-Conventional Energy Sources

17. Clear guidelines for research and development work in new and renewable energy technologies need to be urgently established to guide the currently isolated efforts of various agencies.

18. The institutional framework for this work also needs to be clarified, in particular the role of the National Science Council.

19. The feasibility of expanding ethanol production by using cassava as a feedstock needs to be carefully examined before investment decisions are made.

20. The economics of using solar water heaters to replace conventionally generated electricity does not appear to warrant a major effort to popularize this application. However, the potential contribution of this source to replacing conventional energy for crop drying could be substantial and needs to be explored further.

21. The costs of generating power from using bagasse more efficiently at the SUCOMA sugar mill need to be compared with the cost of supplying this power from ESCOM's system, so that a decision can be made in this regard.

22. The potential for expanded use of cotton seed husks as boiler fuel in the Blantyre area should be examined.

Conservation

23. The pattern of energy consumption and the potential for increased efficiency of energy use in the industrial sector need to be examined further.

Institutions

24. The terms of reference of the Contingency Planning Unit in the Office of the President and Cabinet should be revised to enable it to focus on the important task of ensuring an uninterrupted supply of fuel. This Unit should also be responsible for the allocation of fuels in the event of a shortage.

25. The Contingency Planning Unit should represent the Government on the tripartite petroleum supply committee proposed above.

26. The responsibility for overall energy policy formulation and the coordination of subsectoral energy agencies should be carried out by the newly established Energy Unit in the Economic Planning Division (EPD).

27. EPD will require technical assistance in the initial 18-24 month period to be able to effectively discharge these responsibilities.

28. The Energy Inventory Group in EPD was disbanded in late 1981 and an Energy Unit has been formed to continue the work. However, as three of the four staff in the Energy Inventory Group are no longer with the new unit, this unit will need considerable strengthening before it can effectively perform its duties of formulating energy sector policy and coordinating the work of the various line agencies. The immediate needs are for at least two more national staff (economist/planner) and for a resident technical advisor for the first 24 months to help train these staff and establish an effective and operational energy planning and management capability.

Energy Sector Developments, August 1982-1983 3/

29. Over the last year, progress has been made in a number of areas in the energy sector. In the fuelwood subsector, the Ministry of Forestry has initiated studies and projects emphasizing the need for energy efficiency for wood-fired curing in the tobacco industry. A comprehensive inventory of various technical packages to improve the efficiency of fuelwood use in the tobacco industry has been completed. This inventory enables a comparison of alternatives in terms of investment costs and benefits. The Government also has initiated efforts in reforestation and fuelwood conservation. In the power subsector, a consultant has been selected to study the country's hydropower potential and recommend a ranking of project sites. The contract for this undertaking is expected to be signed shortly. Construction of a 20 MW generation project is expected to start this year and be completed in 1986-87. The petroleum supply system within the country has been streamlined and alternative supply routes from the neighboring states have been developed; efforts have been made to maintain an adequate contingency reserve stock. A uniform gasoline price has been established throughout the country.

30. It is now necessary to define an overall medium-term strategy for energy supply and utilization and to prepare a least-cost power development plan. For this purpose, the Government's institutional capability in the area of energy planning would need to be strengthened. The institutional issue was examined by a Bank/UNDP mission which visited Malawi in August 1983, and is being addressed under the Bank's Technical Assitance Project currently under implementation in conjunction with the second Structural Adjustment Credit. Under this project, assistance is also being provided for a pilot project to improve fuelwood efficiency in tobacco curing.

3/ Report No. 013/84, Malawi Energy Assessment Status Report, January 1984.

31. There have been a number of developments in energy consumption since the Assessment in August 1982. The consumption of petroleum products has decreased moderately. There has been a small decrease in gasoline and kerosene consumption; diesel oil demand has declined by about 3%. Electricity demand has remained constant over the year, mainly because of high tariffs, economic slowdown, and supply constraints in some parts of the country. Tariffs were increased by about 10% in April 1983, and new tariffs were to be proposed for Government approval in January 1984.

32. On the supply side, there has not been any appreciable change since last year. The transportation of imported petroleum products through Mozambique (the shortest route) experienced continued difficulties. Hence, alternative transit routes from South Africa via Zimbabwe and Zambia have had to be developed although these routes are more expensive. The Dwangwa ethanol plant which had supplied 6.5 million liters during the previous year went on full production, with a target to supply 10 million liters by the end of 1983. The ethanol is used as transport fuel in 20% blend with imported gasoline.

MAURITIUS: ENERGY BALANCE, 1979
(thousand tonnes of oil equivalent)

			Petroleum Products						
	Coal	Bagasse	LPG	Gasoline	Kerosene	Diesel	Fuel Oil	Hydro	Total
Primary Supply									
Production	-	337.8	-	-	-	-	-	13.1	350.9
Imports	0.9	-	2.1	48.1	26.2	60.0	74.3	-	211.6
Conversion Losses		134.1	-	-	-	3.9	38.6	8.5	185.1
Net Supply/Demand	0.9	203.7	2.1	48.1	26.2	56.1	35.7	4.6	377.4
Demand									
Residential	-	2.2	2.1	-	26.2	0.8	8.1	1.8	41.2
Commercial	-	1.1	-	-	-	0.4	4.1	0.9	6.5
Industrial	0.9	199.5	-	-	-	0.6	20.3	1.2	232.5
Transport	-	-	-	48.1	-	54.0	-	-	102.1
Other	-	0.9	-	-	-	0.3	3.2	0.7	5.1

toe = 11.34 mn kcal
kWh = 2520 kcal

MAURITIUS 1/

1. Mauritius' primary energy requirements are met in roughly equal proportion from indigenous bagasse and imported petroleum, but these two sources are used in very different ways. Bagasse, a by-product of the sugar industry, is used almost exclusively to meet the energy needs of that industry and its contribution as a direct energy source to the rest of the economy is at present negligible. The energy requirements of the economy, excluding the sugar sector, are met primarily (90%) from imported petroleum products supplemented by a small amount of hydro-electricity and coal.

2. The crux of Mauritius' energy problem is the rising cost of these petroleum imports. Although less than 186,000 toe in 1980, they absorb 7% of GDP and 16% of the country's scarce export earnings. By way of contrast, the comparable figures for 1973 were 3% and 6% respectively. While the bulk of the increase in the oil import bill -- from $10 million in 1983 to approximately $61 million in 1980 2/ -- is attributable to increases in the international price of petroleum, over which Mauritius had no control, a large part was due to the rapid rates of growth of petroleum consumption in the mid-1970s. The main reason for this was, of course, the generally buoyant economic climate that resulted from the boom in world sugar prices which, in effect, insulated Mauritius from the impact of the first round of world oil price increases. The five year period after 1973 saw an increase in both the rate of growth of the economy (the GNP growth rate was 25% above that of the preceeding five years) and in the ratio of petroleum consumption per dollar of GNP (which increased from 0.19 kg of oil equivalent in 1973 to 0.24 kg of oil equivalent in 1978).

3. Since 1978, however, this situation has changed dramatically. The doubling of world oil prices in 1979 came at a time when the Mauritian economy was already having difficulty in adjusting to lower revenues from sugar exports and a general reduction in living standards. Under these circumstances, the response to higher oil prices was sharp and immediate -- between 1978 and 1980 the consumption of petroleum products declined from a peak of 210,000 toe to 186,000 toe. While this provided a much needed measure of interim relief to the balance of payments, it should not be interpreted as the beginning of a longer term trend. Virtually all of the decrease in petroleum consumption occurred in 1980, a year in which both income and output fell and the island was

---

1/ Adapted from Report No. 3510-MAS, December 1981.

2/ This excludes approximately $18 million worth of jet fuel imports which were used to meet the requirements of international airlines refueling in Mauritius and are consequently treated as reexports.

Economic Context

Mauritius is a small and densely populated island. Despite expansion of other sectors since the 1970s, the economy remains dominated by sugar production for export. With a per capita GNP of US$1,040 in 1979, Mauritius enjoys the standard of living of a middle income country. Basic needs are substantially covered through Government programs although about 12% of the island's population of one million people still live in absolute poverty.

Since independence in 1968, the Government has sought to lay the basis for the diversification of the economy by encouraging tourism, tea cultivation and the establishment of industrial units in an export processing zone (EPZ). Economic growth averaged 7.3% annually between 1970 and 1977; employment growth was sufficient to halve unemployment rates and there was a moderate expansion in the quantum of exports.

In recent years, however, severe economic difficulties have emerged. The collapse of world sugar prices in 1976, the slowdown in the growth of EPZ exports and a sharp increase in the price of oil and other imports have combined to produce a rapid deterioration in the balance of payments. As a result, the current account deficit has grown substantially and is expected to reach $160 million in 1981, equivalent to 14% of GDP. To finance this gap, Mauritius has had to resort to increasing amounts of non-project debt on hard terms.

The Government has become increasingly aware of these problems and has formulated a comprehensive program of adjustments to deal with them. On the basis of this program, it has obtained a structural adjustment loan from the Bank, complementing the assistance provided by the IMF in the form of a SDR 31.3 million Compensatory Financing Facility. The key elements of the adjustment program are to maintain an annual economic growth rate of about 3.5% for the next few years and to reduce the external deficit on the current account to about 8% of GDP by FY85 in an attempt to keep the debt service ratio below 15% in normal years. This strategy will require restructuring and reorienting investment to more productive sectors; restricting the growth in public and private consumption; and reducing the size of the public investment program relative to GDP. It will also require a series of supply side measures to strengthen and diversify the export production base while promoting fuller exploitation of the economy's import substitution potential.

struck by an unusually severe season of cyclones, whose only benefit was a 40% increase in the level of hydro-electric generation which reduced the demand for oil by a further 5,000 tons.

4. This situation is not expected to continue. The Government's plan for the 1980's calls for sustained economic growth in the region of 3.5% per annum and this will in turn require a higher level of energy supply. However, if the Government is to ensure that the economy's legitimate energy requirements are met at least cost, a conscious planning effort is required because a break from past trends will be needed. The mission therefore projected two alternative scenarios for the 1980s. The first is the "Base Case" scenario which broadly assumes the continuation of existing trends and only includes energy development projects in the implementation stages. On this basis, the demand for primary energy is projected to rise from 211,000 toe in 1980 to 330,000 toe by the end of the decade. 3/ Ninety percent of this demand would continue to be met from imported oil at a projected cost in 1990 of $140 million in 1980 dollars which would be equivalent to nine percent of GDP. This is a level which would pose a serious threat to the country's external payments situation and its other developmental objectives. However, this scenario is not an inevitable one.

5. The mission also developed an alternative scenario, the "Accelerated Energy Program" (AEP). Moving to this program will entail first, accelerating the substitution of cheaper energy sources -- both indigenous and imported -- for costly oil; and second, increasing the efficiency with which all forms of energy are used in the economy so that a given level of output can be achieved with a lower level of primary energy input. The main supply side options envisaged under the program are a tenfold increase in the contribution of bagasse as an energy source through improvements in the efficiency with which it is utilized to generate electricity and, second, the setting up of a coal-fired power plant in the latter half of the decade. On the demand side, a concerted program of energy conservation to complement the already realistic pricing policy for energy products will result in a further moderation of energy consumption growth.

6. Successful implementation of the Accelerated Energy Program would result in a primary energy consumption level in 1990 of 295,000 toe of which 58% or 172,000 toe would be met from imported oil. Although this scenario would require the annual import of about 80,000 tons of coal, the projected energy import bill by 1990 would be substantially lower -- by $52 million in 1980 dollars. Mauritius would still depend on imported oil for over half of its energy needs but this would be a far more manageable level than the one resulting under the Base Case (BC)

3/ All projections of primary energy consumption exclude the energy produced and consumed internally by the sugar industry.

Scenario. The two scenarios and their impact on imported energy are compared in the table below.

ENERGY CONSUMPTION AND SUPPLY PROJECTIONS
(thousand toe)

	Actual	BC Scenario		AEP Scenario	
	1980	1985	1995	1985	1990
Primary Energy Demand	211	270	330	270	330
Less Conservation	-	-	-	15	35
Net Primary Energy Demand	211	270	330	255	295
Met from:					
Petroleum	185.9	235.6	295.6	196.3	172.0
Other Sources	25.1	34.4	34.4	58.7	123.0
% Imported Petroleum & Coal)	89	88	90	77	71

7. Achieving these savings will require a substantial amount of investment in the energy sector, primarily for the setting up of a coal fired power plant and a nationwide program to increase the effciency of bagasse used for electricity generation. The cost of these projects still needs to be worked out in greater detail but the preliminary estimates which have been made suggest that the cost of the first is likely to be in the range of $45-50 million, and that of the second in the range of $45-70 million (all in 1980 $). Some additional investment will also be required in connection with the implementation of an enhanced energy conservation program and an initial small project for ethanol production but these have yet to be quantified and they are in any event unlikely to be substantial. Even allowing a conservative figure of $15 million for them and assuming the upper end of the range for the two major projects, total investment costs for the Accelerated Energy Program of $135 million (in 1980 dollars) compare very favorably with the projected annual savings figure of $52 million (in 1980 dollars) cited above. Naturally, all of these figures need to be worked out in greater detail than is possible in this report. Rather, they represent the type of questions which should be examined in the course of preparing a national energy plan which is also a principal recommendation. However, these figures do show that the net benefits associated with an Accelerated Energy Program are likely to be large and particularly important to Mauritius since the tight external payments situation is expected to continue.

8. Finally, the timely implementation of the AEP will depend critically on strengthening the currently weak and fragmented institutional framework for the energy sector. The Government recognizes this

problem and has recently taken the important and welcome decision to set up a small energy planning unit in the Ministry of Economic Planning and Development. This unit will coordinate the work being done on various energy issues by different Government, private and international agencies. It will also consolidate and expand the existing energy data base and prepare, over the next two years, a long term national energy plan. To discharge these responsibilities, the energy planning unit will require considerable technical assistance in the initial stages. The most important element of this package would be an experienced energy advisor whose services would be required for a period of 18-24 months to help establish the unit and define its scope of work and staffing requirements. The UNDP has indicated that it would be willing to help finance these services through its ongoing program of assistance in Mauritius, but additional financial support from other donor agencies is also likely to be needed.

Energy Sector Developments, 1981-1983 4/

9. Very slow economic growth and continued high energy costs have been reflected in the stagnant demand for energy during 1981-82. As the following table shows, electricity production and sales remained virtually unchanged since 1980 (itself a year in which there was no growth over the previous year). However, the pattern of electricity generation has altered, with production from the sugar factories increasing by more than 60% as a result of new plant and efficiency improvements and the signing of new contracts by the CEB for higher purchase volumes. At the same time, poor rainfall in 1981 led to a sharp drop in hydro generation which had to be offset by increased use of diesel plant, resulting in a 40% increase in the average cost of electricity production in that year. This higher cost has been a source of concern to the CEB, particularly because electricity tariffs have only increased by 10% since April 1981. This situation should be alleviated by the 15% increase in tariffs that has just been announced. On the supply side, no new CEB plant has been commissioned since the installation of the 2 x 12 MW diesel sets at Port Louis in September 1981. Work on the Champagne Hydro-Electric scheme is proceeding and the project is expected to be completed by March 1984.

10. In the petroleum subsector, with the exception of fuel oil whose demand is essentially determined by the need for thermal electricity generation, the consumption of all products has been stagnant or declining since 1980. (See table below). The cost of oil imports rose from US$57.5 million in 1980 to US$67.0 million in 1981, largely because of higher fuel oil use in the power sector but also because of higher

---

4/ Report No. 008/83, Mauritius Energy Assessment Status Report, October 1983.

unit prices. In 1982, however, lower demand and reduced prices caused the oil import bill to drop to US$54.7 million.

ELECTRICITY STATISTICS, 1980-82

	1980	1981	1982
Maximum demand (MW)	83.5	81.1	86.2
Sales (GWh)	290	291	293
Generation (GWh)	355	362	363
- hydro	82.8	59.7	93.4
- sugar industry purchases	26.7	30.9	43.3
- oil thermal	245.4	271.3	226.1
Average cost per kWh produced (incl. purchases	0.50 cs	0.72 cs	0.61 cs

Source: CEB

11. In terms of petroleum supply, an important development has been the introduction, in April 1983, of direct Government purchase of about a quarter of the island's internal petroleum product requirements through a bilateral agreement with the Kuwait Petroleum Corporation. The Government is also investigating whether additional procurement on a Government-to-Government basis from other oil producing states could help reduce the cost of the country's oil import requirements.

PETROLEUM STATISTICS, 1980-82

Product	Consumption a/		
	1980	1981	1982
	('000 barrels)		
Gasolines	336.1	310.6	259.7
Gas Oil	427.3	447.8	439.8
Kerosene	161.2	132.8	128.7
Fuel Oil	448.5	533.8	409.1
Others	42.0	38.2	41.5
TOTAL	1415.1	1643.2	1278.8

a/ Excludes bunker sales.
Source: Shell (Mauritius) Ltd.

This page is blank

MOROCCO: ENERGY BALANCE, 1981
(thousand tonnes of oil equivalent)

	Non-Commercial Energy					Petroleum Products								
	Wood	Charcoal	Total	Coal & Coke	Crude Oil	LPG	Gasolines	Middle Distillates	Fuel Oil	Total	Natural Gas	Electricity	Total Commercial Energy	Total
Primary Supply														
Production	2725		2725	352	19						64	254	689	3414
Imports				27	4513								4540	4540
Exports				-30									-30	-30
Stock changes				50	-188								-138	-138
Total	2725		2725	397	4344						64	254	5059	7784
Transformation and Losses														
Oil Refining					-4167	180	553	1384	1767	3884	-21		-304	-304
Refined Product Imports						143			42	185			185	185
Refined Product Exports						-9	-207			-216			-216	-216
Thermal Public Power Generation				-345				-3	-700	-703		999	-49	-49
Plant Use and Losses											-3	-198	-201	-201
Other Thermal Power Generation									-87	-87		116	29	29
Charcoal Production	-317	79	-238											-238
Non-Energy Use	-125		-125		-177				-48	-48			-225	-350
Refined Product Stock Changes						-7	15	1	-43	-38			-38	-38
Net Supply/Demand	2283	79	2362	52	0	307	362	1382	926	2977	40	1171	4240	6602
Demand														
Industry														
Phosphates									208	208	30	135	373	373
Cement									329	329		90	419	419
Others				49		11		133	329	473	10	454	986	986
Transportation & Services							362	1063	35	17460		171	1673	1673
Agriculture								134	9	143		61	204	204
Households	2283	79	2362	4		296		53	17	366		260	630	2992
Total	2283	79	2362	53		307	362	1383	926	2978	40	1171	4242	6604

toe = 10,2 mn kcal
kWh = 2500 kcal

MOROCCO 1/

1. The Moroccan economy faces serious balance-of-payments difficulties symbolized by a chronic current account deficit which reached $1.9 billion or 13% of GDP in 1981. The rising cost of energy has contributed markedly to this situation, and although recent gas discoveries hold out some prospect for alleviating the oil import burden in the long term, the extent of these is still quite uncertain, and investment requirements for development of indigenous energy supplies are very substantial. Given the country's constrained capital situation, the uncertainty surrounding future domestic gas availability, and the fact that some of its energy investment options have high costs and perhaps marginal to unattractive returns, an extremely careful selection of investment priorities is vital.

2. Morocco faces two serious energy problems simultaneously, one involving imported oil and the balance of payments and the other involving woodfuels (fuelwood and charcoal) and the energy needs of low-income households. The magnitude of these problems can be illustrated by a few statistics: 85% of the commercial energy consumed in Morocco is derived from imported oil whose cost (about $1 bn annually) consumes about 40% of export earnings. At the same time, wood, the principal non-commercial energy source for a substantial share of Morocco's population, and which is estimated to account for about 35% of total energy consumption, is being harvested at an estimated three times the rate at which it is growing back.

3. These problems are severe and cannot be solved in the short term. In the immediate future the energy balance can only be modified by measures to restrain the growth of energy demand through pricing of energy products and electricity and complementary measures to promote energy conservation. Improvement of the energy balance in the medium to longer term can only be achieved by the development of economically viable domestic energy resources. A short-term strategy should include the following priority actions: (i) expediting exploration, appraisal and, if viable, development of gas reserves; (ii) further and very careful evaluation of the technical/economic viability of those energy investment options for which the economic returns may be low (oil shale, domestic coal, certain hydro projects); (iii) emphasis on improving the efficiency of energy use in the industrial, transport, power, residential and commercial sectors, including a carefully balanced inter-fuel pricing strategy and inter-fuel substitution, (iv) increased attention to expanding reforestation efforts; and (v) measures to strengthen energy planning, particularly in the power sector, and strengthening of the key energy enterprises and coordination between them.

1/ Adapted from Report No. 4157-MOR, March 1984.

Economic Context

Compared with many developing countries, Morocco is well endowed with natural resources. Morocco has the world's largest and most easily recoverable phosphate reserves, which makes the phosphate sector a key export sector. Other minerals such as iron ore, manganese, lead and zinc are also exported, but in much smaller amounts. Morocco also has a relatively good agricultural potential. In addition, Morocco's proximity to Europe has favored trade, tourism, and labor migration with the EEC countries. The current population is 21.3 million and is growing at 3.0% p.a. About 41% of the population is urban, predominantly concentrated along the northwestern coastal strip between Casablanca and Kenitra.

During the 1970s, substantial investments were undertaken by the Government to promote economic growth, while a growing concern for social development and equity also led to a considerable expansion of social programs. The results, however, have not been commensurate with the country's efforts and potential, reflecting, in part, the fact that both public and private investments have not always made the best use of resources. Growth has been erratic, and while relatively high on average, has been associated with severe financial imbalances. Domestic savings have been persistently low and their share in GDP has been declining. The Moroccan economy in the 1980s is faced with a severe external resource constraint and the urgent need to make more efficient use of resources, in order to achieve adjustment and growth and make progress towards its social goals with relatively less investment than in the past.

Energy Resources and Supply

4. Morocco has a number of energy resource development options, but each of these faces uncertainties and constraints and much work remains to be done to define an energy investment program that is based on acceptable economic returns and reflects the country's financial constraints. Options and priorities are as follows:

Natural Gas

5. The recently discovered gas reserve at Meskala have introduced the possibility that natural gas could be an energy source of major significance in Morocco, but the precise scale of this project is still beset by many uncertainties. Further drilling and analysis of the Meskala field is needed to clarify the amount of producible reserves. Current tentative estimates place recoverable reserves at between 10 and 50 million toe, implying that production from Meskala could fall in the

range of 1 to 5 million toe/yr. 2/ These technical uncertainties are exacerbated by institutional constraints. While the top managment of the national oil company, ONAREP, which is responsible for work on the Meskala field, is competent, the company's middle management lacks experience in several important technical fields. Appropriate steps are therefore being taken to reinforce ONAREP's ability to carry out the exploration and appraisal of Essaouira, including: (i) creation of a working group composed of ONAREP staff and experienced expatriate explorationists, (ii) contracting a reservoir engineering firm and technical specialists from an international drilling contractor and (iii) simplification of financial control procedures to reduce delays. In addition, a management consulting firm is working with ONAREP to develop a longer term corporate action plan. All of these efforts are important to the success of this work.

6. It is estimated that gas could be produced and delivered to industry at about 20-50% of the cost of the oil it replaces. About one-half of that commercial energy demand is accounted for by large scale individual and power plants that, taking account of their location, can be economically converted to gas. On favorable assumptions, it is possible that natural gas from Meskala alone could replace up to 60% of current oil imports (mainly fuel oil) within 10 years.

7. There are other geologically promising areas of Morocco that have not been adequately explored and could contain additional oil and gas deposits. Three new exploration joint-venture agreements between the national oil company and foreign partners have been signed since the fall of 1981. This is a welcome development and should be further extended.

8. There is no doubt that the highest priority in the energy sector is expediting the exploration, appraisal and development work on natural gas, starting with Meskala, with a view to achieving rapid and sizeable relief on the balance of payments. This involves action on two fronts. The first, and most urgent need is to carry out the work described in paragraph 5 to reinforce ONAREP's technical staff, develop a long-term corporate plan, and streamline managerial and financial procedures in relation to expenditures at Meskala. The second is to improve the framework for increasing the participation of foreign companies in the exploration and development of gas in other promising areas.

Oil Shale

9. Morocco's oil shale resources are immense (several billion toe) and the technical problems involved in their development through either retorting to extract liquids or direct combustion in power plants, do not appear insurmountable. However, it should be recognized that the technology for the exploitation of oil shale is still not well established

---

2/ Petroleum consumption is currently about 4 million toe/yr.

and there is considerable doubt whether the economic costs of such development would be less than the imported oil that it would replace. It is advisable that no major commitment be made to development of shale retorting prior to the satisfactory outcome of current engineering studies in early 1984. In addition, the plan to order an experimental power plant burning shale should be shelved until there is a better evaluation of the costs of oil shale development in relation to alternative energy sources.

Hydropower

10. Morocco's hydro-power resources offer additional opportunities for reducing dependence on oil imports, but not on the scale of possible gas or shale developments. Total hydro potential is estimated at 1.1 million toe/yr. Forty percent of this is already developed, and the Government plans to develop virtually all the rest over the next two decades.

11. The first group of planned investments in hydro power are multipurpose projects (including the Dchar el Oued multipurpose dam and a group of inter-related dams in the Sebou watershed) which rely heavily on agricultural and other benefits for their economic justification. A simplified and tentative cost-benefit analysis indicates that construction of the Sebou dams may not be economically justified in view of the low incremental benefits of the irrigation component, which appear to provide the largest share of net benefits. These results indicate that these projects should be carefully examined to establish their economic viability within the context of overall water resource and power system development priorities. Coordination with MARA is essential to establishing the optimal development schedule for these projects taking into account the rate at which land can be put under irrigation and the "backlog" of land yet to be irrigated from existing dams. Thermal power alternatives to hydro development are discussed below under Demand Management.

Domestic Coal

12. Coal resources stand at 60 to 80 million toe, but mining conditions are difficult and substantial investments will be needed to maintain the current production of 730,000 tpa (7% of commercial energy supply). 3/ With some mechanization, it is expected that production could increase to 1.0 million tpa in a first stage and about 2.0 million Tpa in a second stage, but such a program will have to take into account such factors as (i) the need for increased coal prices and an improved financial situation for the coal mining company (significant but insufficient progress was made in this direction in 1982), (ii) the

---

3/ 365,000 toe of domestic coal out of total consumption of about 5.3 million toe in 1982.

results of the pilot mechanization project (the first year's results are generally positive), (iii) market constraints (the market for the first million Tpa appears reasonably well assured, that for the second still needs to be established), and (iv) the facilities needed to substitute coal for oil in industrial plants. The possible utilization of imported coal is discussed under Demand Management below.

Fuelwood

13. Alongside the priorities for action in the commercial energy area is that of balancing the demand for fuelwood with the productivity of Morocco's forests. Currently, about 11 million m^3 of wood are harvested while only about 3 million m^3 grow back each year. Current reforestation efforts cover only about 10,000 ha of new land each year because of three main problems: the very limited amount of information available on the location, quality, and exploitable volumes of Moroccan forests; the lack of incentives for the private sector and local authorities to invest in reforestation, and the limited financial, managerial and technical resources of the Forestry Directorate of the Ministry of Agriculture. Consequently, the forest area is shrinking at about 20,000 ha/yr (i.e. 0.4% of the present natural forest area of 5.1 million ha). Reversing this decline is important not only to assure an adequate future supply of traditional fuels, but also in maintaining agriculturally important soil, water, and forage balances. Meeting the estimated fuelwood demand in the year 2000 would require reforestation at a rate of about 50,000 ha/yr, over twice the maximum achieved to date (20,000 ha/yr). Measures that are urgently needed to alleviate the constraints to accelerated reforestation include a reallocation of investment resources to the sector in areas where it is shown to be viable, and the introduction of appropriate incentives where necessary to stimulate investment. There should be better management of existing forests to improve production and control grazing which causes damage. In addition, the Renewable Energy Development Center (CDER) should devote a large share of its resources to work that can help with the woodfuel problem by leading to efficiency improvements and inter-fuel substitution in cooking and heating within the economic reach of low-income households, as well as by exploring the substitution of biomass for wood where appropriate.

Solar and Wind Energy

14. Solar and wind resources are widely available sources of energy in Morocco, but are not likely to contribute significantly to national energy supplies in the short or medium term. However, the production of improved solar water heaters as well as the rehabilitation or replacement of windmills for water pumping or small-scale electricity generation should be explored, particularly for use in remote rural areas not connected to the national electricity grid.

Demand Management

15. Total demand for commercial energy is now about 4.8 million toe/yr and could rise to 7-8 million toe/yr by 1990. However, unless the natural gas prospects are sufficiently large to replace large proportions of Morocco's energy imports, this increased energy demand would place untenable stress on Morocco's balance of payments. The rate of demand growth and the mix of fuels consumed in the various end-use sectors should be moderated by effective demand management measures.

Energy Efficiency and Fuel Substitution

16. Compared to other developing countries with similar economic structures, Morocco's commercial energy consumption per unit of GDP is below average overall as well as in the consumption of electricity and the lighter fuels generally used in transportation and by households and small businesses. Although Moroccan industry is reasonably efficient overall in its energy use, straightforward conservation measures based on European standards would save roughly 5% of the energy consumed by the industrial sector at lower cost than an equivalent increase in supply. Opportunities for efficiency improvements in the rest of the economy are difficult to estimate, but significant reductions may be possible in fuel requirements for inter-city trucking if licensing restrictions on large capacity trucks that discourage their effective utilization can be altered.

17. Periodic review of industrial and thermal power plant fuel supply plans at the national and regional levels will be essential to make the best use of possibilities for (a) substitution of fuel oil by coal (imported or domestic), natural gas or even oil shale, and (b) energy conservation and co-generation of electricity and process steam in major industrial plants. The 40% of Morocco's commercial energy consumption that is accounted for by fuel oil either directly or indirectly (via thermal power plants) offers a variety of opportunities for inter-fuel substitution and for conservation. Importing coal in place of at least some of the oil imports is one approach to reducing the cost of energy imports. The major thermal power plant now under construction (Mohammedia III and IV) is being built with a view to firing with imported coal, and conversion of several cement plants to coal is under consideration. There is less scope for converting from oil to coal than from oil to gas, especially in existing plants: however, roughly 45% of incremental projected commercial energy demand could be met by imported coal as opposed to about 70% by gas. The savings that could be obtained through coal imports will depend largely on the capacity of Morocco's ports to handle large coal carriers: it now costs about as much to bring coal across the Atlantic to Morocco as it does to buy it f.o.b. the principal US export ports because of restrictions on the size of ships that can be received in Moroccan ports. The cost of port development to receive larger carriers, and other transportation and storage infrastructure, will need to be taken into account to determine the least cost coal

supply option for comparison with other substitution alternatives. Further studies should also be carried out leading to investment and other measures so that viable efficiency-improvement opportunities are realized. This work should include the necessary energy audit and other preparatory studies to define energy-saving and fuel substitution measures in industry, power and transport. A coordinated set of decisions regarding individual industrial plants, transportation infrastructure, and the power system is needed to effect major changes. The close cooperation of several ministries is needed.

18. Determination of the best options for electric power supply also requires improved analysis of alternative power sources. The power system is projected to be short of capacity within five years, and alternative investment programs should be prepared and evaluated now for the medium and longer term. These investment programs should include not only the direct, separable costs involved in power generation but also the infrastructure investments (dam construction, in the case of hydropower and port storage and transportation infrastructure in the case of coal) whose costs do not appear to be taken into account in the selection of energy investments. With respect to hydro projects, a sub-commission on water projects has been established to develop a water resource development plan based on an analysis of the overall costs and benefits of proposed projects.

Pricing

19. Energy pricing is currently oriented principally toward the regulation of suppliers rather than the management of demand. A new industrial investment code providing incentives for energy conservation has been promulgated, but conservation should be further encouraged in the transport, household, commercial and small industrial sectors through appropriate pricing incentives applied to groups or classes of users. Improved coordination across ministerial jurisdiction is needed in this field to ensure that decisions on pricing regulations for each type of energy and other regulations and incentives that indirectly affect energy use that are now generally made independently do not, taken together, produce undesired results. Three areas need attention:

(a) Electricity tariffs. The average price at which electricity is sold to consumers in Morocco is only 60-70% of the estimated cost of meeting incremental demand for electricity and, as a result, the electric utility is unable to finance its agreed share of its investment program. The low price of electricity may also have contributed to rapid growth of consumption: electricity consumption accelerated in the second half of the 1970s, while consumption of other energy forms grew more slowly than in the first half. The electricity rate structure includes many extremely complex geographic variations that bear little or no relation to the cost of service, but is, conversely, too simplified in terms of time-of-day, seasonal, and peak-load pricing to large users. Electricity tariffs need to

be generally increased and their structure rationalized, both to facilitate the financing of power investments, and to stimulate the more efficient use of electrical energy.

(b) Coal prices. Given the financial problems of the coal company mentioned earlier, it is necessary that a revised coal price be established not only to stimulate efficient coal/oil substitution, but also to facilitate the sound financing of future coal investments if they are shown to be economically viable.

(c) Natural gas pricing. The Meskala discovery and the prospect of gas becoming a major component of the national energy balance now requires that a gas pricing policy be developed. The uncertainty of the volume of future supplies from Meskala complicates the determination of such a policy, as the utilization options and related opportunity costs for gas are partly a function of the volume of supply. Nevertheless, the lack of an appropriate gas pricing policy could lead to delays in development of the Meskala discovery while negotiations with major consumers drag on and revenue uncertainties complicate financing. It may be appropriate to establish a policy of setting gas prices to the users at levels which, for the marginal gas user, would make production costs using gas equal to those using the most competitive fuel. Given that the Moroccan market for fuel oil as a boiler fuel is large, and much of it could be switched to gas, it would seem appropriate for the time being to link the gas price to that of fuel oil, with enough of a discount to justify conversion. If, later, reserves are found to be sufficiently large that it appears advantageous to encourage lower-value uses, prices would have to be adjusted accordingly.

Institutional Issues

20. Institutional issues involving coordination among public and semi-public enterprises need to be resolved in a number of subsectors. As regards petroleum refining and distribution, coordination among enterprises might be improved while at the same time reducing the need for the Ministry of Energy and Mines to be involved in their day-to-day operations. The generation and distribution of electricity is fragmented and hampered by problems of technical and economic coordination between ministries which need to be addressed at the highest levels.

THIS PAGE BLANK

NEPAL: ENERGY BALANCE, FY 1980/81
(thousand tonnes of oil equivalent)

	Fuelwood	Charcoal	Crop Wastes	Animal Wastes	Biogas	Coal	Petroleum	Electricity	Total
Supply									
Production	2,722.9	0.1	28	57	0.5			56.1	2,864.6
Imports						50.2	111.4	3.8	165.4
Exports								-0.3	-0.3
Transformation	-0.5	—	—	-2.0	—	-2.2	-3.7	-46.1	54.5
Net Supply/Demand	2,722.4	0.1	28	55	0.5	48	107.7	13.5	2,975.2
Demand									
Households	2,676.5	0.1	28	55	0.5		30.3	6.6	2,797.0
Transport							64.5		64.5
Industry/Commerce	45.9					48	8.2	6.5	105.6
Agriculture							4.7		4.7
Other								0.4	0.4

toe = 10.2 mn kcal
kWh = 2900 kcal (production)
= 860 kcal (consumption)

NEPAL 1/

1. Nepal's energy problems stem from the chronic imbalance between energy consumption and energy resource endowment. The bulk of Nepal's energy requirements are met by fuelwood from the country's disappearing forests, while Nepal's immense water resources have been almost untapped. Insufficient and unreliable electricity supplies and the high cost of distributing imported fuels have been major constraints to development.

2. A growing awareness of the urgency of these problems has lead to the Nepalese Government to search for an appropriate energy strategy and the Mission attempted to contribute to those efforts by exaining issues in the fuelwood/forestry sector, the scope for biogas and for privately-owned micro-turbines tied to agro-processing, issues involved in the development of hydro power, energy pricing, and institutional issues. The major recommendations of the report are summarized in the next few pages.

3. The Mission found that short-term options in the energy sector are limited and medium- to long-term solutions require major investments. The two most important aspects of the energy strategy proposed are that future energy demand should be met through (a) increased afforestation and (b) the development of large and medium-sized hydro projects, which offer scope for exporting electricity. A major effort in energy sector development will be required; anything less would be insufficient to meet Nepal's future energy needs and could not prevent severe environmental degradation or payments for mineral fuel imports from absorbing an excessive proportion of Nepal's foreign exchange earnings.

4. The severity of the fuelwood problem requires that Nepal give high priority to forestry programs. Not only must the emphasis of the Forest Department be shifted to stress social forestry but the scale of the required afforestation effort will call for a mjor change in the mobilization of human, institutional and financial resources assigned to the sector. In the power sector, the medium-term strategy of reducing unit electricity costs and expanding exports through constructing 200-400 MW plants was also accepted. Extensive studies, system planning, and negotitation on exports will be required, however, to make the strategy a reality.

1/ Adapted from Report No. 4474-NEP, August 1983.

Economic Context

Despite tremendous changes in the three decades since Nepal emerged from its long self-imposed isolation, the country still faces formidable development challenges which are compounded by its remoteness and land-locked status. During the 1970s, per capita economic growth stagnated and agricultural production failed even to keep pace with population growth; GDP per capita was only US$140 in 1980.

Recommendations for Action by Nepal

5. Priority should be given to the following policy decisions and investments in order to begin the task of developing Nepal's energy sector:

Policy Decisions

(a) A strong and continuing commitment by the Government to tackle the institutional, manpower, and financial constraints required to increase the tempo of afforestation. Specific recommendations include:

(i) Arrangements to transfer public forests and lands to the panchayats for planting and protection should be greatly simplified and accelerated.

(ii) A 20- to 25-year afforestation plan for all districts should be drawn up within which projects, investments, institutional and manpower requirements can be defined. Proposals to reorient the Forestry Department toward social forestry will also be a critical component of the plan. In anticipation of greatly accelerated planting:

- a survey to identify individual plots of land in each district and village available for forestry programs should be carried out immediately;
- the intake of students at the Forestry Institute in Hetauda should be enlarged;
- 40 candidates for forest officers should be sent abroad
- the Planning, Programming and Monitoring Office (PPMO) within the Ministry of Forestry and Watershed Management should be strengthened to build upon the experience obtained from forestry projects such as those financed by IDA.

(b) To reduce the consumption of fuelwood more quickly, a decision should be made to accelerate the dissemination of improved cooking stoves (ICS). Building on experience in existing projects, an intensive pilot project to disseminate 100,000 ICS over five years in the Kathmandu Valley should be undertaken immediately. At the same time, other areas suitable for similar intensive projects should be identified and necessary modifications made in the ICS design so that the program can be extended to other areas as soon as possible.

(c) Recent efforts to rationalize energy prices to foster conservation need to be extended. An increase in electric power tariffs has already been made. Additional increases are to follow. A decision should be taken to raise the price of fuelwood supplied by the Fuelwood Corporation of Nepal to urban areas at least to market levels, thereby assuring that fuelwood users share in the high economic cost of using fuelwood.

(d) Support is needed for a program to resolve problems encountered with community size biogas (CSB) plants as a prelude to more extensive dissemination. A two-year systematic monitoring program of existing CSB plants and four newly designed ones should be carried out. Family size plants should continue to be disseminated as long as demand exists. A simple subsidy which in essence refunds the one-third of the equipment cost due to taxes on biogas plant components should be set up to encourage their use.

(e) In the power sector, the long-run energy strategy envisaged by the mission depends on a dramatic reduction in the cost of electricity by making fuller use of all the energy generated by a well-sequenced development, starting with the current generation of run-of-river plants, then developing medium-sized storage schemes, and culminating in the completion of mega projects after the turn of the century. In particular, this stategy calls for:

(i) Systematic hydrological studies of major river basins needed to provide the basis for developing Nepal's water potential.

(ii) Additional feasibility studies of four-five hydro sites as selected by the Water and Energy Commission (WEC). WEC is surveying the most promising sites for early development; this work should receive continued support. A 25- to 30-year prospective investment strategy should be prepared to provide a framework for reviewing individual projects. The strategy would be updated as additional data became available.

(iii) A substantial increase in the existing 25 MW power trade agreements with India and agreement on the price at which power is to be traded. This would permit more optimum sizing of power plants and eliminate the need for thermal back-up during the next decade.

(iv) Consultant assistance in reviewing the current program, site selection, supervision of construction, and training of staff for small hydro development.

(v) Formulation of a 10 to 15-year program for replacing existing traditional water wheels with multi-purpose power units and cross flow turbines to provide pwoerand mechanical energy to the Hills. At the same time, the licensing requirement for private entrepreneurs to sell electricity in the Hills should be waived.

(vi) Better management of the energy sector will also require improved efficiency in securing energy supplies. For example, an urgent effort is needed by the Ministry of Commerce and Supplies to expand, regulate and streamline coal imports from India, possibly along the lines of the Nepal Oil Corporation.

Institutional Reform

(a) The Nepal Electricity Authority is being formed by merging the Nepal Electricity Corporation and the Electricity Department into one organization, and the facilities at the Butwal Technical Institute are expanding. The Small Hydel Development Board might be more effectively integrated into the new electricity authority.

(b) The WEC should be provided with more autonomy and well defined intervention points in the energy sector so that it can better function as a commission with overall responsibility for energy planning.

(c) The renewable energy work of the energy planning directorate of WEC could be strengthened by adding a full-time economist to work on renewables.

(d) Strengthening the forestry aspect of energy planning by adding a forester to WEC should be considered.

Investment to 1990

(a) Electric power is the largest component of the energy program, amounting to about one billion dollars to FY 1991. Much of this consists of outlays for Marsyangdi, Sapt Gandaki, Kulekhani II and Devighat, transmission, distribution and rural

electrification, and a central dispatching station. The mission recommends that a further $20-$30 million be allocated for basin studies to supplement existing ones and for feasibility studies of four to five hydro sites selected by WEC.

(b) In the forestry sector, investment increases from $2.4 million in 1984/85 to $9.0 million in 1989/90 and $14.2 million by the year 2000 under the moderate scenario. Under the accelerated scenario, investment increases from $3.7 million in 1984/85, to $20 million in 1989/90, and $55 million in the year 2000. The dissemination of improved (smokeless, higher efficiency cooking stoves is the single most important action in the field of energy conservation because it directly addresses the urgent problems of deforestation and domestic fuel scarcity and does not require complex technology or major financial investments. An intensive pilot project for the Kathmandu Valley and other areas up to 1990 is recommended for finance under a technical assistance program. Under the accelerated scenario, investment in the stoves progrm is estimated at US$1 million a year during the 1990s.

(c) Technical assistance is critical to this whole program. The mission was impressed by the assistance already provided WEC by the Canadian team. To assist the Government in implementing many of the recommendations, the mission strongly recommends that technical assistance be enlarge to carry out the following activities:

(i) $0.5 million to draw up a 25 to 30-year power development strategy.

(ii) $250,000 for a survey to identify individual parcels of land available for forestry programs in each district and village to use in formulating a 20 to 25-year afforestation plan.

(iii) $2-2.5 million to carry out an intensive dissemination program for improved cooking stoves in the Kathmandu Valley and other locations.

(iv) $75,000 to build four pilot community-size biogas plants and carry out a two-year systematic monitoring program.

(v) $1.2 million to finance two year forestry training for 40 candidates outside Nepal.

(vi) $250,000 assistance to the Research Center for Applied Science and Technology (RECAST) for long and short-term staff training in energy planning and to acquire modern research equipment.

Overall Investment Summary

6. The accelerated energy program calls for a substantial increase in investment expenditures but, allowing for a pick up in economic growth, expenditures would be no more than 4.4% of GDP by the year 2000 compared with 2.4% in 1980. The energy sector could be absorbing about 20% of total investments during the 1990s, an approximate level for a country at Nepal's stage of development.

this page blank

NIGER: ENERGY BALANCE, 1981
(tonnes of oil equivalent)

	Fuelwood	Charcoal	Agricultural and Animal Residues	Coal	Petroleum Products: Butane	Motor Gasoline	Aviation Gasoline	Jet Fuel	Kero-sene	Gas Oil	Fuel Oil	Total	Electricity	Total
Supply														
Primary Production	838,590		168	17,025										855,783
Imports					502	41,067	741	17,624	4,362	84,571	2,779	151,646	30,740	182,386
Re-exports (bunkers)								(17,601)						(17,601)
Stock Changes			(50)	(2,156)	(31)	(424)		(23)	97	11,562		11,181		8,975
Total	838,590		118	14,869	471	40,643	741	0	4,459	96,133	2,779	162,827	30,740	1,029,543
Transformation and Losses														
Charcoal Production	(2,425)	2,425												0
Power Generation				(14,869)						(29,697)		(29,697)	44,785	219
Conversion Losses	(11,550)												(51,300)	(62,850)
Transmission/Distribution Losses													(2,635)	(2,635)
Net Supply/Demand	824,615	2,425	118		471	40,643	741		4,459	66,436	2,779	115,529	21,590	964,277
Demand														
Mining					64					18,476		18,540	9,180	27,720
Industry					165					3,500	2,779	6,444	2,635	9,079
Small Industry	82,460	2,425	115							1,000		1,000	255	86,255
Construction (buildings, roads)										28,000		28,000	340	28,340
Commerce					38							38	935	973
Transport						40,643	741			14,500		55,884	170	56,054
Households	742,155		3		170				4,459			4,629	4,505	751,292
Public Administration					34							34	3,145	3,179
Communications/Miscellaneous													425	425
Agriculture										960		960		960

toe = 10.2 mn kcal
kWh = 2600 kcal

NIGER 1/

1. One of the least developed countries in the world, Niger has a very low consumption of energy, about 180 kgoe per capita a year. Like other low income countries, Niger faces a double energy crisis: overexploitation of its meager fuelwood resources which, given the predominantly rural nature of the economy, provide four-fifths of the country's gross energy supply (mostly for cooking), and a rising energy import bill. Because its territory is 75% desert, with only 12% of the land considered arable, and given the increasing desertification due to the destruction of the natural forest cover, the fuelwood crisis is actually the more serious of the two. A third major problem is the backlog in integrated power system planning in a country with very limited electrification.

Energy Resources

2. Niger's greatest potential source of energy is uranium, of which it is the fourth largest producer in the world, with a production of 4,370 tonnes (1981) and reasonably assured reserves of about 160,000 tonnes. However, the small size of the foreseeable power demand offers no encouragement for the development of nuclear power, and uranium will probably remain Niger's principal export commodity.

3. The Anou-Araren coal deposits in the north of the country consist of about 9.4 million tonnes at 3,650 kcal/kg, and are now being used exclusively to generate power for the nearby uranium mines. A recent discovery near Solomi, about 30 km north of Anou-Araren, could indicate a significant deposit of higher quality coal (7000 kcal/kg). There have been various indications of lignite deposits further south, the most promising of which (near Tahoua) has probable reserves evaluated at 2.6 million tonnes, with a calorific value of 4,000 kcal/kg.

4. Although the significance of a recent oil discovery in the Agadem basin in the east is still being evaluated, it seems possible that reserves may be large enough to warrant development, at least for the domestic market.

5. Niger's hydro resources are concentrated in the River Niger and its tributaries, where an estimated 2,090 GWh for an average hydrological year could be developed at three sites: Kandadji, W, and Dyodyonga. However, about 830 GWh of this total depends on international agreements and therefore would not be exclusively for Niger's use.

1/ Adapted from Report No. 4642-NIG, May 1984.

Economic Context

Landlocked in the Sahel and with a population of 5.8 million, Niger is one of the least developed countries in the world. Its territory (1,267,000 km^2) is mainly desert (75%); only 12% of the land is considered arable, and only 2.5% is actually under cultivation, with soil fertility low and declining. Rainfall is low and irregular, resulting in periodic droughts. Per capita income was estimated at US$330 in 1980 and, with population growing at 2.8% p.a., has actually declined over the past decade, despite the short-lived uranium boom. The present adult literacy rate is 8% and life expectancy at birth 43 years. The urban population accounts for only 10% of the total but is rapidly growing, especially in Niamey. Sixteen percent of the rural population is nomadic.

Niger's natural resource base is both limited and geographically unbalanced. Scarce water supplies limit agriculture to the Niger Valley and the zone along the Nigerian frontier where 90% of the population lives. The rich uranium deposits discovered in the 1960s, coal, and some small tin deposits are all located in the north central desert region, 600-800 km away from the heavily populated area. Iron ore and phosphate rock deposits hold promise for development but exploitation of these low value/high volume mineral resources is impeded by Niger's landlocked position.

Recent economic growth has been marked by two major overlapping events: (a) the Sahel drought of 1973-74, resulting in heavy losses to agriculture and livestock and a declining economy; and (b) the start-up of uranium mining in 1971, and the rapid expansion of this industry until 1981 when it contributed 70% of export earnings and an important share of government revenues. The recovery from the drought was speeded up by the return of favorable weather conditions and government policies aimed at rapid restoration of the cattle population and food self-sufficiency. Given the remote location of the uranium deposits, the mining industry has remained an economic enclave in the desert with linkage effects limited mainly to the power, construction and transport industries. Reflecting these developments, real GDP growth turned again positive in 1976 and accelerated from 3.5% in 1977 to 13.6% in 1979. However, in the wake of the second large rise in oil prices in 1979-80 and the ensuing world economic recession, the growth rate dropped to 5% in 1980 and close to zero in 1982.

6. As for wood, Niger's natural forest cover is estimated on the order of 15 million hectares, limited in the main to the southern part of the country. Because much of the wood is located far from centers of consumption, only 1.4 of the 4.2 million m^3 of the mean annual increment in 1980 are estimated to have been available.

7. In 1979/80, Niger produced an estimated theoretical maximum energy potential of 2.2 million toe in crop residues and animal waste, but because of competing uses and technical, economic, and social constraints, less than 5% of this amount could have been used for energy conversion.

8. Solar energy is abundant in Niger. In the south, the average total radiation is 6 $kWh/m^2/day$ (an average of about 200 $kgoe/m^2/year$), the average daily duration of sunlight varying from 8.5 to 9.5 hours. However, the only current uses of solar energy are for telecommunications in isolated areas and heating water, so that its contribution to meeting Niger's energy needs is minimal. Wind resources are very poor in Niger, and the potential for small hydro development is insignificant.

Alleviating the Fuelwood Shortage: Household Energy Strategies

9. On a country-wide basis fuelwood demand and supply are roughly in balance at present. However, the total net available increment of fuelwood (1.4 million m^3) accounts for only about 35% of fuelwood demand (4.1 million m^3). The result is a massive overexploitation of the forest cover in those areas near the centers of consumption. The growing scarcity and rising prices of fuelwood mean that many poor urban dwellers cannot afford more than one warm meal a day. Moreover, the overexploitation is causing a decline in soil fertility and desertification, which will result in heavy losses in agricultural production. If current trends persist, Niger's already large fuelwood deficit in and around the areas of consumption will more than double by the year 2000.

10. There are several options for tackling the fuelwood crisis, among them: (a) increasing the supply of wood by reforestation and especially by improved forest management; (b) increasing the amount of useful energy derived from wood by the widespread dissemination of improved cooking stoves; and (c) substituting other sources of energy for fuelwood.

11. Although increasing the supply of fuelwood should be vigorously pursued, the scope for it is limited by several constraints to forest development: (a) poor soils, limited rainfall, and a lack of forestry technical packages well-adapted to marginal lands in these arid and semi-arid zones with only one peak of rainfall; (b) the difficulty of protecting the natural forest cover from overuse (too much cutting, clearing, grazing, burning, etc.); and (c) a difficulty in obtaining full and sustained governmental commitment and popular participation, although some

progress in this regard is being made. Adding the maximum new fuelwood supplies which realistically could be obtained by reforestation and improved forest management to the projected net available supply of fuelwood from existing resources will meet only about 30% of the demand in the year 2000 based on current per capita consumption. The other 70% therefore will have to be either eliminated or substituted for by using improved woodstoves or cooking with alternative fuels in order to avoid having to change eating habits.

12. Many different groups in Niger are attempting to develop and disseminate an improved woodstove in rural as well as urban areas. Efforts have been directed toward a fixed cement or banco stove. The most effective improved stove procedure for reducing the demand for wood in the short term is to focus on developing an appropriate stove model to disseminate to carefully selected groups in urban and peri-urban areas, where the fuelwood shortage is most acutely felt. To this end, it is essential to come up with a wood-burning stove that is portable, provides a significant increase in end-use efficiency over current cooking methods, is inexpensive, and, to the extent possible, is suitable for charcoal, groundnut shell briquettes, and perhaps lignite. The Upper Volta portable metal fuelwood stove would appear to meet most of these criteria.

13. Possible substitutes for fuelwood include: charcoal produced in Niger, domestic coal and lignite, imported kerosene and butane, electricity, locally produced groundnut shell briquettes, and solar energy. Because the main urban areas can still obtain firewood from within a radius of 100 km, only minimal amounts of charcoal are produced and consumed. The ever increasing fuelwood demand from the main population centers and the resulting destruction of the forest cover around them mean that fuelwood supplies will require increasingly longer truck hauls. The production and marketing of charcoal might therefore appear attractive. However, wood from the natural forest of Niger does not lend itself well to charcoal production, and the ecologically detrimental consequences of using large amounts of wood to produce charcoal poses a significant problem.

14. The Anou-Araren coal presents serious difficulties in that, in addition to the high cost of transporting it to populated areas, it requires pre-coking to eliminate noxious tar fumes. In the absence of data on the coal of Solomi, it is not yet possible to determine its possible uses, from an economic point of view. However, preliminary combustion tests, in appropriate stoves, of briquettes made from this coal, have produced positive results from a technical point of view. The Government of Niger has requested technical assistance from the Government of Japan in evaluating the workable deposits and in defining the technology for preparing and using this coal, principally for residential needs. The limited testing to date indicates that the Tahoua lignite is well suited as a fuelwood substitute, having no detrimental tar content. The probable lignite reserves could supply 20% of the cooking needs of all the families in Niger for about eight years, but more information is needed

on the quantities available, the quality of the lignite, and likely consumer acceptance before its potential as a fuelwood substitute can be properly assessed.

15. Taking end-use efficiencies into account, the price of kerosene for cooking, whether subsidized or not, compares favorably with the current market price for fuelwood, even though the latter is well below the wood's economic cost in most areas. However, there is a need for a simple, inexpensive kerosene stove (e.g. the Indian Nutan model) which is better adapted to traditional Nigerien cooking than the models now available. Because of the high cost of butane and electricity, and of the equipment involved, they must be ruled out as cooking fuels for the majority of Nigeriens.

16. Groundnut shell briquettes hold promise as a fuelwood substitute, but only on a much more reduced scale than kerosene and, potentially, lignite. Had all the groundnut shells from the 1980/81 growing season been compacted into briquettes, the 17,000 toe made available would have come to no more than 2% of the total 1981 consumption of fuelwood for the country as a whole. However, 17,000 toe would have amounted to a significant 35% of fuelwood consumption in the city of Niamey for the same year. Groundnut shells thus could help alleviate the fuelwood shortage where it is the most critical. As for solar energy, a cooker well enough adapted to traditional cooking methods to gain popular acceptance has not yet been devised.

Recommendations

17. Given the limits to increasing the supply of wood, relief of the fuelwood crisis can most readily be obtained by improved cooking stoves, while at the moment the most promising substitutes are kerosene, lignite, and, to a minor extent, groundnut shell briquettes. The mission therefore recommends that the following actions be undertaken simultaneously, all of which are of the highest priority but have been ranked in terms of decreasing short term practical importance:

(a) Concerning improved stoves:

(i) Centralization of efforts concerning improved stoves within the Directorate of Energy (DE) of the Ministry of Mines and Industry. The DE should closely monitor national and international developments in this area with a view to evolving a policy and a plan of action for producing and disseminating appropriate models of improved stoves.

(ii) Dissemination on an experimental basis in Niamey of an adapted model of the metal stove which recently has been successfully introduced in Ouagadougou. This project should benefit from the equipment of the laboratories of ONERSOL for testing and modifying improved stoves. The woodstove experts whose services will be required under

this project could also provide assistance to the DE in managing the tasks described in (i) above.

(b) Concerning lignite:

(i) A systematic drilling program to firm up lignite reserves at Tahoua, and a reconnaissance program, with possible subsequent exploration, in the Filingue area. Estimated cost: US$850,000.

(ii) Combustion tests of the Tahoua lignite to determine the quantities required for preparing typical Nigerien meals. These tests should be integrated with the development of a suitable stove for lignite.

(iii) Depending on the results of (i) and (ii), studies of the demand for lignite as a fuelwood substitute and in industry and power generation, in order to estimate the scale of mining operations and therefore the mining costs.

(c) In evaluating the workable reserves of the Solomi coal and defining the technology for preparing and using this resource ensuring that the costs of coal production, transport, preparation, and utilization (e.g. the cost of producing stoves for residential use) are analyzed as a function of a study of the demand for this coal as a substitute for wood or for use by industry.

(d) Promotion of kerosene as a cooking fuel by either acquiring a suitable existing design, or designing and then disseminating a kerosene stove suited to traditional cooking. The DE should serve as focal point in this effort and turn to the laboratories of the National Solar Energy Authority (ONERSOL) for research work on these stoves.

(e) Pursuit of the tree planting and improved forestry management objectives outlined in the report. Estimated cost: about US$9 million p.a. from 1984 through 1988, and US$10 million p.a. from 1989 through 2018. Such a long-term forestry effort would require a specific complementary forestry training program.

(f) Investigation of new forestry technical packages which are well adapted to marginal lands in arid and semi-arid zones.

(g) A study to determine a specific action program to promote the use of groundnut shell briquettes for residential needs. The study should be carried out in parallel with the design of an improved stove suitable for both these briquettes and wood.

Reducing the Energy Import Bill

18. Until early 1981, Niger depended entirely on imports, not only of petroleum products but also of electricity from Nigeria, to supply its commercial energy needs. Since then, domestic coal has substituted for gas oil in generating power for the uranium mines, which saved, on a calorific basis, the equivalent of about 20% of Niger's total petroleum product consumption in 1982. However, given Niger's landlocked position and the resulting high cost of petroleum products (US$54 per bbl in Niamey in 1982, net of taxes and distributors' margin), total energy imports in 1982 still amounted to 18% of the merchandise import bill and nearly 31% of merchandise export revenues. Options for reducing the energy import bill consist of substituting domestic resources and/or cheaper imported alternatives for imported energy, and conservation.

19. With respect to substitution, the main possibilities are: oil from the Agadem basin; Anou-Araren and Solomi coal; Tahoua lignite; hydropower, both Nigerien and as electricity imported from Nigeria; and groundnut shells. From present indications, it seems unlikely that the most recent Agaden permit oil find by the SNEA/EXXON/TEXACO consortium would warrant an export project, but it may be of great value, subject to an economic study, for exploitation for the domestic market. The Government will need to determine what strategy to adopt for further petroleum exploration and development, particularly in view of the fact that the consortium's obligations under the present contract have been fulfilled, and this could lead to a halt in further exploration.

20. More Anou-Araren coal cannot be used for power generation than is currently burned to meet the demand in the adjacent uranium mines and nearby towns of Arlit and Agadez because of the coal deposit's great distance from other centers of power demand. Other possibilities for substituting this coal for petroleum products do not exist at this time because of the coal's excessive ash content and the high cost of transporting it to potential consumers in the south of the country, even though it may be possible to reduce the transport cost by carrying the coal in trucks otherwise making empty return trips to the south. As for the Solomi coal, additional information is needed on its volume, quality and cost of exploitation before its uses as a substitute for petroleum products in industry or power generation can be evaluated. A preliminary analysis of the Tahoua lignite suggests that it is probably suitable for use in the cement industry, among others, as a substitute for gas oil to produce process heat, as well as for power generation. In addition, given large enough reserves it would cost only about 40% as much as gas oil c.i.f. Niamey. Although of lower quality than the Solomi coal, the Tahoua lignite lies close to the region where electricity demand grows fastest, and therefore its use for power generation should receive priority attention. However, more needs to be known about the quantities and the quality (especially with respect to combustion for cooking) of the lignite before setting priorities for its use as a gas oil or fuelwood substitute.

21. Power imports from Nigeria, currently priced at US¢4.5 per kWh and accounting for about 75% of Niger's non-mining supply of electricity, are in themselves substituting for very costly fuel at diesel generation plants (at US¢11.0 per kWh). As long as secondary energy supplied by Nigeria remains cheaper than any domestic alternative, it is an element to be considered in assessing Niger's own limited hydro potential. A study taking all the relevant alternatives of supply into account in a least-cost system expansion plan has recently begun under an IDA Power Credit.

22. In calorific terms, the 1980/81 cost of groundnut shell briquettes c.i.f. Niamey amounted to about 40% of that of gas oil. These briquettes have displaced gas oil in industry in the past, but this has been discontinued. The company marketing these briquettes is having great difficulty convincing industrial enterprises to substitute these briquettes for gas oil, largely because they consider the supply of briquettes unreliable. Therefore, it seems appropriate to concentrate on using these briquettes for residential needs. An improved stove which is suitable for both wood and briquettes will have to be developed to alleviate householders' fears of an unreliable supply of briquettes.

23. The Agadem oil deposits, the Tahoua lignite and the Solomi coal deserve the greatest attention as possible substitutes for imported petroleum products. With respect to national energy resources in general and Niger's hydro potential in particular, it should be remembered that their development does not always improve the country's balance of payments. In the case of the power plant which burns Anou-Araren coal, for example, savings on the displaced gas oil amount to only CFAF 2.5 billion (US$7.5 million) p.a., compared to debt service payments of about CFAF 4.5 billion (US$13 million) p.a. up to at least 1990.

24. Given the small size of Niger's manufacturing sector, the prime areas for conserving imported energy are transport and air conditioning, particularly of office buildings. The largest transport enterprise has already reduced its fuel consumption per kilometer by 22% over a four year period, mainly by training in fuel efficient driving. The Ministry of Public Works and the other 400 transport operators in Niger also need to train their drivers in fuel efficiency.

25. Office air conditioning accounts for about 25% of electricity consumption in Niamey. Significant energy savings (25-30%) have been achieved by equipping new public sector buildings with modern central air conditioning; further gains could be made by enforcing energy efficient design and building standards in future construction. Substantial energy savings remain to be realized in old public buildings with room air conditioning units by means of the measures recommended below.

Recommendations

26. As part of a plan of action to reduce Niger's energy import bill, the mission recommends (in addition to lignite exploration):

(a) The Government's continued urgent consideration of: (i) the feasibility of appraising and producing the Sokhor find, keeping in mind the desirability of proceeding rapidly with such a project to avoid rig mobilization costs (US$10 million); and (ii) determination of a strategy for petroleum exploration and development. The Bank's Petroleum Projects Division concerned is in touch with the Government on both of these points.

(b) Combustion tests to determine the potential for using lignite in industry and power generation.

(c) As mentioned above, an analysis of the cost of producing Solomi coal in relation to the demand for its use in industry and power generation.

(d) Institution of a course in fuel-efficient driving techniques open to any driver interested in taking it. This course might be incorporated in the program of the driver training center which is to be established in the Ministry of Public Works under the upcoming IDA Fourth Highway Project.

(e) For conservation in buildings:

(i) ensuring that energy efficient design and building guidelines are followed;

(ii) simple insulation measures ensuring tight closing of windows and doors, to be undertaken without delay in all public buildings as appropriate, once the typical cost and related conservation benefits have been established;

(iii) institution of office temperature norms and their control; and

(iv) replacement of worn out air conditioners by more energy efficient models and introduction of air coolers based on the evaporation of water. A pilot project involving selected public buildings in Niamey should be considered to test the suitability and effectiveness of these more efficient models and air coolers. A prefeasibility study initiated by the mission has been carried out by the Ministry of Public Works in cooperation with the Directorate of Energy. Estimated cost: CFAF 100 million (US$300,000), not counting the cost of new air conditioners (CFAF 297 million or US$900,000) to replace existing ones.

Other measures of less urgency: initiation of a research program to study the economic feasibility of mini-photovoltaic systems in isolated centers; evaluation by the Ministry of Mines and Industry of the potential for energy economies in industry; and Government relaxation of

the prescribed level of stocks of petroleum products to an equivalent of 30 days of consumption, instead of investing in additional storage capacity and acquiring the supplementary stocks.

Electric Power Subsector Development

27. Because the existing interconnection with Nigeria will be fully utilized for capacity imports by 1984 and for energy imports by 1992, the main issue in the development of the power subsector is power supply planning for the Niger Valley. The supply problems of the remaining load centers do, however, deserve careful consideration because it is the isolated centers that will require increasing quantities of imported gas oil.

28. With respect to the supply of the Niger Valley, the national electric utility's (NIGELEC) short-term planning (to about 1989) appears sound, based as it is on the maintenance of sufficient thermal capacity in Niamey to cover the peak, while taking maximum advantage of the interconnection contract with Nigeria to import energy and save fuel expenses. For some time, longer-term planning has been tailored around the assumed commissioning date of the Kandadji hydro-scheme. Other possibilities are the W run-of-river hydro project, the Dyodyonga storage project on the border with Benin, and an expanded interconnection with Nigeria for importing secondary energy and, eventually, seasonal power interchange. All available options ought to be examined to arrive at a least cost program of development.

29. As for the secondary load centers, clusters of small towns and villages should gradually be connected by transmission lines and serviced from one efficient diesel plant. Although the least cost solution may be connection by 20 kV lines, from a longer term perspective it may be preferable to build 66 kV lines initially operated at 20 kV, with substations of 1,000-2,000 kVA.

30. The power system development study, recently begun under an IDA Power Credit, will examine the various options and their possible combinations with a view to evolving a comprehensive power sector development program to 2020 for the Niger Valley and to 1990 for the secondary centers.

Energy Prices and Taxes

31. The level and structure of current prices for petroleum products in Niger provide the right signals for promoting their efficient energy use. Regarding the electricity tariff, its level and structure were revised in October 1983 to reflect the long run marginal cost (LRMC) of power supply in Niger. Based on an all-diesel investment program for

1985-90, a recent tariff study has developed a "reference" electricity tariff reflecting the estimated LRMC as tempered by considerations of social, financial and administrative expediency. The new tariff consists of a fixed component calculated by making an adjustment to the "reference" tariff to permit financial equilibrium of NIGELEC, and a variable component which represents the cost of fuel and the power imported from Nigeria. The Government thus has integrated the "reference" tariff into the current tariff, the latter being subject to modification at the request of NIGELEC from time to time as its financial position may require. The mission supports the recent tariff revision and the pursuit of the Government's policy of electricity pricing to approach long run marginal cost.

32. With respect to fuelwood, its economic cost is reflected by both the cost of reforestation and the cost of deforestation and ensuing desertification. Estimates of this economic cost are certain to show that it is well above the current market prices, high as these may seem, particularly to urban consumers. In addition, as the owner and operator of the national forests, the Government is entitled to a stumpage fee to capture some or all of the excess profits (economic rent) realized by the private operators supplying fuelwood. The second IDA-assisted forestry project provides for studies of the organization of the fuelwood market and of appropriate prices and stumpage fees for fuelwood from plantations and natural forests which reflect its economic cost. The Credit Agreement stipulates that such prices and fees be established by the end of 1983. Proper economic pricing of fuelwood is the basic prerequisite for conserving it through improved cooking stoves and the use of less costly substitutes, both of which are the prime responses to Niger's fuelwood crisis.

Recommendations

33. The mission recommends:

(a) Establishment of appropriate fuelwood prices and stumpage fees by end 1984.

(b) Once combustion tests on the Tahoua lignite have been carried out, a comprehensive study should be made of comparative energy prices reflecting economic cost with particular reference to providing energy in urban areas, especially with respect to fuelwood substitution.

Institutional Issues

34. The extreme scarcity of qualified manpower in Niger is the main constraint to planning and operational work, both at the subsector level and for the energy sector as a whole.

35. In the forestry subsector, the Directorate of Forestry and Fauna suffers from limited forestry planning and inventory control. In addition, there is a need for a more organized exploitation of fuelwood resources. With respect to renewable energy other than wood, the principal institutional weaknesses are a lack of overall planning due to the multiplicity of organizations involved, and a lack of economic analysis and market studies.

36. In the petroleum subsector, the Directorate of Energy (DE) lacks the staff and equipment to fulfill its role of acquiring, understanding, and storing the information generated by foreign exploration companies. This is particularly important because the Government may need to promote the areas in question in the future.

37. The three main institutional issues in the power subsector are: (a) the lack of a single agency responsible for overall, long-term power planning; (b) the usefulness of a concession system whereby the State plays a dual role as the authority supervising the management of the electricity concession and, since it owns 90% of the utility's capital, that of the agency being supervised; and (c) the increasing subsidization by its power subsector activities of the company's operation of water supply systems.

38. Given the manpower shortage even at the subsector level and the fact that seven ministries and at least as many operating agencies are directly concerned with energy in Niger, the sector lacks an integrated, overall approach to the country's energy problems. Moreover, no Government agency has responsibility for energy conservation in general. The Directorate of Energy (DE) within the Ministry of Mines and Industry (MMI) is responsible for the formulation of national energy policies in accordance with Government objectives, but, in addition to its staff constraints, its position in the Government does not give it the necessary authority to coordinate energy sector activities.

Recommendations

39. The mission recommends:

(a) Strengthening overall energy planning by appointing an energy economist experienced in general energy supply and demand studies, pricing analyses, optimization techniques, and financing as Energy Adviser to the Ministry of Mines and Industry. Excluding the hydrocarbons and coal unit, the DE should focus exclusively on formulating and coordinating national energy policy.

(b) Government examination of the possibility of launching as soon as possible a forestry training program which would complement the planting and improved forest management objectives.

(c) Expansion of the scope of ONERSOL's work. ONERSOL should take the lead in formulating an overall strategy for developing Niger's renewable energy resources and coordinate the activities of the agencies already involved in this field. The mission supports the proposal already made by the Directorate of Energy to the Ministry of Higher Education and Scientific Research, the supervisory Ministry of ONERSOL, to broaden ONERSOL's field of activity as indicated above. Once the exact role of ONERSOL has been determined by the Government, it will be necessary to define technical assistance in terms of training and equipment required by ONERSOL to manage its work program.

(d) Assistance in oil and gas exploration to the DE's hydrocarbons and coal unit, which, according to a preliminary evaluation, would involve: (i) assistance for retrieval and storage of data, including new equipment; (ii) collaboration of expatriate experts with staff of the hydrocarbons and coal unit on well defined specific problems; (iii) assistance in revising the petroleum law and agreements; and (iv) training of Nigeriens in geology, geophysics, economics, and engineering.

(e) Strengthening the capacity of the DE's hydrocarbons and coal unit to coordinate the overall development of the coal/lignite sector by retaining the services of a visiting coal/lignite specialist.

(f) The establishment of a process and the capability for integrated power system planning. The undertaking of a power system development study and an institutional study of the power sector under the IDA Power Credit represent the first steps toward setting up such a planning process and capability. The mission also supports the current examination, under an IDA Water Supply Project, of the problem of subsidization of water supply by NIGELEC's power subsector activities, with a view to establishing in due course a separate water supply entity, thus freeing NIGELEC to concentrate on power supply.

(g) Creation of a special energy conservation unit within the Construction Directorate of the Ministry of Public Works, especially to implement the conservation measures recommended in above. Setting up such a conservation unit will require equipment (including vehicles), the services of an expatriate specialist for two years, and the training of Nigerien personnel in air-conditioning engineering.

Other equally important but less urgent recommendations relating to energy sector institutions include: (a) Government encouragement for setting up private organizations for the transport of fuelwood while increasing Government control over the wood supply chain, including transport; and (b) pursuit of current efforts, under the IDA Power Credit, to come up with a staff development plan for NIGELEC.

NIGERIA: COMMERCIAL ENERGY BALANCE, 1980
(thousand tonnes of oil equivalent)

	Coal	Crude Oil	Petroleum Products: LPG	Motor Gasoline	Aviation Gasoline	Dual Purpose Kerosene	Gas Oil	High Pour Fuel Oil	Low Pour Fuel Oil	Total Petroleum Products	Natural Gas	Electricity	Total
Primary Supply													
Production	96	102,768	-	-	-	-	-	-	-	-	18,025	601	121,490
Imports	-	-	-	1,302	4	475	406	-	-	2,187	-	-	2,187
Primary Exports	(3)	96,202	-	-	-	-	-	-	-	-	-	-	(96,205)
Total	93	6,566	-	1,302	4	475	406	-	-	2,187	18,025	601	27,472
Transformation and Losses													
Oil Refining	-	(5,933)	61	1,543	-	860	1,723	1,178	568	5,933	-	-	
Thermal Power Generation	(12)	-	-	-	-	-	(192)	-	(63)	(255)	(1,047)	1,915	0
Conversion Losses/Energy Sector Use	-	(633)	-	-	-	-	-	-	-	-	-	(1,313)	(1,946)
Transmission/Distribution Losses	-	-	-	-	-	-	-	-	-	-	-	(191)	(191)
Secondary Supply	81	-	61	2,845	4	1,355	1,937	1,178	505	7,865	16,978	411	25,335
Secondary Exports	-	-	(26)	-	-	(30)	(55)	(850)	(3)	(964)	-	(9)	(973)
Balancing Items	-	-	6	194	2	(91)	120	(85)	5	151	(15,885)	-	(15,734)
Net Supply/Demand	81	-	41	3,039	6	1,214	2,002	243	507	7,052	1,093	402	8,628
Demand Supply													
Households	6	-	41	-	-	850	-	-	-	891	-	190	1,087
Transport	2	-	-	3,039	6	364	2,002	-	-	5,411	-	-	5,413
Industry/Commerce	73	-	-	-	-	-	-	243	507	750	1,093	209	2,125
Other	-	-	-	-	-	-	-	-	-	-	-	3	3

toe = 10.2 mn kcal
kWh = 2700 kcal (production)
= 860 kcal (consumption)

NIGERIA 1/

1. Nigeria's current economic problems revolve around what is known to many large producers and exporters of petroleum as the "oil syndrome". Major efforts are needed to diversify the economy and preserve petroleum for export by substituting more abundant domestic energy resources such as natural gas, LPG, coal and hydro.

2. The major policy issues in the energy sector are as follows:

(a) The domestic energy development program as defined in the Fourth National Development Plan calls for expenditures of some US$7.5 billion in the public sector between 1981 and 1985, excluding the cost of the joint venture oil exploration program and a possible LNG export plant. How realistic is this level of expenditure and how does it compare in priority to investments needed in other sectors?

(b) The need to develop the very abundant proven reserves of natural gas as a substitute for petroleum and as the major fuel for industrial/commercial developments appears urgent. What are the best ways to promote its use among residential and commercial customers? What preferences should be given to the use of associated gas? How much associated gas can be used economically?

(c) LPG from both refinery runs and natural gas appears to be a promising alternative fuel for the transport, household and commercial sectors. What is the proper approach to developing these outlets?

(d) Electric power facilities need improvement and, in some cases, major rehabilitation, as supply bottlenecks have reached crisis proportions. What should be done about it? Furthermore, major system expansion will be needed. Should it be based largely on the use of natural gas? What programs will foster this development? How much of an electric power program appears warranted?

(e) A significant expansion of petroleum refining capacity is underway. How large a program is economically justified? What is the best way to minimize the costs of supplying petroleum products to the country?

1/ Adapted from Report No. 4440-UNI, August 1983.

Economic Context

Before 1973-74, Nigeria ranked among the world's poorest countries, with a per capita income of US$250 in 1970. It had a predominantly agricultural economy, with manufacturing accounting for less than ten percent of GDP. After 1974, GDP grew at a high rate for several years, and oil revenues propelled most of this growth. During this time the Government underwrote massive programs for infrastructure investments in transport, heavy industry, communication, education, etc. which, for the most part, supported the modern sectors of the economy. The traditional sectors grew little or even declined during the 1970s. The very modest growth in employment that took place was in the dominant modern sectors. Since 1978, GDP has remained essentially unchanged, fluctuating around ₦ 30 billion (US$45 billion) in 1977/78 prices. Crude oil production in 1982 accounted for 14% of GDP, 94% of the value of exports, and 82% of government revenues.

Heavy dependence on the oil sector has caused distortions in the foreign exchange rate, domestic prices and wages, and has encouraged costly stop-and-go policies that vary with the fortunes of the international oil market. At the same time, domestic consumption of petroleum products is growing rapidly, threatening to absorb a larger and larger share of the resource's diminishing productive potential. First, in years when oil exports were falling and oil prices declined (1978/79 and, again, since 1981), there were drastic across-the-board reductions in current expenditures, investments and imports, which resulted in costly disruptions to the whole economy. Second, the large export surpluses from oil caused an overvaluation of the Naira, favoring imports at the expense of domestic production and making it difficult to maintain exports from non-oil sectors. Third, the rapid growth in domestic demand for petroleum products has put longer term oil export earnings in jeopardy.

The economic outlook for the immediate future is uncertain, at best. Recent long-run projections prepared by the World Bank indicate modest rates of economic growth -- around 2.9% a year until 1985 and 3.5% until 1990. If certain structural changes can be brought about soon, leading to an improvement in economic performance, then growth could probably pick up to five percent a year. Earlier predictions of growth rates for oil production now appear rather optimistic. Lower oil exports and lower oil prices may continue to force major reductions in government expenditures. Given this economic environment, there is a critical need to carefully evaluate investments in domestic energy systems, especially those designed to improve institutional and pricing policies.

(f) Energy conservation and interfuel substitution both present serious problems. What revisions in absolute and relative petroleum prices are required, first: to set them equal, on average, to prevailing world market prices, second: to create incentives for using resources that are in abundant supply, and, third: to provide the various levels of Government revenues required for infrastructure, such as highway and traffic services?

(g) How can price negotiations be completed with suppliers of needed, non-associated natural gas in time to avoid holding up planned gas pipeline projects? How might field production priorities for oil be set to take into account associated gas gathering facilities?

(h) At what levels should prices be set, given the goals of encouraging consumers to use natural gas over other fuels and also yielding substantial revenues to Government?

(i) What are the best ways to improve the organizational structure and performance of the major Government-owned energy supply institutions such as the National Electric Power Authority (NEPA), Nigerian National Petroleum Corporation (NNPC), and the National Coal Corporation (NCC)?

(j) How can energy planning be strengthened to integrate subsector planning among independent agencies?

(k) How can improvements be made in energy demand forecasting capabilities to avoid costly mistakes in investment planning?

(l) What is the economic priority and proper timing for rationalizing the coal mining operations?

(m) What policies are needed to ensure adequate fuelwood supplies for the rural sector?

Proposed Action Program and Policy Recommendations

Projected Investments

3. The Mission has identified an investment program which aims at providing reliable, efficient and low-cost energy supply systems to support Nigeria's economic development programs through the mid-1990s. The program will cost about US$16.5 billion to 1995, substantially less than the sectoral programs originally considered by the various Nigerian energy sector entities. However, even further reductions may be required in the face of falling oil revenues, which the Mission feels can be made, if carefully done, without seriously inhibiting economic growth. The

"core" investments identified in the table below come to US$11.4 billion; they exclude some projects with expected economic rates of return below 15% p.a. and a few capital intensive long-gestation projects that might be postponed if financial resources remain tight.

4. In the "core" investment scenario, all new hydro plants would be replaced by heavy-duty gas turbine plants; the gas pipeline investments would be limited to completing the line to Ajaokuta without further extension for the time being, and constructing the pipeline to Lagos and minor installations in the gas producing regions themselves. In the petroleum sector, investments would be limited to one new refinery at Port Harcourt and the completion of existing debottlenecking facilities; LPG use would be based on refinery outputs only. The major result of excluding some of these investments from the "core" program would be felt in the long term; in the short run, there would be increased offshore processing of petroleum products, higher operating and maintenance costs with thermal electric generation, and a somewhat slower substitution of the use of gas for petroleum.

INVESTMENT PROGRAM TO 1995

	Investments Reviewed and Considered Priorities By Mission		Highest Priority "Core" Investments	
	(US$ Billion, 1982)	(%)	(US$ Billion, 1982)	(%)
Electric Power	10.5	64.0	7.6	68
Natural Gas	3.1	19.0	2.3	21
LPG	1.0	6.0	0.4	4
Refineries	1.7	10.0	0.8	7
Coal	0.1	0.5	0.1	-
Firewood, etc.	0.1	0.5	0.1	-
Total	16.5	100.0	11.2	100.0

5. Excluded from the "core" program for purposes of comparison are the proposed LNG plant, estimated to cost about US$4 billion, which the Mission has briefly reviewed and supports, and the planned NNPC exploration and petroleum joint venture expenditures, which were not reviewed by the Mission but which were projected in the Fourth National Development Plan to be around US$7.6 billion for the five-year period until 1985. Also excluded are a number of small, routine investments by NNPC.

6. Electric power, with US$10.5 billion and 64% of the total investment program, will require by far the largest share, followed by natural gas with US$3.1 billion and 19%, and refineries with US$1.7

billion and 10%. As will be shown later, however, some of these investments probably could be postponed for several years without seriously affecting the economy. For example, there is some question whether a second new refinery to be used in the export of petroleum products is economically justified at this time. In the power sector, deferring costly hydro projects for alternative gas-fired units could reduce needed investments for the late 1980s and early 1990s by as much as US$2.8 billion.

7. Although the priority projects identified for the next 10 to 15 years are substantially less costly than the total plans being considered by the energy subsectors and operating agencies, possible savings during the next few years are reasonably significant. The difference between priority investments and investments incorporated in the Fourth Five Year Plan will amount to a reduction of 20% per annum, even though many of the projects to be completed in that period are already under construction. The table below shows estimated annual average expenditures of about US$1.5 billion as promulgated in the Fourth National Development Program, versus approximately US$1.2 billion in the list of priority investments for 1982-85. The average annual investments reviewed and considered priority for the years through 1995 would maintain this level. The Mission's highest priority "core" investment would reduce this level to slightly over US$800 million per year.

PROPOSED ANNUAL AVERAGE INVESTMENTS TO 1995
(US$ million, 1982)

Sector	Fourth National Development Plan 1981-85	Mission's Priority Investments 82-85	86-90	91-95	82-95	Highest Priority "Core" 82-95
Electric Power (NEPA)	978	730	710	797	756	546
Natural Gas	318	282	159	237	222	174
Petroleum Refining	203	134	120	119	123	60
LPG	-	17	64	127	73	29
Firewood, etc.	n.a.	5	5	5	5	5
Coal	25	8	3	3	4	4
Total	1,524	1,176	1,061	1,288	1,183	818

Natural Gas

8. The Mission recommends the following items be included in whatever investment plan is supported for the energy sector during the rest of the 1980s:

(a) Construction of the Warri-Lagos gas pipeline at an initial cost of approximately US$850 million, including gas gathering systems for other related systems, with completion preferably by 1985 but not later than 1986, to avoid costly fuel oil imports for the Igbin power plant;

(b) Completion of the gas supply line to the Afam power station to bring the 420 MW Afam IV power plant into operation and thereby relieve power shortages in the NEPA system;

(c) Review of the timing for extending the Warri-Ajaokuta gas pipeline further north, given the uncertainty about future gas demand in these regions;

(d) Review of the timing for other proposed gas pipeline systems under consideration, in view of the construction schedules and needs of new power plants, chemical industries, etc.;

LPG

(a) Systematic development and extension of LPG supplies which are available from refineries for the domestic market, with emphasis on LPG as a vehicle fuel for commercial operations and as a household fuel in selected urban markets such as Greater Lagos and Kaduna/Kano;

(b) Development of LPG gas extraction plants on major gas pipelines as warranted by market developments;

(c) Construction of an LPG gas pipeline to Lagos when LPG quantities make this economically feasible;

(d) Immediate conversion of the LPG distribution system and facilities which are designed for low-pressure, butane-rich mixes to utilize high-pressure, propane-rich systems;

Electric Power

(a) Implementation of a major rehabilitation and improvement program for NEPA's power system, estimated to cost US$200-400 million, to reduce the estimated one billion dollars per year (N 0.7 billion) in economic losses caused by power shortages;

(b) As part of the above, establishment of an immediate revolving fund of foreign exchange with an initial allocation of US$70 million for NEPA to acquire spare parts;

(c) Revisions in the generation expansion program by reevaluating demand projections, reducing planned reserve capacity margins, and emphasizing lower-cost, gas-fired plants over coal and hydro plants. These changes could conceivably reduce NEPA's

estimated investment requirements until 1990 by several billion dollars; replacing all remaining proposed hydro-plants with gas turbines would save another US$2.7 billion in investment funds between 1990 and 1995.

Solid Fuels

(d) Review of coal production facilities aimed at a major rationalization based on a sound and, preferably, non-subsidized production/marketing strategy; rehabilitation of the existing mines would cost about US$20-30 million, another US$20-30 million may be needed for future exploration programs;

(e) Conducting a survey of rural/urban household energy consumption patterns to identify the areas with serious demand/supply imbalances, with specific emphasis on fuelwoods.

(f) Introduction of policies to provide fast-growing seedlings for firewood production in rural areas which would require investment of only about ₦ 43 (US$64) per rural family;

(g) Development of dissemination programs to introduce more efficient wood stoves in rural areas;

(h) Review of current programs for large-scale firewood plantations in the north, given their apparent high costs;

Policy and Institutional Issues

(a) There is need for a substantive, integrated energy sector planning staff with the in-house capability and authority to assess sector policies, evaluate investment programs, and coordinate energy sector activities with those of federal and state government departments and other economic sectors;

(b) Fundamental revisions are needed in investment and foreign exchange fund allocations for ongoing projects. First, assurance must be obtained from import licence and financial authorities that needed funds for maintenance and spare parts are made available on demand. Second, regardless of their urgency, new projects should not be started until both domestic and foreign funding has been assured and guaranteed through the stage of project completion;

(c) A strong gas authority with operational autonomy should be created to undertake the planned gas investments and to operate and maintain the gas supply facilities. Cooperative arrangements should be set up between the new entity and a foreign gas utility experienced in gas transmission and distribution, for appropriate technical assistance during the start-up years;

(d) The pace of negotiations between the Goverment and potential non-associated gas suppliers should be accelerated to reach agreement on appropriate and secure gas transfer prices to the gas authority;

(e) NEPA's internal management authority should be strengthened and granted more autonomy. The company should be released from the restrictions of the civil service pay regulations. The breakup of NEPA into separate entities is not recommended, as this would unnecessarily dilute scarce management capabilities, lead to duplication of efforts, non-standardization of equipment and very likely eliminate the possibility of a uniform tariff throughout the country, which in the past has been politically important;

(f) The complex, overstaffed structure of the National Coal Company administration should be simplified to reduce costs;

(g) Major efforts are needed to develop better in-house demand forecasting capabilities within NEPA and NNPC to avoid costly planning and investment mistakes.

Energy Pricing

(a) Domestic energy prices should be adjusted gradually to reflect, at a minimum, the economic cost of supply for gas and LPG and the corresponding value in world markets for petroleum products. In addition, transport fuel prices should be raised to make a contribution to the cost of infrastructure. Specifically, this would mean:

(i) Retail gasoline prices should be raised from Kobo 20 (US$0.30)/liter to well above its economic cost of K20.8 (US$0.31)/liter.

(ii) Gasoil should be raised from its current price of K11 (US$0.16)/liter to K20.2 (US$0.30), just slightly above its economic costs, to maintain price parity with kerosene and avoid large-scale substitution between those two fuels.

(iii) The price of kerosene should be raised quite a bit above its current price of K10.5/liter, (US$3.17/MMBTU), although it would be difficult to raise it to its full economic value of K20.0 (US$6.04/Million BTU). This policy should allow kerosene to maintain its role as a low-cost household cooking fuel requiring, at most, five percent of the monthly income of an unskilled urban laborer.

(iv) Efforts should be made to reduce current LPG retail prices from K18.1/liter (US$11.31/MMBTU) to about K15.2 (US$6.88/MMBTU) to make it more competitive with kerosene in household markets and gasoline in transportation.

(v) Fuel oil prices should be raised by a factor of three or four to their economic cost (to ₦ 100-120 (US$150-300)/ton depending on grade) to open up the market for natural gas.

(vi) The Mission proposes an average doubling of petroleum product prices to bring them up to true economic levels. This would produce an additional ₦ 1.5 billion (US$2.2 billion/year in net governmental revenues by 1985. The additional excise charges recommended for transport fuel would raise revenues even further.

(vii) Delivered natural gas prices to very large users could be set as low as ₦ 1.00/thousand cubic feet (MCF) (US$1.45/ million BTU) to reflect economic costs including an assumed ten percent net return on investments. To other users, minimum delivered costs would have to range between ₦ 1.32 (US$1.97) for large users to ₦ 3.22 (US$4.81) per MCF for smaller users. Since these prices would be much lower than those of other energy sources, an additional excise tax of 50-75% could be imposed to raise revenue. Switching from petroleum products to gas, where possible, would only become uneconomic if crude prices were to fall below $15/bbl.

(viii) Although electric power tariffs are higher than long-run marginal costs, they are not high enough to cover current financial costs. As operating efficiency is very low at present, improvements could be made here to lower costs. The Mission therefore recommends efforts to reduce costs rather than increase tariffs, except for inflationary price adjustments. This policy should be reviewed by early 1984, however, to see if it is still appropriate in light of evolving system's costs.

Energy Conservation

(a) There appears to be considerable scope for conserving energy in Nigeria. While specific studies are lacking, it is apparent that general housekeeping improvements could reduce industrial and commercial energy consumption by significant margins. The Mission studied the petroleum refining industry and found a potential US$150 million in annual savings from energy conservation. Major savings in petroleum fuels could be realized by improving the service reliability of NEPA. This would eliminate substantial amounts of diesel fuels and gasoline, estimated to be 400,000-500,000 tpa. Other areas where potential savings would be large are traffic control and improved traffic flow management. Observation of present road traffic patterns and congestion in Lagos indicates that 40-50% of gasoline and diesel consumption could be eliminated if better traffic management measures were introduced. A major study of policies to encourage improvements in energy efficiency is needed.

PAPUA NEW GUINEA: ENERGY BALANCE, 1980
(thousand tonnes of oil equivalent)

	Petroleum Products											
	Non-Commercial	LPG	Motor Gasoline	Aviation Gasoline	Jet Fuel	Kerosene	Distillate	Residual Fuel Oil	Total	Electricity	Total Commercial	Total
Primary Supply												
Production	434									90	90	524
Imports		4	90	8	49	19	233	216	619		619	619
Total	434	4	90	8	49	19	233	216	619	90	709	1143
Transformation and Losses												
Thermal Power Generation							-38	-210	-248	16	-232	-232
Energy Sector Use & Losses										-4	-4	-4
Net Supply/Demand	434	4	90	8	49	19	195	6	371	102	473	907
Demand												
Mining							35		35	66	101	101
Other Industrial	48	2					32	6	40	14	54	102
Transport											288	
Road			90				105		195		195	195
Air				8	49				57		57	57
Coastal							20		20		20	20
Agriculture							3		3		3	3
Commerce		2							2	7	9	9
Public Service						1			1	5	6	6
Domestic												
Rural	363					8			8		8	371
Urban	23	1				10			10	10	20	45

toe = 10 mn kcal
kWh = 3070 kcal (hydro)
= 860 kcal (electricity)

PAPUA NEW GUINEA 1/

1. Papua New Guinea (PNG), with a population of 3 million, is relatively well-endowed with energy resources - hydro potential conservatively estimated at 14,000 MW, gas reserves (from six discovery wells) already estimated at a possible 1.5 to 5.0 trillion cu. ft. with large sedimentary basin areas yet to be explored, a large biomass potential from its forests and good solar energy potential. Despite this, PNG is currently dependent on petroleum product imports for meeting most of its commercial energy needs. Petroleum products account for nearly 55% of all energy consumption and 87% of all commercial energy consumption. Because of rising world oil prices and increasing demand for petroleum products, the share of export revenue spent on oil imports has risen from about 3% in 1972 to an estimated 24% in 1981. The 1981 oil imports are estimated at US$209 million (CIF) and amount to over 8% of GNP, 30% of gross domestic investment, and 80% of net external assistance. Without major efforts by the government, energy imports will soon impose an intolerable burden on the economy.

2. The country's energy options are severely constrained by the small size of total domestic energy demand, as well as the geographical fragmentation of the market, which leads to high investment and operating costs per unit of output. Careful planning is therefore essential to determine the appropriate options available for substituting imported petroleum products by indigenous energy sources. In recognition of this, the Government of PNG established in 1978 an Energy Planning Unit (EPU) in the Department of Minerals and Energy (DME) and by 1979 had issued a "White Paper" outlining its energy objectives and policies. The "White Paper" emphasized the role of renewables in alleviating PNG's energy problems, particularly ethanol for the transport sector (which consumes 45% of all petroleum products), wood pyrolysis for the industrial sector and solar water heating and photovoltaics for households, and EPU betgan promoting projects in these areas, many of which, following further analysis and feasibility studies, have since been abandoned or reduced in scope. More conventional areas of activity tended to be neglected and energy planning did not advance significantly. However, in late 1980 the EPU began to place more emphasis on the electricity sub-sector, where 40% of petroleum products are used, where multiple options are available for substituting the oil used in power generation and where severe and widespread operational and financial difficulties were being experienced. More recently, some attention is being paid to the prospective use of onshore and offshore reserves of natural gas, to hydro development and to energy conservation. Energy planning, including analysis, policy and monitoring for the entire energy sector, covering all producer and user sectors and sub-sectors, still has to mature and in

---

1/ Adapted from Report No. 3882-PNG, June 1982.

this report the mission makes various recommendations for developing and strengthening the energy planning process. In addition to institutional strengthening, there is an urgent need to implement further studies to evaluate more fully the different energy supply options, especially those that will lead to firming up reserves of gas and oil, hydro and coal, so that decisions on which combination of energy sources is optimal to satisfy the medium-to-long-term demand of the various user groups can be taken in the near future.

Energy Consumption

3. The energy sector of PNG has developed alongside the various enclaves which have characterized the country's industrial, economic and urban development. The major enclave is Bougainville Copper, Ltd. (BCL), which is on Bougainville Island separated from the country's major demand centers, and which consumes nearly 62% of all electricity generated and 40% of all petroleum products, either for power generation or as distillates for various mining and ore processing operations, such as crushing, drying, etc. Another copper mining enclave, Ok Tedi, on the main Island of New Guinea close to the Indonesian border, is being developed and will start production in the mid-eighties. The country's urban enclaves,which have a large expatriate population whose pattern of living is set by modern developed country standards, consume most of the remaining electricity and petroleum products in the household, commercial and private transport sectors. Over half of the country's 32,000 household consumers of electricity in 1980 were in the two towns of Port Moresby and Lae, whose combined population is only 180,000 (6% of the total population of 3 million). The consumption of commercial energy in the rural sector (87% of population) is a meager 1.1% of the country's total commercial energy consumption.

4. Total primary energy consumption in 1980 is estimated at 1,143,000 tonnes of oil equivalent (TOE), of which 709,000 TOE (62%) is commercial energy, mostly in the form of petroleum products, and 434,000 tonnes (38%) is non-commercial energy, mainly fuelwood. Per capita consumption of total energy at 2.8 barrels of oil equivalent (BOE) is approximately the same as in middle income developing countries in Asia (Indonesia 2.2 BOE, Thailand 2.7 BOE, Philippines 2.8 BOE) though the pattern of consumption, as noted above, is substantially different.

5. PNG has become increasingly dependent on commercial energy in the past decade. Commercial energy consumption (mainly petroleum products) grew from 44% of total energy consumption in 1970 to 62% in 1980. The commercial energy GDP ratio has grown at a much faster rate (7.8%) compared to the total energy/GDP ratio (4.2%) over the last ten years. The increase in oil consumption is partly due to the use of oil for power generation and continuous operation of the gas turbine in Port Moresby, which was originally intended only as a stand-by, and to the start-up of operations by BCL.

6. The transport and electricity sectors consume nearly 45% and 40% of all petroleum products respectively The growth rates of these two sectors, and especially the strategy adopted for future power generation among many available options (hydro, oil, gas, coal), will largely determine the growth of petroleum product consumption. Industry (including agricultural processing but excluding BCL) accounts for only 14% of electricity consumption (of which nearly a third is from captive plant) and 6% of petroleum product consumption. Both industry and commerce have suffered from the unreliable public electricity supply and have been forced to own and operate captive generating plants, mainly in the form of small diesel sets. In addition, there is also substantial suppressed demand for electricity because ELCOM, the electric utility, is beset by its own management and financial problems and has not been able to fulfill its role adequately as a public utility with the responsibility of providing reliable power to all consumers at reasonable cost.

Energy Forecast for 1985 and 1990

Demand

7. Forecasts made by the Bank suggest a GNP rate of growth of 4% per annum over the decade, perhaps higher in the early part as Ok Tedi starts production. (By 1986, this mine might account for an additional 10% of GNP, suggesting that growth elsewhere may be below 4%.) This is comparable to growth over the past decade, during which energy demand grew steadily. Based on assumed sectoral growth rates, projections made for BCL and Ok Tedi, and population growth rates, energy demand forecasts have been made for 1985 and 1990, and are summarized below:

FORECAST FINAL ENERGY CONSUMPTION FOR 1985 AND 1990
(thousand toe)

	Electricity	Petroleum	Woodfuel	Total
1985				
Households	12	22	430	464
Industry	126	93	--	219
Transport	--	297	--	297
Others (Agr. and Commerce)	15	8	70	93
	153	420a/	500	1,073
1990				
Households	17	28	473	518
Industry	172	122	--	294
Transport	--	367	--	367
Others (Agr. and Commerce)	20	9	88	117
	209	526b/	561	1,296
Growth Rates(%) c/				
1980-85	8.5	2.5	2.9	3.4
1985-90	6.4	4.6	2.3	3.9
1980-90	7.4	3.6	2.6	3.7

a/ Does not include 392,000 TOE used for power generation, already included under electricity.

b/ Does not include 475,000 TOE used for power generation, already included under electricity.

c/ Historial growth rates in final energy consumption during the seventies are as follows:

1970-75	9.3%	(BCL started operation in 1973)
1975-80	3.6%	
1970-80	6.4%	

Supply

8. Not much can be done on the supply side to alter the picture for 1985 due to the short-lead time avilable. However, the mission assumed that BCL may, by then, switch to coal-fired thermal plan (2 x 45 MW), instead of continued reliance on fuel oil. The options available for 1990 are numerous and for the purpose of illustrating a few of these options and the magnitudes involved, three preliminary supply scenarios have been quantified by the mission: (a) Case A (Gas) assumes that Pasca gas field will be developed and gas piped to Port Moresby for power generation and possibly methanol production while hydro is being developed at BCL; (b) Case B (Coal) assumes that a 25MW coal-fired thermal station will be built in Port Moresby, and BCL will switch to coal; (c) Case C (BAU) describes business as usual scenario with

continued dependence on imported oil. Supply patterns corresponding to the three scenarios outlined above are summarized below:

ENERGY SUPPLY IN 1990
UNDER THREE POSSIBLE SCENARIOS
(thousand toe)

	Case A	Case B	Case C
	(Gas) a/	(Coal)	(BAU)
Production			
Gas and Condensates	302	43	43
Hydro b/	304	197	243
Plus Imports			
Coal	304	447	--
Petroleum	573	598	988
Less Exports			
Condensates	-178	--	--
Total Commercial Energy Available	1305	1285	1274
Less Transformation losses (generation and other losses)	-570	-550	-538
Total Final Consumption Energy Consumption	735	735	735
Non-commercial Energy	561	561	561
Total Final Energy Consumption	1296	1296	1296

a/ The report also shows Case A (Gas) in detail without the production and export of methanol.
b/ Assuming 28% efficiency.

Investment

9. Possible investment outlays in the energy sector for each of the scenarios mentioned above are as follows:

INVESTMENT IN THE ENERGY SECTOR, 1981-1990 a/
(Million US Dollars)

	Case A b/ (Gas)	Case B (Coal)	Case C (BAU)
ELCOM			
Investment to 1985 c/	130.0	130.0	130.0
Other investment	15.0	15.0	15.0
Port Moresby electricity	12.0	43.5	67.5
Gas Field Development	150.0	-	-
Gas Pipelines to Port Moresby	90.0	-	-
BCL - Hydro	150.0	-	-
BCL - Coal	132.0	200.0	49.5
Ok Tedi Diesel	18.0	18.0	18.0
Ok Tedi Hydro	150.0	150.0	150.0
Total	847.0	555.0	430.0

a/ Excluding investment in oil and gas exploration at or over US$30 million per annum.
b/ Does not include investment in a methanol plant (roughly estimated at US$300 million for a 2,000 tons per day capacity) considered as a possibility under Case A.
c/ Includes investment in Barikewa gas turbine and Rouna 4 ($71.0 m), Pauanda ($9.6 m), and Warrangoi ($49.4 m).

10. The direct balance of payments of thse three scenarios are shown below;

FORECAST OF NET FUEL IMPORTS, 1985 AND 1990
(1980 US$)

	1980	1985	1990		
			A (Gas)	B (Coal)	C (BAU)
Imports of fuels	619	812	877	1045	988
Cost of fuel imports (million US$)	188.0	287.0	290	319	381
Less energy exports (million US$) a/	-	-	71	-	-
Net Energy import cost (million US$)	188.0	287.0	219	319	381

a/ Condensates only, i.e. no methanol exports included (valued at about US$138 million).

11. If total exports of goods and services grow at 4% per annum from 1985-1990 (as assumed in Bank calculations), they will yield $1750 million in 1990 (1980 prices). Net imports of energy in 1990 range from $219-$381 million, or from 13%-22% of export revenue. If methanol is produced and exported as envisaged under Case (A) the economics of this option become extremely favorable. A 2,000 ton per day plant would be able to produce about 660,000 tons per annum. At about US$210/per ton, this would yield an additional US$138 million in foreign exchange, reducing the import bill under Case A to US$81 million or 5% of export earnings (which is below its share in 1969-70).

12. In sum, although larger quantities are imported in Case B than in Case C, the import bill is lower because cheaper coal substitutes for more expensive fuel oil used in Case C. Case A has an additional attraction in that it provides gas at Port Moresby for an export oriented petrochemical industry such as methanol. Although Case A (Gas) without methanol exports is attractive, it looks even more so with methanol exports. Thus, in spite of the fact that investment costs in Case A are the highest, such investment will result in drastically reducing the country's oil imports.

13. These scenarios have been done only for the purpose of illustrating the options available in the energy sector and the order of magnitude of energy imports and their costs. Detailed studies will be required to estimate the profitability or otherwise of the different components of these the scenarios, or other scenarios. In any event, potential investments in this sector will be dependent upon the availability of the resources necessary to finance these investments even assuming acceptable levels of profitability.

Energy Resources

Electricity

14. PNG's largest energy resource is its hydroelectric potential with many potential hydroelectric sites, particularly on the Fly, Purari, and Kikori Rivers flowing into the Gulf of Papua and the Musa River flowing into the Oro Bay. The total potential is conservatively estimated at 14,000 MW (or nearly 5 kw per capita, one of the highest in the world). However, because of the fragmented nature of the country and limited demand in any one locality, development of large hydro resources has not been feasible and only some of the smaller run-of-river schemes have been implemented. One difficulty in planning hydro development is the lack of stream gauging records for all except the largest rivers, and the mission recommends that urgent action be taken to introduce new gauging stations on potential hydro sites for which no records exist. Attempts have been made to synthesize data from general rainfall records, the characteristics of similar streams, and from gauges installed in the relatively short period when any given project is under consideration.

Hydro plants installed on the basis of such inadequate data have not met expectations and both minimum and average flows are seriously below the amounts designed for. Consequently, it has been necessary to provide thermal back-up (based on petroleum products) to deliver much of the energy required. Given the nature of the hydro schemes in operation and under consideration, thermal back-up will continue to be essential and should be included in all power sector plans.

15. Plans for future power generation must include some or all of the following:

(a) First, by expansion of existing hydro sites and a detailed investigation of other possible sites for feeding the Port Moresby/Ramu grids. The mission supports, subject to a detailed economic appraisal, ELCOM's present plans to build another hydroelectric power station (Rouna 4) in the Port Moresby area since this is the only hydro option available in the short-to-medium term that will add to the energy available. However, as with other hydroplants, this will have a low firm plant factor, perhaps no more than 20% in dry years, which will be insufficient to supply the demand on the Port Moresby systems which has a load factor over 60%. At present, a gas turbine at Port Moresby is being used to meet the short fall in dry years and some form of thermal back-up will continue to be needed.

(b) Second, by the use of imported coal at BCL and Port Moresby. In the latter case, the mission strongly recommends a reappraisal of the 25 MW coal-fired thermal plant proposed by consultants.

(c) Third, by use of natural gas resources, particularly the Barikewa reserves for the Ramu grid but also, possibly, the Pasca/Uramu reserves for the Port Moresby grid.

(d) Fourthly, by using wood-wastes for power generation for the Ramu grid, which the mission considers worthy of further examination, although the mission concurs with ELCOM's views that wood supplies in the Port Moresby area are insufficient to sustain even a 10 MW wood-burning plant on a long-term basis.

(e) Since other mining metallurgical enclaves (besides Ok Tedi) are being considered the mission recommends that an inventory of all major hydro sites (over 50 MW) be compiled and from this list preliminary feasibility studies of 3-4 selected hydro sites for such enclaves be started.

(f) Finally, least cost studies of the various alternatives of expanding the ELCOM power system be continued over a longer (15-20 year) time frame.

Oil and Gas

16. Substantial exploration work has been done in the oil and gas subsector in the past fifty years, with mainly gas finds. A consultant's report, reviewing and cataloging all work done to date, is now ready. The Papuan Basin contains most of the gas found, mainly in two offshore wells (Pasca and Uramu) and four onshore wells (Barikewa, Iehi, Bwata, and Kuru). On the basis of these discoveries, gas reserves are estimated to be 1.5-5.0 trillion cubic feet (TCF).

17. The pressing need for hydrocarbon fuels in the economy, coupled with the availability of gas, calls for a greater sense of urgency in using this valuable resource. As the situation now stands, the oil companies have little incentive to develop the proven reserves for domestic use for power considering the small fragmented demand centers and degree of industrialization of the country, unless they can be associated with export-oriented industries. The Government should therefore:

(a) Require speedier exploration and appraisal of discoveries already made by oil companies as their work programs come up for periodic review under the terms of the licenses already granted. If possible reserves are considered too small for export (as may be the case with Barikewa), consideration should be given to providing incentives to the oil companies for developing such fields for the domestic market or alternatively, persuading them to relinquish the areas concerned.

(b) Carry out as soon as possible a gas utilization study on the onshore-offshore gasfields, mainly to establish the feasibility of development of each of the individual gas fields, and evaluate a combination of gas utilization options including: (1) a gas-fired power plant using onshore gas from Barikewa with transmission to the Ramu System in the north and possibly to Port Moresby; (2) a pipeline from Pasca and/or Uramu to Port Moresby for power generation including recovery of condensates and LPG; (3) methanol production for local and export markets; (4) an LNG plant (somewhere in the range of 75-500 mmcf/d capacity); and (5) ammonia/urea production.

Coal

18. Coal occurrences have been found in the Morobe and Gulf Provinces and near Madang but no active follow-up work has been considered necessary to firm up reserves. They have generally been small deposits of low grade coal with seams dipping at moderate angles. From the meager data available, it is likely that technically recoverable reserves exist in both Morobe and Gulf Provinces and that Pindiu, Purari, and Hohoro areas may be the most promising. The viability of open cut mines in these areas should be examined for the purpose of power

generation in Lae and Port Moresby as an alternative to the use of imported steam coal, after more geological work and the firming up of reserves has been done. For this purpose, the reserves required are modest (about 5 million tons) and it is likely that external technical assistance will be available.

Geothermal

19. There are surface evidences of hydrothermal activity in the form of seeps and geysers at temperatures of 90°/95°C, particularly in the Rabaul, Hoskins and Talasea thermal areas of New Britain and the Deidei and Iamalele thermal areas of Fergusson Island. As electricity consumption in these areas is small and there is no consumption of steam for process purposes, there is no urgency in developing the potential, but some priority may be given to identifying the potential of the Rabaul thermal areas.

Renewables

20. PNG has had a comprehensive program to produce energy from renewable sources. The main objective of the renewables programs has been to substitute oil in the transport sector by ethanol, produced from cassava, sugarcane, molasses or sago palm. However, many of the projects originally included in the program were based on technology that had not been perfected; scarce funds have already been spent on experimental ventures with disappointing results. The eventual potential for energy production from these sourcesmight be immense, but their technical and economic viability needs to be proven with minimal expenditures, particularly in the conext of potential development of oil and gas.

(a) Ethanol: Considerable emphasis has been placed on developing ethanol from biomass as a substitute for motor fuel. A cassava-based project at the Baiyer River is under development at present, and studies have been undertaken for at least four other projects (based on molasses, cassava plus sugarcane, sugarcane, and sago palm, respectively). A potential six million litre/annum molasses-based project the Ramu Valley seems economically attrative, but it is unlikely that any other new projects will prove viable. The economic justification for completing the Baiyer River Project is only marginal. EPU's published target in 1979 of 130 million litres per annum by 1990 has been recognized as unrealistic and has been reduced first to 36 million and more recently to 10 million. The Government should carefully review the economic justification of any further investment in ethanol projects;

(b) Wood: Wood resources are tremendous (covering 40 million hectares) and fuelwood contributes about 40% of total energy consumption. Nearly 95% of the fuelwood is consumed in households, the remaining 5% being consumed in the industrial sector, particularly agricultural processing where is accounts

for about 62% of all energy use. It is expected that the consumption of fuelwood will rise in proportion to the increase in population growth. The scope for its utilization in the industrial sector for heat and for power generation needs closer study. Attempts at using pyrolysis of wood wastes in industry at Lae have failed due to various technical difficulties. Gasification has only been attempted on an experimental scale. Studies for the utilization of the considerable wood wastes through wood gasification and steam generation should continue to be made. The possibility of running small diesel generating sets with wood gas in remote areas needs to be pursued as the technology is faily well proven. Wood burning conventional power generation has been considered by ELCOM and rejected, but may be worth a second look, particularly at Lae-Bulolo.

21. With respect to other renewables:

(a) The mission supports EPU's decision that no further investment in biogas should be made. In any event, the biogas plant in Lae has failed and the one installed at Waghi Mek Coffee Plant is inoperable due to technical difficulties.

(b) The mission also supports EPU's decision to halt further investment in pyrolysis due to the technical difficulties encountered in using the wood wastes in the Lae area.

(c) Solar water heating has had great success in residential and commercial buildings and is economically viable. The mission commends the measures taken by Government for this purpose, especially the provision of tax incentives for the installation of solar water heaters.

(d) Photo-voltaic cells are very expensive and are not economically viable at present given the very low consumption of kerosene for lighting purposes in rural households. As the cost of cells declines in the future with improved technology, further investment in them for other applications, particularly in telecommunications, may become more attractive, and therefore the current, relatively low, levels of funding may continue.

Institutional Issues

22. In the petroleum subsector, the Geological Survey Division within the Department of Minerals and Energy has responsibility for technical advice on all matters concerning oil and gas, coal and geothermal energy. However, the same Division is also responsible for

similar activities in the mining sector, which due to its importance in the economy, tends to receive higher priority, leading to some neglect of the energy sector. A small group of expatriates and PNG nationals, all geologists and geophysicists, look after both minerals and oil and gas. There is no staff experienced in petroleum matters. In view of the importance of oil and gas, the Geological Survey division ought to be strengthened by drawing on outside expertise to oversee the implementation of the Government's exploration policies and eventually, as delineation of reserves progresses and commercial discoveries are made and developed, the option of having a separate agency for oil and gas should be considered.

23. In the power sector, mismanagement, lack of planning and, until recently, tariffs that did not reflect cost, were the primary causes of ELCOM's financial difficulties and the power shortages in the late 1970s. The situation further worsened in 1980/81 due to failure of the hydro system 2/ and the larger reliance on diesel-fueled turbines. However, it is only fair to point out that some of the trouble originated from policies and actions taken before independence, and despite attempts aimed at speedy improvement, it has been difficult to catch up. In addition to a new General Manager, who has been recruited for a five-year contract, four expatriate technical staff have been hired for three years to help run ELCOM, and this is likely to improve matters.

24. The Energy Planning Unit should continue to be part of the Department of Minerals and Energy. However, its size, role and emphasis should be redefined as follows:

(a) EPU should function as an overall energy study and planning agency for all the energy subsectors including oil and gas, power, and coal, and not focus mainly on renewable energy planning. In order to make realistic demand forecasts for all energy subsectors, EPU should work closely with ELCOM and the various agencies dealing with the primarily energy subsectors and the Forestry Office of Department of Primary Industries (DPI). EPU's expertise should be diversified so that it can handle these new responsibilities as well as effectively monitor energy policies, programs, and conservation measures.

(b) In order to emphasize the importance of overall energy planning, the promotion and implementation of renewable energy projects and conservation measures could be entrusted to a separate unit under the Planning and Policy Divison.

2/ Exemplified by turbine breakage, siltation, drought, etc.

Energy Sector Developments, November 1981 - June 1983 3/

25. On the demand side, the consumption of both petroleum products and electricity stagnated in 1982, partly because GDP fell by an estimated 1% and partly because of the sharp rise in electricity tariffs in January 1982. Total petroleum product consumption in 1982 is estimated at 644 ktoe (1981: 675 ktoe) and total electricity generation in the public system was 442 GWh (1981: 460 GWh). Because of continued poor rainfall, thermal generation accounted for 36% of total generation (the same as in 1981). The oil import bill in 1982 was also the same as in 1981. Despite the fall in crude oil prices, 1983 oil imports will not cost significantly less because of the devaluation of the Kina in March 1983 (about 10% against the US dollar). After increases of 70% in the period November 1980 - December 1981, electricity tariffs remained constant up to May 1983. In June 1983, the tariff structure was revised to provide a uniform national tariff of 16.0 toea/kWh (average sales price in 1982 was about 13 toea/kWh). The new tariff structure results in a serious disparity between costs and tariffs for the various independent supply grids because the costs of power supply in these grids are very different.

26. On the supply side, the main developments have been in the petroleum sector. There has been an increase in exploration interest with Shell/Amoco applying for a license in the North New Guinea basin and some smaller companies applying for licenses in the Gulf area (south of Pasca) and in areas adjoining the Barikewa concession. Some preliminary seismic and geochemical work has also been undertaken in the Cape Vogel basin. There has been a gas and condensate discovery by Gulf oil at Juha in the Southern Highlands. The potential of this deposit (initial flows 8.3 MMCFD of gas and 580 barrels/day of condensate) is being investigated. An important negative development has been the blowout of the second Pasca well in February 1983, which has still not been stemmed. The inadequate and slow response in dealing with the blowout problem has highlighted the urgent need to streamline and strengthen the Government's capability for managing petroleum exploration and development. This is reinforced by the need to formulate quickly a comprehensive strategy for the utilization of proven gas resources.

27. In the other energy subsectors, important developments include the commissioning of a second 20MW gas turbine in the Port Moresby system. The Ramu ethanol project is progressing according to schedule and agreements have been reached with the oil companies to market a 20% ethanol blend gasoline in the Lae area when production starts later this year. Finally, considerable progress has been made in identifying and realizing the potential for improved energy efficiency in the industrial and commercial sectors.

3/ Adapted from Report No. 006/83, Papua New Guinea Energy Assessment Status Report, July 1983.

PERU: ENERGY BALANCE, 1981
(thousand tonnes of oil equivalent)

	Non-Commercial Energy	Commercial Energy					Total
		Crude Oil	Petroleum Products	Gas	Electricity	Total	
Primary Supply							
Production	3538	9901		1032	2643	13576	17114
Exports		(2117)				(2117)	(2117)
Flared Gas				(278)		(278)	(278)
Total	3538	7784		754	2643	11181	14719
Transformation							
Oil Refining		(7784)	7673	(95)		(206)	(206)
Thermal Power Generation			(458)	(82)	540		
Energy Sector Use			(199)	(512)	(11)	(772)	(722)
Balancing Item	(383)		(339)	(65)	(898)	(1302)	(1685)
Secondary Supply	3155		6677		2274	8951	12106
International Product Trade							
Imports			10			10	10
Exports			(875)			(875)	(875)
Net Supply/Demand	3155		5812		2274	8086	11241
Demand							
Industry	377		1085		700	1785	2162
Transportation			2501			2501	2501
Households	2710		882		752	1634	4344
Mining			571		660	1231	1231
Others	68		773		162	935	1003

toe = 10 mn kcal
kWh = 2450 kcal

PERU 1/

1. Peru is richly endowed with energy resources. Its largest known resource is hydro power, of which less than four percent of the total potential has been developed. 2/ Hydrocarbon resources are represented by about 1.4 billion barrels of oil (836 proven and 538 probable) and 1.9 TCF of natural gas. Coal resources are estimated at about one billion tons (126 proven, but not necessarily economically recoverable, and 871 inferred). Peru also has abundant forest resources which cover almost 60% of the total land area. More than 95% of this resource is located in the thinly populated Selva region; however, fuelwood is scarce in most of the more populous area.

2. In 1981, per capita energy consumption was 690 kgoe. 3/ Biomass energy sources 4/ met about 32% of the total demand (70% of the energy consumption in the residential sector), with commercial energy 5/ providing the other 68%. Most of the energy consumed in rural areas is biomass, 6/ and the annual per capita consumption of commercial energy there is very low -- estimated to be less than 100 kgoe, as against more than 700 kgoe in the urban population. The modern Peruvian economy is based on liquid fuels, which supply more than 70% of commercial energy requirements. Petroleum accounts for 60% of energy consumption in the industrial sector, 67% in the mining sector, and 100% in the transport sector. The table below reveals the large disparities between commercial energy resources and consumption patterns.

1/ Adapted from Report No. 4677-PE, January 1984.

2/ Less than 2,000 MW of an estimated 58,000 has been developed.

3/ Latin American average 1,000 kgoe.

4/ Includes fuelwood, charcoal, animal dung and agricultural residues.

5/ Hydrocarbon fuels, coal and electricity.

6/ 33% of Peru's population lives in rural areas.

Economic Context

Peru has an area of about 1.3 million km^2, supporting a population of 17 million; 29% live in the Lima area, 38% in other urban areas, and 33% in rural areas. The Andes Mountains divide the country into three distinct regions: a narrow strip of coastal deserts which holds about 46% of the population and most of the modern economic activity; the mountain region (the Sierra) with 24% of the total population and most of the traditional agricultural activity; and the sparsely-populated tropical rain forest of the Amazon Basin (the Selva). The rugged topography limits trade between these three regions. Peru's natural resources include large mineral despoits, petroleum, and a significant fishing potential in coastal waters. Only about five percent of the country's land area is suitable for crops, and almost 90% of this agricultural land is already in use. Peruvian agriculture depends heavily on irrigation, especially in Costa.

In 1981, GDP and per capital income totalled US$22 billion and US$1,294 (in 1980 dollars), respectively. GDP growth averaged 4.8 percent in real terms during 1970-75, but dropped to 1.1 percent during 1975-78. Real GDP growth resumed in 1979 and continued during 1980-81 at a rate of about 3.9 percent per year before slowing again in the second half of 1981 and 1982.

Since 1973, there has been an almost continuous acceleration of inflation, which in 1982 reduced 72%. Marked changes in the relative prices of good and services and the erosion of real wages and salaries have had a deleterious effect on income distribution and have caused a diversion of human and capital resources. Negative interest rages for deposits prevented the adequate mobilization of financial savings, and negative interest rates for credit did not promote the best use of scarce resources.

Despite auterity efforts, the 1982 public sector deficit was equivalent to 8.8 percent of GDP. The balance of payments deficit was US$1.6 billion and GDP growth slowed to 0.3 percent, industrial output fell by more than two percent, and inflatio continued at 7773 percent. Peru's economic difficulties in 1983 have been compounded by natural disasters suffered during the first half of the year. These include heavy rains and flooding in the northern part of the country, a severe drought in the south, massive landslides in the central area, and a reduction in the fish catch. A preliminary estimate of the cost of replacing the infrastructure damaged by natural diasters amounts for US$400 million (equivalent to about 2% of GDP or 26% of the 1982 public investment budget). Since 1981, civil unrest has increased with an expansion of terrorist activities in the highlands and, occasionally, in Lima, making it even more difficult to manage the national economy.

COMMERCIAL ENERGY RESOURCES VS. CONSUMPTION, 1981

	Resources		Final Consumption	
	(Million toe)	(%)	(Million toe)	(%)
Petroleum a/	200	4	5.95	73.0
Natural Gas a/	45	1	0.12	1.7
Coal b/	84	2	0.06	0.7
Hydro c/	4777	93	2.0	24.6
Total	5106	100.0	8.1	100.0

a/ Includes proven and probable reserves.
b/ Proven reserves.
c/ 390,000 GWh/year for 50 years (1 GWh = 245 toe).

Source: MEM and Mission estimates

3. Peru's economic crisis has forced, or at least coincided with, a reevaluation of investment programs, pricing policies, and institutional arrangements in the energy sector with a view to increasing the efficiency with which investment, manpower, and energy resources are used. The shortage of financial resources is especially important in the electric power sector, where an unrealistic and to some extent unnecessarily ambitious investment program must be, and is being, cut back and rationalized. Hyper-inflationary conditions have made it difficult to increase real energy prices, but significant progress has been made, especially with respect to petroleum products. A new organizational structure for the electricity sector has been enacted into law and the national oil company is undergoing substantial internal reorganization.

4. Stepped-up efforts are required to improve the energy situation in Peru. Priority areas for action are discussed below under six headings: (1) Fuelwood and Forestry; (2) Oil and Gas; (3) Electricity; (4) Coal; (5) Energy Efficiency and Fuel Substitution, and (6) Pricing.

Recommended Energy Strategy

Fuelwood and Forestry

5. The majority of the Peruvian population depends on fuelwood and residues for cooking fuel. Fuelwood supplies are becoming more scarce, especially in the Sierra region, which has less than half a percent of the nation's forest resources. Reforestation efforts need to be vigorously accelerated in order to slow down the depletion of growing stock. The principal reforestation activity now underway in the Sierra is a

five-year project being implemented with the help of the FAO and financial support from Dutch bilateral aid that will eventually reach a rate of 30,000 ha/yr by 1990. A 10-year follow-up phase is planned but not yet financed.

6. In the Costa, forestry development priorities include erosion control, protection of water catchments, and development of fuelwood plantations in the northern costal area. In the Selva Alta, forestry priorities cover the control of logging operations, improved protection and management of logged-over forest, restoration of limited areas of degraded land, and controlled clearance and settlement of forest areas suitable for agriculture. In the Selva Baja, forest development priorities include the preparation and application of plans for forest management and exploitation, park and wildlife conservation and management, and control of logging operations and clearance for settlement.

7. Building up local capacity to manage reforestation projects is a prerequisite to significantly increasing the scope of the program. There is an urgent need to train more technical staff for field work, and especially non-degree technicians and extensionists. Training could be achieved through the establishment of special training centers and "mobile training units" to expand the capacity of central nurseries. There is also a need for short courses to train management-level field staff in social forestry, as their approach to rural afforestation is often too technical to motivate communities to plant trees. Revising the incentive system within the National Forestry and Fauna Institute (INFOR) (e.g., through a higher per diem for going into the field) may help to encourage forest engineers to do more "hands-on" work.

8. The division of labor between the two forestry agencies, the Bureau of Forestry and Fauna (DGFF) and INFOR, merits reexamination in view of the apparent overlap between their area of responsibility. If reverting to a united forest service is too cumbersome, official consideration should be given to establishing the DGFF and the INFOR as planning and executing agencies for the Selva and the Sierra/Costa, respectively. Overlapping areas of responsibility among the Forestry Centers (CENFORS) and the forest districts should also be clarified.

9. There is a need for more comprehensive planning in the forestry sector, particularly for the fuelwood subsector, focusing on the needs of the Sierra population. Immediate steps should be taken to formulate a national reforestation plan and work program, delineating the successive phases and components, and strengthening local capacity for rural/social forestry. This activity would require improved coordination of external aid for the fuelwood subsector.

10. Technical assistance projects that would expand successful ongoing projects or carry them to a more advanced stage could include: (i) evaluation of completed reforestation and coordination of work currently being implemented; (ii) expanded training of sub-professional forest technicians; (iii) species trials, including research on multipurpose

species; (iv) development of improved cooking stoves and more efficient wood burning devices; (v) strengthening of the CENFORs; (vi) protection from livestock; (vii) feasibility study for producing charcoal in the Selva; (viii) identification of the potential for integrated agroforestry activities, the potential for creating small wood products industies with fuelwood or charcoal as by-products, and for stimulating private tree-farming.

Oil and Gas

11. Petroleum is the dominant source of energy in Peru, meeting about 70% of the country's commercial energy requirements in 1981. Peru's oil production increased almost threefold between 1976 and 1979, when a pipeline across the Andes was completed and field discovered in the mid 1970s in the Amazon basin were brought into production. Oil exports have been a substantial source of foreign exchange for Peru since 1979. In 1981, petroleum exports accounted for 24% (US$777.8 million) of the country's exports and about a third of its petroleum production.

12. The present level of exploration is not adequate to maintain existing production levels. The reserves-to-production ratio has been declining since 1976 and is close to the limit beyond which present production levels cannot be sustained. Of the 75 million hectares in Peru considered to be prospective for petroleum, only 15 million are undergoing any form of exploration.

13. The national oil company, Petroperu, does not have the staff or financial strength necessary to mount the needed effort, and modifications to the system of exploration and development contracts with foreign oil companies appear called for. The current system particularly discourages the search for the small and medium scale finds that are the only size fields so far discovered in Peru. Additional incentives may also be needed to encourage the more costly development of heavy oil fields. Finally, the accounting and taxation system for oil companies should be revised to correct distorsions resulting from the high rates of inflation and devaluation of the sol.

14. There have been small discoveries in areas under active production and secondary recovery, rehabilitation, and other projects in these areas have contributed more to increases in reserves and production since the opening of the Transandean pipeline than exploration and development in new areas. There remains a substantial apparent potential for projects of this type. Petroperu is in a position to undertake some of these projects but probably not all of them; consideration might be given to promoting service or joint venture contracts in secondary recovery or enhancement recovery projects.

15. At the same time as new foreign investment is sought, efforts to enhance Petroperu's capacity should be continued and extended. Routine use should be made of consultants not only to do specialized jobs but also to expedite projects when Petroperu's technical and

administrative staffing shortages would otherwise force delays. Although Petroperu is still suffering from the loss of key staff abroad and to the private sector, this phenomenon no longer appears to be a major problem for the company, since some have returned. Emphasis should now be placed on recruiting and holding younger staff and giving them experience working with senior staff and consultants.

16. Consideration should also be given to steps that would reduce the range of Petroperu's responsibilities to a more manageable level and put it on a financial footing such that its accounts would reasonably reflect the success or failure of its own operations as an oil company and depend less on performance of its contractors and Government pricing and tax policy. Such steps could include:

(a) allowing Petroperu to operate under the same conditions as other oil companies for exploration and production activities;

(b) operating the refineries on a service basis and transferring subsidies on domestic petroleum prices to the government budget.

17. Natural Gas. There are two areas with significant known natural gas reserves. One is the Aguaytia structure (not currently in production) in the central Selva area about 500 km from Lima in a block assigned to Petroperu, where non-associated gas has been discovered. The other is in the northwest (about 1,000 km from Lima) where associated gas is produced in onshore areas operated by Petroperu and offshore by Belco, a foreign-owned private company. While the scale of production and utilization is very limited at present, the recent discovery of possibly substantial non-associated offshore gas reserves by Belco has raised interest in the possibility that natural gas could become an important energy source in Peru. However, important uncertainties must be resolved before any project to develop this resource can be implemented.

18. One issue concerns the size of the reserves. Data from the wells drilled to date, which were tested at about 5 MMCFD, cannot confirm that sufficient reserves or production potential exist to make a development project economically viable. A study needs to be made of the size, classification and deliverability of reserves before negotiating any gas purchase agreement with Belco. A second issue is the market. A preliminary assessment of the potential use of natural gas indicates that the most important near to medium term prospect lies in replacing diesel in the power sector in the northwest, where 20 MMCFD might be used by 1987.

19. The Government should pursue its plans to develop this resource, as use of natural gas would free petroleum products for export. The short-term plan should focus on a small project for developing the offshore non-associated gas reserves and transporting this gas to Talara, Piura and, possibly, Chiclayo. The project would serve the power

market in the northwest region 7/ and permit some industrial fuel substitution. The preliminary cost estimate of delivering gas to Piura is about US$2.15/MMBTU. 8/ This gas would substitute for diesel oil currently being used as power generating fuel and which has a cost of US$5/MMBTU.

20. The Government should undertake a detailed study of natural gas and electric power supply options in the northwest. The study should determine the optimum timing, location, and type of electric power facilities to be installed to satisfy the load growth in the Tumbes to Chiclayo area. In view of the limited funds available to the national electric utility, Electroperu, it would appear preferable to create a regional enterprise with private capital participation to generate electricity. Electroperu and the major industrial consumers in the area, including Petroperu oil companies could be shareholders of such an enterprise.

21. Petroperu should also study the benefits of pursuing potential gas savings which have been identified in the northwest area. In particular, (i) Petroperu should make a field survey to identify the location and extent of inefficient uses of gas in onshore field operations and determine the economics of conservation measures; (ii) steps should lso be taken to reduce residential consumption in Talara to reasonable levels (it is estimated that 90%, the equivalent of about 800 barrels per day, is currently wasted); (iii) a decision should also be taken on whether to continue the operation of the fertilizer plant given the low price of imported fertilizer.

22. For the longer term, the potential reserves in the Central Selva area should be further investigated as a potential alternative to supplying the potential natural gas market in and around Lima and the non-associated gas potential in the onshore coastal area in the Northwest should be further explored.

Electricity

23. The electric sector has recently completed an updated Master Plan. However, the projects included in this plan have not yet been financed. A series of projects, primarily hydro, is in various stages of planning, but Electroperu and the regional utilities do not have the financial and management capacity to undertake and complete them all on a

---

7/ The northwest region suffers serious power shortages which constrain its economic growth. Alternatives to the present costly isolated generators include small, expensive hydroelectric schemes costing a minimum of US$3000/kW, or connection to the central system by a 500 km transmission line.

8/ Assuming a 13% discount rate.

timely basis. A strategy for effectively dealing with these problems would need to include steps to:

(a) raise and restructure tariffs to give the utilities the resources they need and to bring incentives to consumers into line with the structure of marginal costs;

(b) implement provisions of the 1982 General Electricity Law calling for decentralization in favor of appropriately sized and staffed regional utilities; and

(c) pursue studies of thermal and medium-scale hydro alternatives to large hydro schemes in order to maintain choices other than gas turbines in the event that these are found unfeasible or subject to substantial cost escalation or delay. The Ministry of Energy and Mines (MEM) has received continuing assistance from the West German government in the past few years in the area of hydroelectric project identification and prefeasibility studies. In addition, IBRD has made two loans, which included financing for studies of several hydroelectric projects. Not all of these studies have been undertaken, however. MEM or Electroperu should update the catalog of hydroelectric projects, taking into account recent hydrological and cost information. This updating would permit a wider selection of plants to be candidates for the power sector medium and long term development plan.

24. The 1982 General Electricity Law aims to decentralize the power sector; entities are to be organized on the basis of existing local and regional enterprises whose radius of action will be enlarged, or regional units of Electroperu, which will be given the appropriate legal form. As of October 1983, four of the eight planned regional utilities have been established. These units should be responsible for all activities involved in providing electric service in their respective regions.

25. During the 1970s, the power sector suffered a considerable outflow of professionals and technically skilled personnel, resulting in decision-making problems and inadequate maintenance of regional power systems. While the problem is not severe for the Lima power system, it is likely to continue in regional utilities, given the relative attractiveness of Lima for skilled staff and the sector's non-competitive pay scales.

26. Revenues from the 20% special tax on electricity sales and the Electrical Development Fund (EDF) 9/ will be administered by Electroperu. Half of the special tax proceeds are to be used for rural electrifica-

---

9/ Up to five percent of total power utility revenue, to be decided by the Tariff Commission.

tion, while the EDF proceeds are to be used to finance electrification works of a social nature. Although Electroperu would be the appropriate agency to allocate funds among the regions for distribution and rural electrification projects, the regional companies are the executing agencies. Regional entities should be given responsibility for selecting, designing, constructing and operating all distribution works within their areas, including those financed by the EDF and the special tax.

27. Priority in the Central North System should be given to harnessing the water resources of the basins of the Rimac, Pativilca and Santa rivers, such as the 130 MW Mayush project, whose feasibility study completed in late 1983. The hydro potential of these rivers has been studied for many years and partially developed, making better use of existing installations and construction of new medium-size plants (100-200 MW installed capacity), feasible with reasonable construction periods. In the event that such projects are delayed, Electroperu should make a detailed analysis of the power supply and decide what type and size of thermal plants to install.

28. The Southwest systems face a complex variety of choices. The geothermal potential of the southwest area could be investigated with a view to electricity generation. 10/ The use of existing hydroelectric plants could be improved by means of regulating works (basin of the Chili River). The viability of the Lluta I (210 MW), according to the updated feasibility study, has been established. The Ministry has recently requested Bank finance for the engineering studies of this project. However, the Molloco (300 MW) hydroelectric project is undefined; if proven economical, it could be built and equipped in stages. The Arequipa and Tacna-Moquegua systems are being interconnected and their frequencies standardized.

29. Both of the Southeast systems serving the Cuzco and the Puno areas appear to have adequate hydrological resources. The existing power stations should be able to supply these markets by the end of the 1980s. However, hydrological studies should be carried out to provide the basis for planning future projects.

30. In the Northwest, isolated electric systems which use diesel sets and gas turbines for thermal generation are being developed in the departments of Tumbes, Piura and Lambayeque. To take advantage of the natural gas in Talara, consideration should be given to linking Talara and Piura by means of transmission lines. Expanding the installed capacity at Piura would be a possible second stage if a gas pipeline

---

10/ Data about geothermal energy resources in Peru are insufficient to estimate the size of the potential. Geological studies financed by the Latin American Energy Organization (OLADE) have identified six areas in southern Peru which appear promising. Further investigations are desirable, involving geophysical and geochemical surveys to select the most promising areas and to identify drilling sites.

carrying natural gas from Talara to the south has been built by that time. Again assuming the availability of natural gas, installed thermal capacity in the second half of the 1980s would be expanded by means of gas turbines.

31. Other isolated systems Because of the difficulties imposed by the country's topography, Peru's abundant, widely-distributed hydro potential should be harnessed, where economic, to supply isolated centers and rural areas. To reduce costs and facilitate the maintenance of these projects, technical designs, construction types and materials should be standardized. This would also facilitate greater participation by domestic industry in equipment supply.

Coal

32. Peru lacks a systematic evaluation of its coal resources, although coal deposits ranging from lignite to anthracite are reported in 18 of its 24 departments. Proven reserves are estimated to be 126 million tons, but economic viability has not been evaluated. Domestic production, after declining from 200,000 tons in 1950 to 14,000 tons in 1975, is now back up to 106,000 tons.

33. To be successful, efforts to further expand coal production will have to overcome substantial obstacles: (i) a lack of suitable coal-burning equipment for the population and industry to use and a lack of expertise to install and operate it; (ii) inappropriate geological conditions for large-scale mechanized mining; (iii) the inability of small and medium-sized mines (100 to 500 tons/day output) to obtain credit in the absence of an assured market; (iv) the difficulty of transporting coal from the mines in the mountains to potential consuming areas on the coast; and (v) an absence of detailed geological surveys examining the occurrences of coal-bearing strata in the mountains. Technical assistance should be provided to strengthen the two entities principally responsible for coal exploration and development.

34. According to the available information, coal deposits in Peru are not generally geologically well-suited to the large, highly mechanized mines (e.g. Alto Chicama) typically envisaged by the large state corporations and their foreign consultants. A number of small private mines now operate in the Alto Chicama area, taking coal by truck to Trujillo, and consideration should be given to organizing an effort to use small private mines to deliver coal to a power station or other potential large-scale user. A pilot program to do this would have to focus first on identifying a suitable combination of mining potential, dual-firing (oil and/or coal) users, and coal transport links.

35. Coal Briquettes. Much of the poorer urban population relies on kerosene for cooking, while poor rural areas rely principally on wood. The price of kerosene is heavily subsidized and demand is increasing; much of it is probably being diverted to illegal uses. The demand for kerosene and wood consumption could be reduced if smokeless coal bri-

quettes could be provided as a substitute. The manufacture of such briquettes could be a local cottage industry in the neighborhood of the mines, where the dust and fines could be used, or a larger, industrial-scale enterprise as demand develops. It would be necessary to find a suitable binder for the coal, and to decide on the shape and size of a standard briquette, for which molds could be made and stoves designed. Potential pollution problems resulting from the sulphur content of coal also should be considered. A prefeasibility study should be done, and bilateral technical assistance has been arranged with South Korea for studying this option.

Energy Demand Management

36. The transportation, industrial, and household markets all appear to offer substantial, cost-effective opportunities for energy conservation and/or inter-fuel substitution. Most attention to date has been focussed on the principal industrial sectors, mining and mineral industries and manufacturing, which altogether account for 37% of Peru's commercial energy consumption. To ascertain with any precision the industrial savings potential would require an energy audit of the industries concerned, and only preliminary studies, principally in the mining and mineral industries sector, have yet been made. However, a general idea of the energy efficiency improvement possibilities for the manufacturing sector was obtained from visits to major consumers and by comparing energy consumption rates with those in other countries and making hypotheses based on the results obtained by conservation efforts elsewhere. Possible savings from various types of energy conservation measures in the mineral and manufacturing sectors are summarized below.

ESTIMATED ENERGY SAVINGS AND INVESTMENTS REQUIRED
IN THE MINERAL INDUSTRIES AND MANUFACTURING SECTORS

Improvements	Mineral Industries		Manufacturing Sector		Implementation Period
	(KTOE)	(US$Million)	(KTOE)	US$Million	(Years)
Maintenance and Operation	40	10	116	23	2
Application of Available Technologies	72	33	127	63	5
Application of New Technologies	96	66	n.a.	n.a.	10

37. Possible savings of the same order of magnitude have been identified in a recent study of energy use in the transport sector, 11/ which consumes about 44% of the petroleum products used in Peru. According to this study, between 17% and 25% of the energy used by road transport, the dominant subsector in terms of energy use, could be saved, principally through improved car maintenance. Slightly lower percentage ranges are estimated for air and rail transport.

38. An estimated 60% of the energy used in the household sector is biomass, largely fuelwood, and it may be possible to save a significant fraction of this by improving the efficiency with which it is used through development and distribution of a simple stove to replace the open fires now used for most cooking. Experience in other countries suggests, however, that it is easier to design an improved stove than to get it into widespread use and that any program of this type should be designed with at least as much strength on the extension side as on the technical design and R&D side.

39. The newly created National Energy Council has been given energy conservation as one of the top items on its agenda, and it may be able to sort out the lack of coordination among the institutions involved with energy efficiency in industry (Ministry of Industry, Ministry of Energy and Mines and the Institute for Industrial Technology Research and Technical Standards (ITINTEC)). These three institutions have made parallel efforts to develop an institutional capability to deal with energy efficiency in industry. Clearly it is important to coordinate the development of policies and legislation on energy conservation as well as the use of available resources inside and outside of government. The specialized nature of the work to be performed and the absence of qualified staff in the field require a centralized public service or autonomous national energy conservation center with a separate legal framework and functional and financial autonomy.

Substitution of Domestic Coal for Fuel Oil

40. Replacement of fuel oil by coal is becoming more common worldwide in the cement and brickmaking industries, thermal power plants, and industries with a high consumption of steam such as the paper and sugar industries. In Peru, conversions to burn coal in boilers and furnaces appear feasible from the technical point of view. However, the absence of a reliable supply, price instability, the distance between production and consumption centers, and the lack of a clear government policy to develop the country's coal resources are very important constraints to a major fuel oil switch to coal. Feasibility studies should be done to analyze the economic and financial aspects in specific cases.

11/ Trans-Energ, "Conservation de la Energia en los sectores Industria y Transporte," 1982.

Pricing

41. In a mixed economy such as Peru's energy pricing is probably the most important policy instrument available to encourage energy conservation and appropriate fuel choices. Between 1970 and 1976, petroleum prices were held at artificially low levels. Since then, the Government has tried to pursue a more realistic pricing policy, and the weighted average price of petroleum products was raised by 60% in 1981, and by 26% in 1982 in dollar terms. In 1983, the Government approved several price increases, bringing the average per gallon price close to international levels, but the aggregate "subsidy" 12/ is still on the order of $380 million annually. The Government's plans to continue dollar price increases in 1983 as required for national budget purposes (about half of the retail price is a tax) and its long term policy is to make prices (except for domestic kerosene) reflect the opportunity cost of the fuels. Since July 1983, however, political pressures have led to a slower rate of increase in energy prices.

42. Average electricity tariffs declined five percent in real terms throughout the 1970s. The Government authorized accelerated nominal tariff increases for late 1981 and 1982 which were just sufficient to keep pace with inflation. Tariff increases have been applied unequally in the past. A recent marginal cost tariff study 13/ for the principal (central north) system showed substantial daily and seasonal variations in the cost of electricity supply, with costs during the dry season (May to November) exceeding costs during the rest of the year. Analysis of the incidence of hidden subsidies and taxes in the current tariff structure shows that residential consumers are the most heavily subsidized, while small industrial and irrigation pumping customers receive a moderate subsidy and commercial customers are overcharged. In order to improve the overall financial investment situation in the power sector, the mission recommends that the Government review the present tariff structure with a view to implementing the recommendations of the recent marginal cost tariff study. 14/

12/ Defined as the difference between retail prices and comparator prices estimated as border price plus distribution margins and adjusted for the 16% general sales tax and a 10% foreign exchange shadow value.

13/ Electricite de France/SOFRELEC. Estudio Tarifario para el sistema interconectado Centro-Norte. Lima, March 1983.

14/ In August 1983, the new and autonomous Tariff Commission was installed according to the 1982 Electricity Law.

Technical Assistance

43. Technical assistance priorities in the energy sector are as follows:

Sector Planning
- Reinforcing the National Energy Commission

Demand Management
- Industrial Audits
- Transport/Commercial/Household Potential
- Establishment of the Energy Conservation Center (Technical assistance, training, legislation and promotion)

Fuelwood
- Organization - Roles of DGFF, INFOR, MEM, etc.
- Planning
  1. Identify, quantity, locate needs, priority areas
  2. Develop workable, replicable modes of operation: for reforestation in Sierra
- Stoves
- Training Program for Technicians

Oil and Gas
- Petroperu Investment Programming and Budgeting
- Petroperu Project Preparation
  1. Exploration
  2. Infill and extension, secondary recovery
- Organization
  1. Petroperu/MEM division or responsibility
  2. Divestiture of pipeline, retailing
- Gas Utilization in the Northwest
- Petroleum Law - Incentives for Exploration, Accounting and Taxation Framework
- Reserves Audit

Power
- Electroperu Investment Programming and Budgeting
  1. Up-date the catalog of hydroelectric projects
  2. Re-estimate project costs
  3. System planning
  4. Small hydro (standardization of technical designs, construction types and materials)
- Implementation of Regionalization
  1. Northwest - set up new utility
  2. Rest of country

Other
- Coal
  1. Reinforcing PROCARBON and INGEMET
  2. Pilot small mines project
  3. Pilot briquetting
- Geothermal Exploration Promotion
- Renewables

This page blank

PORTUGAL: ENERGY BALANCE, 1982
(thousand tonnes of oil equivalent)

	Solid Fuels	Oil	Gas	Electricity	Total
Primary Supply					
Production	794			1,553	2,347
Imports	267	9,871		290	10,428
Exports		-251		-34	-285
Bunkers		-427			-427
Stock Change	-17	+134			117
Total	1,044	9,327		1,809	12,180
Transformation and Losses					
Thermal Power Generation, Transmission, and Distribution	-142	-1,828		1,878	-92
Gas Production		-60	58	-3	-5
Oil Refining		-672		-20	-692
Losses/Energy Sector Use	-42	-13	-1	-2,341	-2,397
Net Supply	860	6,754	57	1,323	8,994
Demand					
Industry					
Iron/Steel	127	41		44	212
Non-Ferrous Metals	33	8		79	120
Chemicals	37	807		109	953
Non-Metallic Minerals	188	853		106	1,147
Others	121	1,034	3	417	1,575
Transport					
Road		2,064			2,064
Other		561		22	583
Commerce/Services	3	206	12	231	452
Households	351	478	42	305	1,176
Agriculture/Fishing		372		10	382
Non-Energy Use		330			330

toe = 10 mn kcal
kWh = 2230 kcal (production)
= 860 kcal (consumption)

PORTUGAL 1/

1. The high cost of energy in Portugal and the country's dependence on imported energy sources are major constraints to its economic development. Imported oil accounts for around 80% of final energy demand and net oil imports absorbed about 30% of export earnings from goods and services in 1982, compared with only 3% in 1973. Including coal and net electricity imports, the import bill for energy was about 33% of exports of goods and services and 67% of merchandise exports. Given its limited domestic energy resource base, Portugal's major energy problem will be how to keep down the cost of imported energy while maintaining acceptable rates of economic growth. This will require a strategy to (a) reduce the energy intensity of GDP through demand management, (b) substitute cheaper energy sources for oil, and (c) promote flexibility in investment to meet future energy demand.

The National Energy Plan

2. The Government's future energy strategy will be partly based on the 1982 version of the draft 1980-2010 National Energy Plan (PEN). The PEN, soon to be discussed in Parliament, is a major achievement providing a comprehensive, sophisticated and flexible policy instrument for energy planning. It considers several objectives in meeting energy needs including the least cost solution, maximization of the use of domestic energy resources and promoting national security by reducing dependence on foreign oil. After careful consideration of all these objectives, the reference strategy was selected, designed to meet future energy requirements at minimum cost to the economy while increasing the security of supply and reducing dependence on imported oil. On the supply side, PEN envisages intensified development of the limited domestic energy resources, mainly hydropower and uranium, while diversifying the sources of imported energy, primarily through a switch from petroleum products to coal and liquified natural gas (LNG). This policy is to be coupled with an intensive energy conservation program to restrain demand.

Domestic Supply Options

3. The domestic energy resource base is relatively limited, consisting mainly of hydropower, wood fuel and uranium. Proven reserves of coal and lignite are small and of poor quality. No commercially exploitable petroleum reserves have been discovered.

1/ Adapted from Report No. 4824-PO, May 1984.

Economic Context

With a population of nearly ten million, Portugal's 1982 GNP per capita was US$2,520. The services sector accounts for 55% of GDP, industry 29%, agriculture 8.5%, and construction 7.5%. In addition to exports of manufacturing goods, the country's largest sources of foreign exchange revenues are workers' remittances and tourism, together accounting for about one-half of total export earnings from goods and services. Major export commodities include, in order of relative importance, textiles and clothing; wood, cork and paper; agricultural products; mineral products; and machinery.

The 1970s witnessed sharp deterioration in several key economic indicators. GDP growth fell from an annual average of 7.3% between 1965 and 1973 to 3.2% p.a. in 1974-80 and 1.5% p.a. in 1981-83. A decline of 1.5% in GDP is projected for 1984. The current account of the balance of payments shifted from a surplus of almost US$350 million in 1973 to a deficit of US$3.2 billion in 1982, largely as a result of the increase in the price of oil. The public sector budget deficit reached 12.6% of GDP by the end of 1982, while the external public debt stood at 57% of GDP.

The dilemma facing the Portuguese Government now is to undertake the structural changes which the country needs while at the same time reduce the balance of payments deficit and keep external debt at a sustainable level. The current Government, which took office in June 1983, has embarked on a stabilization program to recover a more sound financial and economic position and restructure large segments of the economy, especially in industrial and energy sectors. As part of this program, the escudo has been devalued, interest rates have increased, and most subsidies have been eliminated. Moreover, the Government has concluded a standby arrangement with the IMF. The current account deficit is expected to be reduced to US$2 billion in 1983 (9% of GDP), and is projected to be further reduced to US$1.25 billion in 1984 (6% of projected GDP).

Imported Energy

4. The PEN projections indicate that imported petroleum and petroleum products would remain the dominant primary energy sources into the latter 1990s, but that their share would decline from their current 80% to 64% in 1990, mainly due to substitution by coal and natural gas, and further reductions to 49% by 2010 are due to the advent of nuclear power production.

5. Despite the intensified development of domestic energy sources, import dependence would actually increase from the 1980 level of 80% to 86% in 1990, as increases in the shares of imported coal and LNG exceed the decline in the share of petroleum. The upward trend is not reversed until the beginning of nuclear power production in 1995, based on domestic uranium, when import dependence would fall to 77% and to 63% by 2010.

Future Energy Demand

6. Given the major economic adjustments the Portuguese economy is undergoing now, it is very difficult to make macroeconomic and related energy projections for the medium term and even more difficult for the long term. Therefore, projections have been revised several times. In the face of this uncertainty, the PEN's scenario approach is to be commended, indicating high and low cases to be updated and refined on a continued basis. The PEN "reference strategy" projects energy demand for a 30-year period (1980-2010) making skillful use of available data and well established computer models (MEDEE2, DFI, WASP and VALORAGUA). The mission finds that the PEN low GDP growth scenario with average annual rates of 3% for 1980-85, 3.5% for 1985-1990, and 4.5% for 1990-2000 high in light of current trends and prospects for the medium term. Furthermore, the mission notes that the forecasting models do not explicitly incorporate the impact of rising absolute real energy prices on overall energy demand in Portugal. However, MEDEE2 implicitly allows for the effect of rising prices in its energy demand scenarios and DFI takes into account relative energy prices in determining the least cost energy supply option.

7. The PEN reference strategy assumes an intensive energy conservation program but projections show the share of imported petroleum still accounting for nearly half of the projected primary energy requirements in the year 2000. However, current efforts to introduce an industrial energy conservation and diversification program, including audits of major energy consuming industries, should give an indication of prospects for a greater energy conservation potential. At the same time, the proposed substitution of three new major primary energy sources (coal, natural gas and uranium) for petroleum within the next decade and beyond could present formidable infrastructure and management requirements which have not yet been thoroughly evaluated and incorporated in the PEN.

Recommendations

8. The mission's recommendations regarding the energy demand projections in the 1982 draft PEN are intended to provide a second opinion on some of the basic assumptions made. Concerning GDP growth assumptions, the mission recommends taking account of estimates below those used for the medium term low growth case in PEN (3.25%). The mission estimates, for example, that using a 2.25% average annual GDP growth rate and retaining specifically the energy/GDP elasticity assumptions implicit in the PEN forecasts (1.50) for the period 1980-90 would result in an increment to primary energy demand about a third less during the period. This illustrates the type of uncertainty Portugal faces in its macroeconomic and energy planning for the medium term. Furthermore, the mission finds the energy/GDP elasticity high compared with countries at a similar stage of development and considering the importance attached to energy conservation in the PEN.

9. The mission recommends that several further checks be made on the projections using a sectoral approach, including a continuation of present efforts to test growth rates of energy demand by sector for internal consistency. Furthermore, the mission supports extending the 1979 input/output (I-O) table to include an energy sector broken down into the main petroleum products, coal and electricity, fitting demand equations to the I-O table and projecting through time. The mission realizes this will require a considerable effort and is likely to yield results only in the longer term.

10. The mission also recommends that the revisions of the PEN projections include testing the influence of the absolute level of energy prices on energy demand, considering the large increases in energy prices that have taken place since 1980 with further price increases expected over the medium term. DGE staff are well aware of this omission in the present version of the MEDEE2 model and a new version of the model is planned, incorporating the price variable for selected industries. In the meantime, however, the mission recommends comparing the results of the PEN models with a single equation econometric approach. It would also be worthwhile to consider alternative assumptions for both energy/GDP and price elasticity coefficients to determine a possible range of outcomes.

11. Following the revisions made to the energy projections as indicated above, the mission recommends testing the impact of the resulting differences on the size, composition and timing of energy projects in the investment program. Such an approach would highlight the costs of uncertainty and focus attention on those decisions which need to be made immediately, otherwise resulting in high costs to the economy, and those which may be postponed at little cost or even benefit (cost savings).

12. Regarding the least cost supply solution, it would be desirable to test its sensitivity to higher discount rates given Portugal's severe capital constraints over the near to medium term, and to lower future

real increases in the prices of petroleum products and coal. The mission was informed that the Ministry of Finance and Planning is now recommending sensitivity testing for the discount rate through the range of 9-14%.

13. Finally, the costs and benefits of the conservation scenarios should be evaluated further to determine whether the "very intensive" conservation program of the "increased security of supply" strategy should be adopted for the reference case. Moreover, the revised supply projections should also allow considerable time for solving the organizational, management and planning problems likely to be encountered, along with infrastructure requirements, associated with major new energy sources.

Electric Power Projections

14. Electricity demand forecasts are derived from the same forecasting models as the overall energy projections and thus appear on the high side for the same reasons mentioned above. An additional consideration in this sector is that the system load factor is assumed to remain close to its present level of 58%, although there is some reason to believe that it may increase along with the substantial expected real increases in electricity prices and the rising share of industrial consumption. Should the load factor improve, there could be savings in generating capacity requirements which might be significant insofar as about 60% of the total investment program is for electric power generation and distribution.

15. As is the practice in many other countries, the electric utility (EDP) optimizes the power investment program only for generation. The mission recommends that EDP make efforts also to optimize the distribution investment program, and compare the economic return on investment generation with that in distribution to improve service and reduce losses.

16. A point which merits further attention is that the PEN's evaluation of electricity supply prospects includes some basic economic and technical assumptions which seem to favor nuclear power. Although the Government is still open to the choice of nuclear technology, the only nuclear option evaluated in the PEN is the pressurized water reactor (PWR) which is available in relatively large units compared to coal, the other major generating option considered. However, the PEN also indicates that in cases where smaller units may be more appropriate in relation to projected electricity demand, the heavy water reactor (HWR), could be considered since it uses natural uranium available in Portugal and is available in 600 MW units, compared to the smallest PWR unit (950 MW) considered in PEN.

17. The proposed use of Rio Maior lignite for power generation is not economically viable, based on data available to the mission. This is

due to the poor quality and high mining cost of the relatively small lignite reserves.

Recommendations

18. The usefulness of present forecasting methods could be further improved by several additional procedures, given the considerable amount of planning expertise already within EDP and Office of Energy (DGE). These include: (a) improving the data base through EDP's establishment of a market and load research section; (b) reviewing the constant system load factor assumption, testing the impact of load factor improvements on investment needs; and (c) reviewing reference strategy assumptions on the discount rate, power station availability, alternative fuel prices and plant costs to better determine the costs and benefits of available options.

19. The mission supports the PEN proposal to study the distribution networks as soon as the integration of municipal undertakings is resolved, to determine investment requirements and other measures to reduce losses and raise the quality of service. Such a study would be appropriate for short to medium term planning only, due to the high degree of uncertainty over the long term. This, however, might more effectively be done as part of a wider study of the EPD system to improve technical efficiency and reduce overall system losses.

20. There is considerable merit in making the planned power expansion program as flexible as possible, particularly in relation to the proposed 950 MW nuclear power option, to avoid premature commitment to significantly large unit sizes involving the risk of excess capacity. To this end, the following options could be considered along with other alternatives: (a) the use of natural uranium based HWR, which could be economically viable on a smaller scale, and (b) the feasibility of a joint nuclear power venture with Spain or France in view of Portugal's and Spain's prospective entry into the EEC. In order to more fully evaluate possible options, it would be desirable to analyze the potential costs and benefits to the economy of a commitment to large power units and the risk of resulting excess capacity.

LNG Option

21. The price at which natural gas could be made available to potential consumers is difficult to determine with current information. Components of this price include the c.i.f. price of LNG, capital costs of infrastructure, and operating costs of the system. The PEN ratios of the LNG price (c.i.f.), the major component of the final gas price, to the prices of alternative fuels (oil and coal) are significantly above their current (July 1983) levels. On the other hand, the capital cost component of the final price for natural gas seems low given the proposed infrastructure investment. Also, operating costs do not appear to ac-

count for (a) the costs of marketing the gas; (b) increased manpower requirements; (c) the costs of adjusting supplies to demand fluctuations; and (d) the costs of individual consumer connection and equipment conversion. A market study has been made by a foreign consultant which gives some prospective market scenarios, but these need further evaluation specifying the additional costs cited above. Other gas options, such as a natural gas pipeline through Spain and local gas distribution systems based initially on LPG/air as nuclei of an eventual national gas network should receive closer attention.

Recommendations

22. Given the uncertainties described above and current information gaps, before proceeding with investment in LNG, it is important that options for natural gas supply be more fully analyzed with emphasis on: (a) the potential market for natural gas in the short and medium term (i.e., to 1990 and 1995); (b) the existing cost estimates for LNG, taking account of the deficiencies identified by the mission; (c) alternative gas options; (d) gas pricing; (e) preliminary design of the gas transmission and distribution system, including appropriate measures for load adjustment purposes: and (f) the organization, manpower and training requirements for a national gas industry, including a review of existing safety standards. The mission estimates that such a reevaluation would be on the order of 25 man-weeks at a cost of US$90,000.

Energy Prices

23. The current Government has moved boldly towards economic pricing of energy. Across-the-board increases in petroleum product prices as of July 1, 1983, have largely eliminated individual product subsidies and improved relative product prices. Subsidies still remain on town gas and fuel oil, but the Government intends to abolish at least the latter over the near term.

24. The most important remaining pricing policy issue is the relative price of gas oil to gasoline, which at present is only 57% of the gasoline price. This pricing structure has given the wrong signal to consumers regarding the economic costs of gas oil consumption and is likely to have contributed to the need for additional gas oil imports, urban traffic congestion and air pollution. Furthermore, higher gas oil requirements combined with the projected reduction in demand for fuel oil due to coal substitution, has led the national oil company, PETROGAL, to consider investment in a hydrocracking facility.

25. Another area of concern is the Government's pricing formula for petroleum products, as this does not specifically allow for the actual costs to PETROGAL, particularly the cost and foreign exchange risk of borrowing to finance imports of crude oil.

26. As for electricity pricing, EDP's electricity bulk tariff, increased several times in recent years, has been made binding on the municipalities still outside the system, and is shortly to be raised again. But some of these municipalities have failed to pass on past rate increases to their customers, resulting in cumulative arrears in payments to EDP amounting to about US$300 million by the end of 1982. EDP expects that with Government support its tariff will be close to LRMC by 1988.

27. A contract between EDP and the coal company (ECD) requires ECD to sell and EDP to buy coal at a price linked to ECD's manpower and 'major' material costs, as long as the price does not exceed the equivalent value of fuel oil. The present price of domestic coal to EDP appears too low to provide a satisfactory financial return to ECD.

Recommendations

28. The real price of gasoline should be held constant and that of gas oil allowed to rise closer to the gasoline price by 1985. The rationale for closing this gap is to signal to consumers the economic cost of high gas oil consumption: (a) higher liquid fuel consumption in the transport sector than might be the case if the gas oil were priced at a level closer to that of gasoline; (b) the encouragement given to the use of heavy vehicles with consequent road track costs; (c) the environmental costs of exhaust emissions and noise in urban areas, which could hinder certain revenue earning activities such as tourism; and (d) increased congestion due to the encouragement of larger vehicles and taxis which have a convenience/price advantage over public transport. A study is recommended to determine how to achieve the relative price alignment, with particular reference to the modal choice in transport and the associated costs and benefits. It is estimated that this study would require about 25 man-weeks at a cost of US$90,000.

29. The effects of a policy to alter the relative prices of gasoline and gas oil should be taken into account in formulating refinery policy, including the option of direct imports of petroleum products to meet requirements.

30. The long-standing negotiations for the revision of the ex-refinery pricing formula for petroleum products should be concluded and a formula agreed upon which would assure full cost recovery for efficient importing and refining of crude oil by PETROGAL, including net financial costs. The treatment of the foreign exchange risks and interest on arrears in payments to PETROGAL from the Foreign Exchange Risk Guarantee Fund and the Supply Fund should be clarified as part of the agreed pricing formula, and, thereafter, appropriately reflected in the accounts of all concerned parties.

31. The mission supports the Goverment's intention of ensuring the timely implementation of the decrees establishing the uniform national electricity tariff and of the process to determine and regularize the payment of the amounts due to EDP from municipalities which have their own low-tension distribution systems.

32. Finally, regarding Lisbon's town gas system, a small technical/economic study also should be undertaken of town gas supply options, including closure of the system and the concomitant expected increase in demand for LPG and electricity. This would require about 10 man-weeks at a cost of US$40,000.

Energy Conservation in the Transportation Sector

33. Energy consumption in the transport sector accounts for 29% of total final energy consumption and is mainly for road vehicles (83% of the total); the transport sector is second in importance only to industry as a target for fuel savings. However, the conservation policy for achieving the fuel savings projected in PEN is not clearly defined mainly because of (a) the divided responsibility between the Ministries of Transport and Energy; (b) the tendency to take decisions on fuel and vehicle taxation independently of an analysis of agreed upon conservation objectives, and (c) the low priority apparently given to the problems of energy consumption in transportation by regional and local officials.

34. Furthermore, improved energy efficiency in the transport sector is constrained by several factors. First of all, the wide differential between the price of gas oil and the price of gasoline is not economically justified. Although a special tax on diesel cars is intended to compensate for this differential, the amount of the tax has not kept pace with changes in the absolute prices of the two fuels. Secondly, technical regulations for vehicles have not been designed to reduce fuel consumption, air pollution and the high number of road accidents. This is especially desirable, given the high average age of vehicles in Portugal. Thirdly, public transport service in Lisbon has deteriorated in the face of population growth, the congestion caused by private cars, and the absence of a well defined public transport policy.

35. Finally, the road haulage market is characterized by overcapacity, leading to underutilization of vehicles, low annual mileage, poor rates of return (and hence, an inability to invest in new, more efficient vehicles), an increasing percentage of "empty" journeys, and excessive fuel consumption. There is considerable scope for improving fuel efficiency and this would reduce fuel costs and the cost per ton kilometer of goods transported, of which fuel cost accounts for some 28%.

Recommendations

36. The mission recommends that the Government appoint an interministerial commission to identify the best way to effectively coordinate conservation efforts in transportation, including (a) development of a transportation energy management plan; (b) collection of reliable statistical information on energy consumption trends in the transport sector; and (c) establishment of procedures for evaluating the results of policy measures.

37. Furthermore, it is important that a follow-up study also be made to determine the feasibility of a number of fiscal and technical measures outlined by the mission. These include a phased program of vehicle inspection, special measures for energy savings in heavy road transport, including fuel consumption control equipment, and the establishment of "freight offices" or information systems to optimize goods transport and thus reduce the number of empty journeys. It is estimated that these will require 70 man-weeks of studies at a cost of US$280,000.

38. The capital costs of the measures recommended for improving the efficiency of energy use in transport would be on the order of US$80 million. These investments are estimated to bring about fuel savings of 225,000 toe per year, or around ten percent of current petroleum product consumption in the transport sector. The resulting annual savings would be US$50 million, in addition to other associated benefits such as reduced air pollution and traffic accidents.

Summary of Recommended Studies

Study	Estimated Cost ($US)
1. Alignment of Gas Oil and Gasoline Prices - 25 man-weeks	90,000
2. Technical/Economic Aspects of Town Gas Supply Options in the Lisbon Area - 10 man-weeks	40,000
3. Reevaluation of the Natural Gas Option - 25 man-weeks	90,000
4. Development of an Energy Management Policy for the Transportation Sector - 70 man-weeks	280,000
Total	500,000

this page blank

RWANDA: ENERGY BALANCE, 1979
(tons of oil equivalent)

	Fuelwood	Charcoal	Agricultural Residues	Peat	Petroleum Products: Gasoline	Petroleum Products: Kerosene	Petroleum Products: Gasoil	Petroleum Products: Other	Electricity	Total
Supply										
Primary Production	800,000	0	170,000	650	0	0	0	0	7,744	978,394
Imports	0	0	0	0	20,089	6,618	12,746	5,370	8,432	53,255
Charcoal Production	-30,000	6,000	0	0	0	0	0	0	0	-24,000
Power Generation	0	0	0	0	0	0	-185	0	130	-55
Total	770,000	6,000	170,000	650	20,089	6,618	12,561	5,370	16,306	1,007,594
Demand and Losses										
Household	730,000	5,500	170,000	0	10,089	5,618	0	0	2,795	924,002
Commercial & Government	25,000	500	0	0	4,000	1,000	0	0	6,325	36,825
Industrial & Mining	15,000	0	0	650	2,000	0	4,000	2,500	4,423	28,573
Transportation & Construction	0	0	0	0	4,000	0	8,561	2,870	0	15,431
Trans/Dist Losses	0	0	0	0	0	0	0	0	2,763	2,763
Total	770,000	6,000	170,000	650	20,089	6,618	12,561	5,370	16,306	1,007,594

toe = 10.5 mn kcal
kWh = 2670 kcal

RWANDA 1/

1. Rwanda is a small, low income, densely-populated landlocked country, and its principal energy problems are related to these characteristics. Most Rwandans are forced by their low incomes to use traditional fuels -- wood when available, agricultural residues when necessary -- for cooking and other basic energy needs. The high density of Rwanda's population relative to both total and arable land area has made woodfuels increasingly scarce and puts reforestation efforts in competition for land with food and cash crop production.

2. As a land-locked country, Rwanda is dependent on overland transport routes crossing other countries for almost all of its imports, including oil. In Rwanda's case, the main route is long and mostly over highways, unit costs are therefore high. Furthermore, events in Uganda have at times closed the route, and there is a perceived danger that this could happen again and a concensus on the principle of establishing a reserve stock of oil products. The inconvenience of crossing Kenyan territory is not so much in terms of security as price: Kenyan insists that Rwanda purchase oil products from its (underutilized) Mombasa refinery and sets export prices above the level Rwanda might expect to pay if it were able to purchase products in the open market and bring them across Kenya in transit. Improvements in transport links between Rwanda and the Indian Ocean across Tanzania are underway and should ease (but will not eliminate) these problems.

3. Rwanda's major hydro resources are found along its boundaries and thus require at least bilateral agreements for development: major sites exist along the Zairean and Tanzanian borders. Rwanda has an electric power grid connected with those of Zaire and Burundi through an existing power plant (Rusizi I) from which all three draw power. The institutional arrangements involved have worked well. However, they have not yet been extended and strengthened to the extent necessary to support the joint hydro development that from a strictly techno-economic perspective is the least-cost option for meeting the growing demand on the system. Rwanda also needs to further an existing agreement with Zaire on development of its only known hydrocarbon resource: the large quantities of methane dissolved in the lower depths of Lake Kivu, which is shared by the two countries.

4. Technical and management skills are scarce in Rwanda. This particularly effects the prospects for developing the country's methane and peat resources because of the major technical questions surrounding these that still need to be resolved, but it also generally inhibits effective policy-making and the planning and everyday management of energy producing, handling, and consuming institutions.

1/ Adapted from Report 3779-RW, June 1982.

Economic Context

Rwanda's GDP per capita in 1979 was about US$200 and population about 4.9 million. Growth rates for 1970-79 averaged 4.1% p.a. for GDP and 2.8% p.a. for population. Agriculture contributed 42% of the GDP, of which four-fifths was subsistence crops. Agricultural exports provide two-thirds of export earnings, with coffee alone accounting for about 60% in 1978/79. Tin ore and tungsten account for about 20% of export earnings. The largest category of imports is consumer goods; petroleum imports account for about 10% of total imports, less than foodstuffs and about equal to textiles.

Energy Consumption and the Economy

5. Energy is consumed in Rwanda predominately in the form of fuelwood and other traditional, non-commercial fuels, including agricultural residues and charcoal that are primarily used for household and institutional cooking and by some small industries. Available data allow only a rough estimate of the volumes involved but these fuels account for over 95% of the total energy consumed. Only a small fraction, predominately charcoal, of the traditional fuels, is marketed.

6. The dominant position of traditional fuels in Rwanda's energy balance reflects the importance of rural, smallholder farming in the economy. Over 95% of Rwanda's inhabitants live on small family farms, working in subsistence agriculture which provides little or no spare land on which to plant energy crops and little or no cash to buy commercial energy. A 1975 study found that nearly half of the rural farmers had a monthly cash income of under 500 RwF (about US$5.50). Fourteen percent report no cash income at all. The principal sources of rural cash income included small-scale coffee production and sales of homemade banana beer. There is little use of hired labor. While Rwanda is fortunate in having relatively good soils, favorable climatic conditions which allow two crops per year in most areas, and variations in climate and elevation which permit a wide variety of crops to be grown, it is mountainous and densely populated. Crop yields are generally low, as fertilizers and improved seeds are virtually unused and agricultural extension is ineffective. With a population of nearly five million and an area of 26,338 km^2, Rwanda has the highest population density of any mainland African country, 183 per km^2.

7. Commercial fuels, namely petroleum products and electricity, account for only 10% of total consumption. Petroleum products (7% of energy consumed(are used by the modern, urban sector, mainly for vehicle fuel. Electricity (3% of total energy consumed) is used for some

industries, government buildings and by upper income urban households. Commercial energy demand is concentrated in the towns (Kigali, the capital, is the largest with a population of about 110,000. The second largest, Butare, has about 25,000 inhabitants) and isolated institutions such as tea factories, missions and mines.

8. Commercial energy consumption grew at an average annual rate of about 9% over the period 1975-80, considerably faster than GDP in real terms. Nonetheless, commercial energy consumption per capita and per unit of GNP remain lower than in most other countries of similar size and income level.

9. No firm foundation exists for projecting Rwanda's future commercial energy consumption. The likelihood of a continuation of the growth pattern of the 1970s (strong GDP growth in spite of weak agricultural performance) appears small because of the continuing deterioration in the country's external terms of trade. Projections of Rwanda's balance of payments show a deterioration from a small surplus position (on average) through the 1975-79 period to a deficit of $170 million by 1985, a level that would be sustainable only with a dramatic increase in official external assistance on capital account that would in turn require both a significant improvement in project preparation and implementation and a significant increase in non-project assistance. Not only is the future macro-economic environment unclear, but the identification and analysis of individual investment projects under consideration for inclusion in the 1982-86 Five-Year Plan was not far advanced at the time of the mission.

Energy Issues and Recommendations

10. There are generally strong associations between specific sources of energy and specific categories of energy demand in the Rwandan economy. The bulk of the population uses firewood and agricultural residues for their 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 transport and construction, while electricity, obtained virtually entirely from imported and domestic hydro, is used in urban areas for lighting and operating electrical machinery. While this compartmentalization is not complete -- some users can and do shift among traditional fuels, oil and electricity for some uses -- and development of Lake Kivu's methane could create a substantial link among methane, electricity and oil users, this division reflects the situation sufficiently well to warrant treating energy in the Rwandan context more as a series of parallel subsectors than as an integrated whole at the present time. This situation suggests that efforts to strengthen Rwanda's energy planning capacity be concentrated at the subsector level.

11. It is worth emphasizing that while it is more convenient to label the energy subsectors according to the 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 any more important than those related to energy demand. In the fuelwood and peat (or "rural household cooking, heating and lighting") subsector in particular, efforts to improve the efficiency with which energy is used appear to offer a higher and faster return than efforts to increase supply.

12. The mission has identified five major areas of priority action, the first and most important of which concerns firewood, charcoal and agricultural wastes. Rwanda's heavy dependence on woodfuels had led to deforestation, particularly in regions that are densely settled. The current and planned reforestation projects, largely financed by external donors, which are overseen by the Director of Waters and Forests in the Ministry of Agriculture and Livestock, appear to make good use of the resources available for tree planting and aerial surveys indicate that there have been increases in tree cover in some areas during the past ten years. Moreover, a work plan for development of a national forestry policy and an overall forestry sector development plan prepared in draft outline in the Directorate of Waters and Forests is a further useful step, although data collection on the extent and type of forestry resources by region, on wood use for various purposes, and on household consumption of fuelwood and agricultural wastes will also be needed to effectively allocate forestry resources. Funds will be needed for this work. Also, effective implementation of reforestation schemes will require a substantial increase and reorientation in forestry extension work and the government should consider increasing budget allocations for this purpose. Until recently, extension workers have functioned primarily as guardians of state forestry plantations and woodlots. They now need to be trained to deal directly and frequently with the rural population with the aim of teaching farmers how to plant and manage their own private woodlots and how to conserve woodfuels and agricultural wastes used by their families for cooking. Improved cookstoves for wood, wastes and charcoal, suitably adapted for local conditions, are an integral part of conservation and a program should be developed to encourage people to convert from their traditional models which use twice as much fuel as the improved models. To ensure forest conservation, charcoal production licensing fees should be introduced and simple improved kiln models should be provided. These could reduce energy loss during the conversion process by up to 30%.

13. Peat might provide a partial substitute for firewood for small industries and for rural institutions in a few areas, and perhaps eventually for urban households that would otherwise purchase fuelwood or charcoal. Detailed information on the extent of Rwanda's peat reserves, and on their potential for exploitation, is still being collected. Indeed, there is an urgent need to determine how much exploitable peat Rwanda actually has. Hydrological surveys should be carried out in certain areas like the Rugezi, which cannot now be considered suitable

for exploitation because of the unknown ecological effects of peat extraction, to determine whether and how it may be possible to exploit them safely. The wet, colloidal peat reserves of the Akanyaru Basin are believed to be substantial in quantity, but extracting and processing them into a usable fuel is likely to be complex and costly. Results of the IDA-financed study of alternatives for exploiting similar but more easily drained bogs in Burundi should be awaited before any substantial investment is made in detailed surveys of Rwanda's share of the basin and in attempting to develop this type of peat. Along with the hydrological surveys needed to reveal the extent and location of Rwanda exploitable peat resources, there is a need to identify and develop suitable markets for peat. Currently, a pyrethrum-drying plant is the largest consumer of peat, and the quantity consumed is very small. If it turns out that the most easily exploited peat is located in remote areas far from potential users, high transport costs may greatly reduce its ability to compete with other fuels, though it may be possible to develop local industries near the peat, once a dependable source of supply has been locted.

14. At the present time, the responsibility for peat activities in Rwanda is in a small office in the Ministry of Natural Resources. If surveys show the feasibility of substantial peat extraction and marketing, a larger staff may be necessary, but for the time being the current arrangement is adequate.

15. The second major priority area is oil. Rwanda has no domestic oil roduction or refining activity, and no apparent prospects for petroleum exploration. Petroleum product imports at 50,000 tons/year are relatively small, accounting for only 10% of total imports (despite an average c.i.f. cost of nearly $100 per barrel(and come to Rwanda by truck from Nairobi, a distance of about 1,250 km. Following a supply interruption during the Uganda war, the government has been concerned to develop a national petroleum reserve. The mission recommends that, before the large, new stockpiling facilities now planned are filled, a contingency plan be developed covering the use and reconstitution of the reserves. The mission also recommends imposition of a storage fee or tax which would pass on the costs of building and maintaining reserves to the consumers who will benefit from them.

16. Rwanda is put at a disadvantage in the petroleum product market by the high cost of transport and the virtual monopoly position of Kenya, which charges a premium of about $15 per barrel for exported oil products over the (hypothetical) cost of gasoline and diesel fuel purchased at spot market prices in the Persian/Arab Gulf and shipped to Mombasa. The mission recommends that consideration be given to the alternative of purchasing oil in international markets and bringing it across Tanzania once the Rusumo-Isaka road is opened.

17. Electricity is another priority area. Most of the electric power consumed in Rwanda is currently purchased from Zaire. Rwanda has,

however, substantial domestic hydroelectric potential, some of which is already utilized. The principal hydropower plant, Ntaruka, was used at twice its regular capacity in 1978 and 1979 to cover electricity requirements prior to completion of the interconnection with Zaire, and is now operating at low capacity to allow the lake to refill. Another hydroplant began operation in February 1982 at Mukungwa. Rwanda has an interconnected power grid which serves eight of the ten provincial capitals; but many of the transmission lines were built to take advantage of foreign offers to finance them without sufficiently considering their economic justification.

18. The major issues in the power sector include institutional arrangements, the development of an overall sector planning capacity and electricity tariffs. There is presently considerable dispersion of responsibilities for the power sector among various institutions, including not only the public water, electricity, and gas utility, ELECTROGAS (responsible for maintenance and operation of the power system), but also the Ministries of Natural Resources (identification of hydrosites), Public Works (construction), and Plan (some planning efforts). The mission suggests that Electrogaz should be given more control over the planning and construction phases of electrical system investments as well as over operation of the system. There is a need for an electric sector development plan to permit Rwanda to make the most efficient use of the resources available to it. A study of the power system currently in progress should provide much of the basis for such a plan, but will need periodic revision and updating. Rwanda may also have a geothermal potential in the regions around the volcanos and Lake Kivu. Chemical analyses of water samples from these areas can be carried out at a relatively low cost, and would provide a better idea of the nature of this resource. Power tariffs are currently set on the basis of operating costs, without an allowance for capital costs. The rates are however, higher than operating costs of electricity operations alone would warrant since they are set to cross-subsidize the water supply operations which Electrogaz also handles. The mission recommends that the tariff review component of an ongoing study of the power sector is given special attention.

19. Another issue, international in scope, but most significant for Rwanda is the Rusizi II hydro-power plant which is being promoted by Rwanda, Zaire and Burundi under the Economic Community of the Great Lakes Countries, through the Energy Organization of the Great Lakes Countries (EGL). This project is clearly the least cost method of providing Rwanda with additional energy. Agreement has been reached on the basic design parameters of this project.

20. Rwanda has access to a unique resource which, depending on how it is developed, could prove a partial substitute for imported oil and/or electricity: the estimated 65 billion Nm^3 of methane dissolved in the bottom strata of Lake Kivu on the border with Zaire, of which some 50

billion Nm^3 are considered recoverable. 2/ A total of 14 million Nm^3 of methane was extracted by a pilot plant and used in a brewery between 1963 and 1976. Key issues in this sector include choice of extraction techniques and the rate of extraction, the need for an agreement with Zaire on exploitation of the resources, and the potential market for large scale production. Development on a large scale will have to proceed cautiously to avoid setting up a pattern of vertical circulation of water within the lake that would cause large quantities of methane to come out of solution, and be dissipated in the atmosphere or cause a major fire or explosion. It is recommended that an international panel of scientist and engineers advise on safety restrictions and lake-monitoring requirements that should be imposed on any scheme to develop the resource.

21. Before any major gas extraction effort can begin, Rwanda and Zaire must reach agreement on terms for implementing an accord signed in 1975. This agreement should be discussed soon and the mission recommends that Rwanda seek an arrangement under which each country would have maximum flexibility on the development of intermediate phase plants, within guidelines set up to safeguard the resource.

22. There are a variety of possible alternative patterns of gas utilization in Rwanda and Because they have different requirements for scale and reliability of methane supply, some are better adapted to the intermediate phase, when the gas extraction technology is still being developed, tested and demonstrated, and others to a later stage when large plants can be built with confidence. Chemical plants to transform the methane into methanol or fertilizer seem unlikely candidates for the next phase of development, although they could later become the principal consumers of the gas. First consideration should probably be given to methane as a fuel, both for vehicles and for use in stationary motors.

23. The Centre d'Etudes et d'Application de l'Energie au Rwanda (CEAER) has had principal responsibility for alternative energy source research and development and has to date focussed its efforts on technologies such as solar water heaters and biogas digestors. The mission suggests that CEAER devote more of its staff time to developing technologies such as improved cook stoves and charcoal kilns.

2/ "Nm^3," "normal cubic meter," or a cubic meter at one atmosphere of pressure and 0^oC. It is equal to about 37.32 scf or "standard cubic feet."

Energy Sector Developments, May 1981 - January 1984 3/

24. The Rwandan Bureau National d'Etudes de Projets (BUNEP-the National Bureau for Project Evaluation) and the Ecole Polytechnique Federale de Lausanne (EPFL-the Federal Polytechnic School of Lausanne) had been retained by the Swiss aid agency, La Direction de la Cooperation du Developpement et de l'Aide Humanitaire, to make a complete study of the electricity supply in Rwanda. In May 1983, they published the results of this work, which was expanded to include an overview of the energy sector as a whole. The study's findings are similar to those of the Assessment Report in most areas and are serving as the basis for developing a national energy policy. The BUNEP/EPFL team drew up a program of energy related actions in order of priority, setting as objectives the alleviation of the fuelwood problem, augmenting the power supply, and limiting petroleum product consumption through the use of unconventional energy sources (e.g., Lake Kivu methane, solar energy, small hydro). The program includes the following activities, among others: the development and dissemination on a national scale of improved woodstoves that are well adapted to Rwanda, reforestation, substitution of charcoal by biomass (papyrus briquettes in particular), dissemination of biogas digestors, extraction of Lake Kivu gas, the supplying of energy to rural centers, setting up an industry to manufacture solar water heaters, and various activities in the power sector (e.g., a study on a rehabilitation of the system, establishing the infrastructure for maintaining the system, setting up an electromechanics training center, strengthening the Gikondo station, prefeasibility studies for the Mukungwa II, Lukarara and Nyakarongo sites, an inventory of hydro-electric sites).

25. The organizational setting of the Government's involvement in the energy sector was modified in early 1984. The Rwandan administration's participation in the sector has been centralized in the General Directorate of Energy of the Ministry of Public Works, Water and Energy (MPWWE) which thus now includes the energy related units of the old Ministry of Natural Resources. The General Directorate of Energy will ensure the coordination of the Government's energy policy. In order to assist the Directorate in achieving this objective, and following up on the BUNEP/EPFL study, Switzerland has offered in priciple technical assistance for a training program on energy planning for the Directorate's staff. The Rwandan authorities are to review with their Swiss counterparts the precise terms of such assistance.

26. With respect to fuelwood, the Government has drafted forestry subsector policy statements consisting of: (a) draft regulations, including a system for the use of existing state plantations, and (b) pro-

---

3/ Adapted from Report No. 017/84, Rwanda Energy Assessment Status Report, May 1984.

posals for the creation of a National Forestry Fund, a Forestry Law, and a Natural Forest Development Scheme. The main objectives of the Fund would be to finance small-scale afforestation programs throughout the country, and to improve the protection of existing plantations. An annual budget for the Fund would be prepared and attached to the central Government's annual budget. The Fund is to finance its operations mainly through revenues from existing plantations, thereby helping to reduce demands on the Government's financial resources. In terms of manpower needs, the Forestry Division of the Water and Forestry Department has received substantial technical assistance from Switzerland and has been strengthened by the hiring of several young Rwandan foresters. However, there is still a lack of trained forestry personnel which hinders the effective management of State forests.

27. On the demand side of fuelwood and charcoal, the top priority given in the BUNEP/EPFL study to the dissemination of improved woodstoves reflects the Government's heightened interest in fuelwood conservation. The role of the newly-formed Directorate of Energy is to include coordinating future work on cooking stoves. Given the increasing depletion of Rwanda's forestry resources, the time required for reforestation and the fact that about 95% of Rwanda's population is rural, the dissemination of an improved woodstove in rural areas is indeed a task which needs to be addressed urgently. Although some models of improved woodstoves have been tried out by different organizations on a small scale in rural areas in Rwanda, there is as yet no well established, ongoing effort to design and field test an improved stove for eventual dissemination on a significant scale. With the help in particular of the Ministry of Social Affairs and Community Development, AIDR (Association Internationale de Developpement Rural) has submitted a proposal to the Government for dissemination of improved woodstoves on a national scale. AIDR's proposal focusses on ensuring follow-up work among stove users (training in proper use and maintenance) by means of the existing extension networks of several ministries. Before launching such a program even on a pilot basis, conclusive field tests would have to be made to establish the technical performance and acceptability to the population of various stove models. Furthermore, the agencies to be involved in the extension work would have to make a more explicit commitment of their resources to this effort, and a plan to coordinate their participation would have to be drawn up.

28. Attempts to introduce improved woodstoves in numerous countries have brought out the importance of adequate project preparation. The potential for the successful development, production, quality control, marketing, and after-sales service of truly efficient stoves must be demonstrated before investing in the subsequent phase of large-scale dissemination. To set up a stove dissemination program in rural Rwanda, a review of the performance and acceptability of the models introduced so far, and an analysis of the incentives which would induce Rwandans in rural areas to use an improved stove are now required. Based on the results of this work and on a thorough understanding of local cooking practices, the designs which hold the most promise for successful

introduction and energy savings should be chosen. These designs could be either completely new or derived from those already in use in Rwanda. Field tests should then be carried out to confirm the viability of the designs, and strategies to promote production and dissemination of the stoves should be worked out. On this basis, a self-sustaining system can eventually be established for producing and disseminating improved woodstoves on a national scale. A component of the IDA Integrated Forestry and Livestock Development Project includes preliminary work on stoves in rural areas along the lines described above (market survey, evaluation of models introduced to date, design and field testing of stove models, analysis of production and dissemination mechanisms, formulation of pilot stove program).

29. While the preliminary work which is necessary for introducing improved woodstoves in rural areas is being carried out, fuelwood conservation should also be promoted through the use of improved stoves in and around Kigali, where: (a) the population is already accustomed to using stoves for cooking, (b) there is already a well-established artisanal production and dissemination structure for traditional stoves, and (c) since up to 25% of family incomes is being spent on charcoal, there is an incentive to switch to models which are more efficient than the traditional one. These considerations suggest that the development of an energy-efficient charcoal stove, which should also be inexpensive and well-adapted to local conditions, could make a significant contribution in the near future to fuelwood conservation efforts. A project in this field would include the design of such a stove and would build on the existing private production and marketing infrastructure to eventually disseminate it on a large scale.

30. Peat production in Rwanda remains problematic. A pyrethrum flower processing plant (OPYRRWA) using peat from the Kiguhu bog remains the principal peat consumer, and the French aid agency, the Fonds d'Aide et de Cooperation, continues to fund cokefaction tests on peat from near Cyangugu. However, the Rwandan authorities working on peat have decided that exploiting the Rugezi bog near Ruhengeri and the Kamiranzovu bog in the Nyungwe forest is not of immediate interest because of the possibility of disturbing their hydrological balances, and the peat in other bogs has proven to have too high an ash content (over 20%) for energy uses. Furthermore, the problems associated with producing peat from the Akanyaru River Basin, where reserves are the most extensive, have not been resolved. In particular, because the draining of the Akanyaru bogs is problematic, production can only take place for a short time each year, during the dry season, and drying the peat presents difficulties. Irish bilateral aid is continuing to assist in pilot production from the Busoro bog in the Akanyaru Basin, and in 1982 peat production by means of a semi-automatic macerating machine was mastered. The bog's total output reached about 500 tonnes in 1982, and more machines would be needed to augment it. This peat was distributed for household cooking and for use in smithies. In the first case, complaints about smoke and the breaking of pots point to the need for a stove designed to burn peat if this fuel is to be used for cooking, and in the second, tests showed that the scrap-iron would not melt.

31. The Finnish firm EKONO has recently proposed to the Government a project to study the possibility of developing another Akanyaru bog known as the Bugesera, which is situated 30 km south of Kigali, and to evaluate possible uses of the peat, in particular to supply a 10-MW power plant.

32. In the petroleum sector, gross domestic consumption of products for energy purposes in 1982 rose to an estimated 47,580 toe, up 9.3% p.a. from 36,391 toe in 1979, while the oil import bill for 1982 amounted to US$49 million, an increase of 28.7% p.a. from US$23 million in 1979. Rwanda continues to buy all of its petroleum products from the Mombasa refinery, and the fact that the Rusumo-Isaka road has not been paved yet has prevented considering the feasibility of purchasing oil in international markets and bringing it across Tanzania in transit, which according to the estimates made in the Assessment Report would reduce Rwanda's oil bill by about 20%.

33. Total electricity sales by ELECTROGAZ grew at an average of about 12.0% p.a., from 52.3 GWh in 1979 to 73.4 GWh in 1982. On the generation side, Lake Bulera, the natural reservoir for the Ntaruka hydro plant whose level was lowered because it was used beyond its annual average availability of about 20 GWh, has not yet returned to its original level. Ntaruka produced 17 GWh in 1982 and was expected to generate 18 GWh in 1983. An IDA assisted Power Project is being prepared to rehabilitate the Ntaruka power station. The Mukungwa hydroelectric generating station, which has been in operation since February 1982, is designed to produce about 48 GWh year when Lake Bulera is refilled. Mukungwa's production was 42 GWh in 1982 and was expected to be about 45 GWh in 1983. Following up on the completed feasibility study of the proposed Gihira hydroelectric generating station (1.5 MW) in northwestern Rwanda near Gisenyi, construction works for the plant were to start at the end of 1983. A 30-kV transmission line connecting Gisenyi to the grid at Ruhengeri is already under construction. The Kreditanstalt fur Wiederaufbau (KfW) is funding both the plant and the transmission line. Rwanda, Burundi, and Zaire have decided to participate in the Ruzizi II hydroelectric project (two 13.3 MW generating units), to be cofinanced by IDA, the European Development Fund, the Government of Italy and the European Development Bank. The project was approved by the IDA Board on December 6, 1983, and work on construction will begin around mid-1984. The plant should come into service in end 1987. A reduced scheme of 80 MW has been decided on for the Rusumo Falls plant on the Kagera River, and invitations to submit feasibility study proposals were to have been sent to consultants at the end of 1983.

34. The BUNEP/EPFL study concludes that an infrastructure (equipment and personnel) to maintain Rwanda's electricity transmission and distribution network needs to be established, and that the network needs to be rehabilitated. The rehabilitation of the transmission system would be undertaken under the proposed IDA Power Project mentioned above, as would the construction of two new transmission lines. The study also emphasizes manpower needs in the power subsector and recommends the

creation of training schools. Bilateral aid from the Federal Republic of Germany to furnish technical expertise to ELECTROGAZ and to train Rwandan counterparts has been considerably reduced. The construction of a training center for ELECTROGAZ, financed under the IDA First Water Supply Project, would be complemented by the provision of training consultants in electricity under the IDA Power Project.

35. With respect to the Lake Kivu methane, the completed, UNDP financed rehabilitation of the Cape Rubona extraction plant resulted in an increase in production to a current level of about 3,000 to 6,000 Nm^3 per day (about 1.0 to 2.0 million Nm^3 per year). As the methane continues to supply a brewery whose total needs amount to about 10,000 to 12,000 Nm^3 per day, ELECTROGAZ has commissioned a study of the feasibility of expanding the production to 20,000 Nm^3 per day (about 7.0 million Nm^3 per year). The European Development Fund is to finance prefeasibility studies for development of the gas at Gisenyi (Rwanda) and Kalehe (Zaire). At Gisenyi, a gas extraction plant (25 million Nm^3 p.a.) would supply a urea plant and a plant to compress the gas for vehicular use, while the gas extraction plant at Kalehe (20 million Nm^3 p.a.) would supply a methanol plant, provide gas as a fuel in the Katana cement plant, and also supply a plant to compress the gas for use in vehicles.

This page blank

SENEGAL: ENERGY BALANCE, 1981
(thousand tonnes of oil equivalent)

	Fuelwood	Charcoal	Crude Oil	Petroleum Products							Natural Gas	Electricity	Total
				LPG	Gasoline	Kerosene	Jet Fuel	Diesel	Fuel Oil	Total			
Primary Supply													
Production	1300	-	-	-	-	-	-	-	-	-	0.2	-	1300.2
Imports	-	-	684.8	6.3	21.1	-	40.1	47.5	82.2	197.2	-	-	882.0
Stock Changes	-	-	(27.2)	(0.2)	(10.5)	2.1	16.4	7.3	(8.4)	6.7	-	-	(20.5)
Total	1300		657.6	6.1	10.6	2.1	46.5	54.8	73.8	203.9	0.2	-	2161.7
Transformation and Losses													
Oil Refining			(657.6)	6.8	138.6	18.1	102.4	133.5	226.1	625.5			(32.1)
Charcoal Production	(339)	120											(219.0)
Power Generation								(7.6)	(184.5)	(192.1)	(0.2)	52.7	(139.6)
Trans/Distrib. Losses												(5.3)	(5.3)
Secondary Exports	—	—	—	(0.8)	(37.0)	(8.5)	(4.9)	(34.1)	(1.5)	(86.8)	-	-	(86.8)
Net Supply	961	120		12.1	112.2	11.7	154.0	146.6	113.9	550.5		47.4	1677.9

toe = 10.2 mn toe
kWh = 2040 kcal (production)
= 860 kcal (consumption)

SENEGAL 1/

1. Senegal faces two main energy problems. First, its almost complete dependence on imported oil for its "commercial" energy places a growing burden on the balance of payments. In 1981, net oil imports absorbed over 50% of merchandise export earnings. Second, overexploitation of the natural forests, which account for over half of the country's energy supplies, is causing rapid deforestation, leading to growing scarcity and rising prices of fuelwood and charcoal.

Government Strategy

2. The Government's policy for solving these problems, known as "RENES", 2/ aims to halve internal consumption of petroleum products by 1990. The Government strategy is:

(a) to substitute indigenous energy such as peat, or other, less costly, imported fuels such as coal for imported petroleum; and

(b) to restrain energy demand by increasing the efficiency of utilization.

Translation of RENES policy into specific operational programs and projects will require the resolution of some important issues, as summarized below. It will also entail a major increase in the allocation of investable resources to the energy sector as the country moves from an essentially recurrent cost-based commercial energy supply system to one where a progressively larger share of energy supply will be produced locally or from imported fuels which have a lower total cost but entail higher capital expenditures.

Supply Options

3. Senegal's indigenous energy resources are significant in relation to its energy needs and also reasonably diversified. They comprise a share of the hydropower potential of the Senegal and Gambia rivers (about 1,400 MW, with an average production capability of 7,500 GWh [1.9 million toe]); limited petroleum resources which have not been well defined; a small natural gas deposit (40,000 toe); about 10 million

---

1/ Adapted from No. Report 4182-SE, July 1983.

2/ "Redeploiement Energetique du Senegal," or "Energy Restructuring of Senegal."

Economic Context

Senegal is a poor country of some six million inhabitants, lying three quarters in the Sahel zone, characterized by low rainfall and periodic drought. Three quarters of the population, which is growing at 2.8% p.a., live in rural areas, and, in a normal year, agriculture exports account for over half of total export earnings. The mainstays of the traditional economy are millet cultivation and nomadic cattle raising for domestic consumption, and groundnut cultivation for export. The modern sector of the economy is concentrated in the area of Dakar, the capital, which has about one million inhabitants, excellent port facilities, an important industrial sector and a small but fast-growing tourism industry.

Since independence in 1960, the economy has grown at only about 2% p.a., while population has grown at 2.5% p.a., so that GDP per capita has declined. The economy is highly vulnerable to fluctuations in the volume and prices of its main exports, groundnuts and phosphates. During the last decade there has been a series of bad crops, and export prices for groundnuts and phosphates also declined sharply after 1975. The adverse effects on the balance of payments have been aggravated by the increases in the price of imported petroleum, resulting in a loss in income since 1974 of roughly 5% of GDP. GNP per capita in 1980 was US$450, close to the bottom end of the range for all middle-income developing countries of US$420-4500.

The Government has embarked on a five-year stabilization and rehabilitation program with Bank and IMF support. The aim is to stabilize the economy in the first two years of the period and to achieve an economic growth rate of about 4% p.a. in the subsequent three years.

dry tons (3.7 million toe) of peat; lignite possibilities; and significant fuelwood potential (1.3 million toe supplied in 1981). The long-term energy potential of biomass (crop and animal residues), and of solar and wind resources, also appears to be significant. The development of all these resources could ultimately supply a good portion of Senegal's energy requirements, but in the short term their development will be restricted by considerations of location, heavy investment requirements and institutional and political factors.

Hydropower

4. Exploitation of the hydropower potential of the Senegal and Gambia rivers is the responsibility of two multinational organizations. 3/ Individual projects can proceed only with the agreement of the member countries, which can cause delays. Furthermore, for most of the projects the irrigation aspect determines the economic justification, while the electricity production aspect is providing, at best, a marginal improvement of the overall rate of return. This low return is largely due to the fact that the sites are 500-760 km from the main load centers in western Senegal, requiring heavy transmission investment.

5. The Manantali dam on a tributary of the Senegal river in Mali is already being developed as an irrigation project, with navigation benefits, but it could also be used to generate 240 MW of power, of which Senegal's agreed share is 40%. Its distance from the main load center at Dakar would involve high transmission costs. To be economic, probably at least half the output (120 MW) would have to be supplied to Senegal. The current estimate of the power station capital cost treats the dam as a "sunk" cost, but political negotiations have not proceeded with the other participants in the project who may wish, in any case, to charge Senegal a "rent" for use of the dam to generate power. Another problem is that the project would make the Senegalese power system heavily dependent on a source of electricity located in another country. Detailed feasibility studies remain to be carried out both for the power station and the transmission line. Kekreti (75 MW) and Sambangalou (135 MW) are the two most promising projects on the Gambia River. They are still at the preliminary study stage and are unlikely to be in operation before the early 1990s.

Oil and Gas

6. The petroleum resources have not been well defined. The Dome Flore field, with probable light oil reserves of 1.8 million toe, is the only discovery to date. The Government is trying to interest foreign

---

3/ The Organization for the Development of the Senegal River (OMVS), whose members are Mali, Mauritania and Senegal; and the Organization for the Development of the Gambia River (OMVG), whose members are Gambia, Guinea, Guinea-Bissau and Senegal.

companies in a possible joint exploration venture with the national oil company, PETROSEN. However, there is a jurisdictional dispute over the area with Guinea-Bissau. The identification of further reserves will depend on the success of the exploration efforts which the Government is now trying to promote. A small natural gas deposit is already being used as fuel for the baseload operation of the combustion turbine at Cap des Biches, and should suffice to generate 90 GWh. However, it is not clear whether this is a better use than for peak operation.

Petroleum Refinery

7. The decision of the shareholders to revamp and expand the capacity of the petroleum refinery from 900,000 to 1.2 million tons seems surprising in the light of the RENES program to halve petroleum product consumption by 1990, but it was apparently based on the export rather than the domestic prospects. Although the market outlook has worsened since the original decision was made, it now seems better to complete the project rather than to abort it, since over 40% of the total cost has been committed. Nevertheless, the appropriate level and mix of operation still needs to be determined.

Peat

8. Various studies are under way to evaluate the feasibility of developing peat deposits found in depressions between dunes north of Dakar, called "Niayes". Potential applications include electricity generation, industrial or household fuel, and use as an organic material for agriculture. The Government favors electricity generation, for which resource is sufficient to supply two 20 MW thermal units over their lives. However, no final decisions can be taken until completion of ongoing peat studies in late 1983. Further work will probably still be required before deciding on specific projects. It is unlikely that peat could be available as a fuel before 1988.

Lignite

9. Lignite occurrences have been reported from drillings for oil, water and phosphates, but virtually no samples are available to test the quality. A proposed reconnaissance program with French financing will determine whether further work is justified. Even if the results of the reconnaissance are favorable, lignite could not be commercially available before the early 1990s, given the lead time for defining the reserves and mounting a mining project.

Fuelwood

10. The natural forest cover has been reduced by 30% in the last thirty years, and on present trends would decline another 20% by the end of the century. The remaining fragile forest cover of the understocked and overpopulated western regions will soon be destroyed unless urgent remedial action is taken. The important conclusion emerging from the

mission's review is that supply could match demand provided effective measures to reduce per capita consumption (efficient cooking stoves) are combined with:

(a) systematic exploitation of the largely untapped forestry potential of eastern Senegal, especially Casamance;

(b) an improvement in management of natural forest in overexploited areas; and

(c) development of rural and state-managed afforestation programs.

However, forestry institutions would need strengthening, and a more rational pricing and taxation policy for fuelwood would be necessary to finance the cost (US$6 million/year in the early 1980s, rising to US$10 million/year in the later 1980s).

Solar and Wind Energy, and Biomass

11. The long term potential for solar and wind energy applications appears significant and small-scale use in isolated locations may soon be feasible if expected cost-reductions and technical improvements are secured. The allocation of investments for solar and wind energy development in the Fifth Plan (1977-1981) was excessive (US$27 million) in the Senegalese context. Moreover, donors have used Senegal to carry out experiments, resulting in an onerous dispersion of effort over too many projects, particularly in solar energy, with unsatisfactory results. Insufficient effort has been devoted to the collection of data on insolation and wind-speeds. The energy potential of crop residues and animal manure has been virtually ignored. The proposed Sixth Plan program is more modest (US$6 million), but suffers from similar defects in that there is little distinction between projects with good near-term potential and those that may only be viable in the longer term.

Imported Coal

12. A recent study concluded that coal could be imported at a landed cost of about US$100/ton, or about 20% cheaper than petroleum of equivalent heat content. Even at this relatively high price, coal-fired electricity generation would be cheaper than oil-fired. Coal could also be substituted for oil in the cement and phosphate industries, depending on the costs of conversion, which are being studied.

Electricity Supply

13. SENELEC's latest development program would lead to premature and excessive investments. It proposes the addition of 285 MW of capacity by 1990 for a system with a current capacity of 175 MW and maximum demand of 108 MW. According to the mission's projection (based on a more realistic load forecast, a less lavish reserve capacity criterion and the retention rather than retirement of old plant), the

addition of 165 MW would probably suffice, with the first unit (a 15 MW combustion turbine) not required until 1986, instead of 1984. Since the mission (June 1982), SENELEC has prepared a revised and somewhat reduced investment program which is being reviewed by the Government. Nevertheless, the mobilization of adequate financing for power development remains a critical issue.

Conservation

14. The mission's review of existing studies and its own investigations confirmed that oil consumption in industry could be substantially reduced by conservation measures. Potential annual savings of 63,000 toe were identified in thirteen major industrial enterprises consuming about 178,000 toe in 1980 (30% of total internal oil consumption). Half the identified savings could be achieved by investments totalling US$16 million with payback periods of less than three years. Savings of nearly 5,000 toe could be secured in transport, at relatively low cost, through introduction of the continuous working day and improved driving techniques in public transport. Other significant potential savings were identified in transportation, but these would require substantial investment (e.g. in public transport), and further study would be needed to determine whether this would be justified. There is also room for significant energy savings through improved building design and more efficient use of energy equipment and appliances, including air conditioners, in commercial buildings and homes.

Energy Pricing

15. Internal prices of petroleum products generally kept pace with international prices until 1982, when retail prices were not increased despite increases in costs. Since the Government guarantees the refinery a minimum of 12% return, this led to a serious reduction in the Government's net revenues from petroleum product taxes.

16. The present subsidies on certain petroleum products, mainly diesel oil for the fishing industry and liquified petroleum gas (LPG) stimulate the demand for these products and are inconsistent with the RENES objective of reducing oil consumption. They should be phased out, including the subsidy on butane. This has failed to achieve its objective of reducing household charcoal consumption, and there is no evidence that its benefits flow to the lower income families. The butane subsidy (which cost US$470,000 per month in mid-1982) could be more usefully allocated to reforestation and acceleration of the "Ban ak Suuf" wood stove program.

17. Failure to apply the indexing formula in the electricity tariff has kept the average electricity price lower than it should have been (by

about 8% in 1981). Non-payment of arrears by Government departments (equivalent to about one year's electricity supply to these consumers) also creates financial problems for SENELEC. Despite recent increases, the present tariff structure and rates do not fully reflect the long-run marginal costs of supply and need to be adjusted in accordance with a tariff study recently completed.

18. Fuelwood retail prices do not reflect the opportunity cost of wood to the economy. The fee for taking wood from the natural forests is less than US$2/m^3, and needs to be brought more in line, over a suitable period, with the fee for wood from official plantations (US$11/m^3). This would also help to meet the rising cost of the forestry development program.

Investment Strategy

19. Despite the scaling down of the electricity development program and the more gradual increase in reforestation efforts that are recommended by the mission, the energy sector will still place a much heavier claim on Government resources in the 1980s than has been the case in the past. The mission's estimates indicate that energy investments during the Sixth Plan period (1982-86) would amount to 16% of total fixed investment and 2.5% of estimated GDP, more than double the corresponding figures for the Fifth Plan period (1977-81). For the latter part of the decade, the mission identified project proposals that together may surpass 20% of fixed investment and 3% of GDP.

20. Given the competing claims of other sectors and the country's overall resource position, there is a real possibility that some of these investments may have to be deferred even at the expense of a continued high level of oil imports. This underlines the importance of developing a clear ranking of the various investment projects in terms of both the magnitude and timing of their expected contribution. An associated financing plan also needs to be drawn up outlining the role of public and private and domestic and external sources of funds. This report provides a preliminary analysis of investment priorities and identifies the additional information required for a more exact definition. In particular, once the relative costs of peat and hydropower development have been better defined, the sequence of investments for electric power development will need to be carefully formulated because this subsector will account for over two-thirds of the proposed new investments in energy. Outside of the power subsector the energy conservation and fuelwood development programs have a priority but will require relatively modest investment. In the petroleum subsector considerable resources may be required in the mid-1980's if the proposed exploration program results in commercial discoveries of oil and gas. However, the drain on Government resources may be limited by the mobilization of private capital sources in developing these resources.

Sector Organization

21. The main institutional issue concerns the effectiveness of the decision-making process. The formal framework is good, with a National Energy Commission, under the President, taking policy decisions after a review of options by a National Energy Committee, under the Minister of Industrial Development and Crafts (MIDC), for which the Department of Energy in MIDC provides the technical secretariat. In practice, the arrangements are not effective because the Energy Department does not deal with the essential petroleum matters. These are handled by the Department of Mines and Geology (also in MIDC), and coordination between these two departments is poor. Neither department, nor the National Energy Commission and Committee, appears to have been effectively involved in some major decisions, such as the expansion of the refinery and the changed procedure for crude oil procurement. The present arrangements therefore need to be strengthened, for which an appropriate program of technical assistance will be required.

Recommendations

Reducing Oil Consumption

22. In the absence of savings through conservation and substitution, internal oil consumption 4/ (589,000 toe in 1981) is projected at 718,000 toe in 1986 and 747,000 toe in 1990. Nearly all the identified savings through conservation could be achieved by 1986, by which date the mission estimates that consumption could be reduced by 68,000 toe (nearly 10%). This could rise to 206,000 toe (28% of estimated requirements) by 1990, mainly through the substitution of coal or peat, and hydropower, for oil in electricity generation. Given the scope for further substitution and conservation, a 40% reduction in oil imports by 1990 should be feasible; a figure which is close to the 50% reduction envisaged under the RENES project.

23. In addition to embarking on a program of petroleum conservation/substitution, a number of immediate actions can be taken by the Government to alleviate some of the problems described above. These include:

4/ Excluding bunker sales of fuel oil, diesel and jet fuel to international transport companies refueling in Senegal.

Demand Management

(a) Accelerate as a matter of high priority, the program to encourage the adoption of the "Ban ak Suuf" improved wood stove; act to expand the utilization of more efficient charcoal production techniques.

(b) Establish a demand management program for electricity, including publicity, technical advice, service and technical audits of major consumers.

Pricing

(c) Reorient retail energy prices towards their economic costs by phasing out the present subsidies for petroleum products.

(d) Arrange for Government departments and other public bodies to pay off, over an agreed period (e.g. one year), the arrears due for electricity supplied by SENELEC.

(e) Allow SENELEC to apply the price change formulae automatically and address the anomalies in the existing electricity tariff structure to bring them more in line with the structure of the cost of electricity supply.

(f) Raise the cost of permits to cut wood in natural forests and increase, the retail prices of wood and charcoal corresponding amount.

Institutional

24. A number of steps will need to be taken if the Energy Department is to function effectively as an energy policy formulation and coordination unit in the Government as is its official mandate. First, there must be stronger commitment at the national policy level to involve this Department in all important energy sector issues. Second, the coordination between this Department and the Department of Mines and Geology and other concerned agencies should be improved. In particular all relevant documents should be routinely circulated to this Department. Third, the technical capabilities of the Energy Department will need to be strengthened through training and technical assistance. With some exceptions, noted below, the organizational structure of the Department is appropriate but its staff needs strengthening, particularly if it is to embark on a national program of energy conservation. An adequate training program needs to be developed, including provision for a possible country specific training course in Dakar using short-term consultants in the relevant fields. Finally, training and technical assistance must be complemented with a budget for providing adequate office supplies, library and documentation and logistical support. In parallel, the salary structure must allow for the recruitment and retention of qualified and experienced staff. A number of other institutional issues which need to be addressed are listed below:

(a) The Hydrocarbons Division of the Department of Mines and Geology (in the MIDC) should be transferred to the Department of Energy (also in the MIDC) to improve the supervision of multinational and Government petroleum companies and the coordination of energy pricing policy. An associated recommendation is that the National Hydrocarbons Commission (responsible for petroleum pricing) should be incorporated into the National Energy Commission (which is responsible for all energy pricing).

(b) The Government should allow the reorganized SENELEC to manage its day to day affairs, and should ensure its financial self-sufficiency. To this end, it is essential to restructure SENELEC's balance sheet. The program contract ("contrat-plan") should include a plan for SENELEC's financial recovery.

(c) The Chairman and Director-General of SENELEC should be appointed for a fixed term with the option of renewal.

(d) The staffing levels in the forestry services are too low to carry out the forestry programs and should be increased.

(e) The coordinating role of the Energy Department in renewable energy development should be strengthened, and the role of the State Secretariat primarily responsible for research in renewable energy (SERST) should be clarified.

(f) The proposed renewable energy program should be revised to (a) concentrate on applications with maximum near-term potential for fuel displacement, (b) provide for the evaluation of biomass energy potential, and (c) establish a network to monitor systematically solar and wind energy resources.

(g) The Office of Energy Conservation in the Energy Department should be given the status of a separate division.

(h) Each energy agency should be required to prepare an annual long-term manpower plan, for consolidation by MIDC into a global plan for the sector.

(i) Non-French foreign university degrees should be recognized in the Civil Service Regulations, and salaries should be related to functions rather than diplomas.

(j) The forestry education curricula should be modified to fit the need for an eventual shift towards reafforestation.

(k) The Government should assign to one unit the responsiblity for coordinating the technical assistance activities of multilateral and bilateral aid agencies in energy.

25. The Government should also continue - if necessary with external financial or technical assistance - a series of studies to help further delineate the longer term strategy for the energy sector. The most important of these studies are:

Development of Energy Supply

(a) Review all of the various peat studies on completion to determine the optimum allocation of the peat between electricity generation, household, industrial fuel and agricultural use, subject to any further work that may be needed, including possible additional testing.

(b) Analyze the possibility of utilizing surplus bagasse to generate electricity for public supply.

(c) Review the merits of utilizing surplus molasses for alcohol production compared with other options, following completion of a Bank-financed feasibility study.

(d) Evaluate the economics and market potential for solar water heaters and, if justified, embark on a program to commercialize them.

(e) Study the possibility, and cost, of discharging coal in the port of Dakar using the facilities for handling phosphate exports.

(f) Review the scope for substituting coal for oil in the cement and phosphate industries following completion of the second phase of the coal import study.

(g) Ensure that the proposed power distribution master plan for rural areas examines the merits of rural electrification within the context of the overall stategy for meeting rural energy requirements.

(h) Update the generation and transmission master plan for electricity supply, in the meantime deferring any decision on the 15-MW combustion turbine proposed by SENELEC for 1984.

(i) Update the cost estimates for the Manantali hydropower project (including an estimate of the cost of transmission to Dakar); study the relative demand for electricity in the three countries that would share the output of this project.

(j) Review the relative merits of the Kekreti and Sambangalou hydropower projects on the Gambia river.

(k) Study the scope for using groundnut shells as fuel. A second stage would be to evaluate the energy potential and application of other agricultural residues.

(l) Undertake an adequate program of research and investigation to develop forestry technical packages suitable for arid and semi-arid zones.

Demand Management and Conservation

(m) Study the feasibility of introducing a continuous working day in the Dakar area.

(n) Study the scope for energy savings through improved building design and more efficient use of energy equipment and appliances.

Technical Assistance

26. Most of the studies listed above will require some external technical assistance for their execution. There is an urgent need to improve the coordination of energy sector assistance in Senegal to avoid potential overlap among the programs of the various donors and to ensure that all the priority activities requiring technical assistance are undertaken as rapidly as possible. To assist in this effort, a detailed list of the priority areas where technical assistance is likely to be required has been discussed with the Government of Senegal and should assist interested donor agencies in programing their energy sector activities in Senegal.

This page blank

SEYCHELLES: ENERGY BALANCE, 1982
(thousand tonnes of oil equivalent)

	Fuelwood	Other Biomass	Total Biomass	Petroleum Products	Electricity	Total Energy
Supply						
Production	2.00	0.88	2.88			2.88
Imports				53.62		53.62
Re-exports (Bunkers)				(25.51)		(25.51)
Domestic Supply	2.00	0.88	2.88	28.11		30.99
Transformation and Losses						
Power Generation				(12.31)	12.31	
Conversion Losses					(8.12)	(8.12)
Transmission and Distribution Losses					(0.35)	(0.35)
Net Supply/Demand	2.00	0.88	2.88	15.80	3.84	22.52
Demand						
Domestic	2.00		2.00	2.58	1.18	5.76
Government/Commercial/ Industry		0.88	0.88	0.42	2.64	3.94
Transport				11.81		11.81
(Public Transport-SPTC)				(1.04)		(1.04)
(Inland Aviation)				(0.37)		(0.37)
Street Lighting					0.02	0.02
Other				0.99		0.99

toe = 10 mn kcal
kWh = 2500 kcal

SEYCHELLES 1/

1. In 1979, the GOS established the Research and Development Unit (RDU) within the Ministry of Planning and External Relations (MPER). Although this unit is not formally responsible for energy matters outside the areas of renewable energy and adaptive research, it is considered responsible for energy planning in the absence of any other body. Responsibilities for the oil and power subsectors also lie within the MPER, but coordination is lacking; important issues relating to petroleum supplies and pricing, the power sector and energy-related land use have not been given appropriate priority. Various other "energy planning" activities have been started or proposed in Seychelles in an ad hoc fashion, and there is a danger of duplication. The Mission therefore recommends that the energy planning role of the RDU be formalized and that it be provided with technical support. The Mission sees the first task of the unit and its support to be the evaluation of existing and proposed technical assistance projects, with the aim of redefining their scope to avoid duplication and ensure that the work is designed according to stated objectives.

Petroleum Supplies

2. The current inland consumption (excluding bunkering) of petroleum products is about 1,100 bbl/day (28,100 toe/year) with middle distillates taking more than 75%. Immediate steps should be taken to relieve the burden of oil imports on foreign exchange resources. First, the possibilities of regional cooperation with neighboring countries such as Mauritius and Madagascar or Uganda and Burundi to pool imports should be investigated in order to reduce import and transport costs. Second, the relative retail prices of petroleum products which encourage the use of diesel and kerosene should be changed to reflect relative import costs. Third, although passenger cars appear to be operating efficiently, the efficiency of the public transportation system could be improved by modernizing the fleet (introducing fuel efficient mini-buses) and reorganizing the routes and schedules.

Hydrocarbon Exploration

3. Except for some airmag surveys done in deep waters, all exploration work in Seychelles has been concentrated offshore within the 200 meter isobath line. Amoco drilled three offshore wells, two of which

---

1/ Adapted from Report No. 4693-SEY, January 1984.

Economic Context

The Republic of Seychelles comprises about 100 islands with a total land area of 400 sq. km. About 88% of the total population (65,000) lives on Mahe. Thirty-two of the islands are granitic and rugged, and none are more than 60 km. from Mahe; the other islands are coralline and are more widely spread. The temperature varies relatively little during the year (Mahe averages 30°C), but rainfall varies considerably from island to island. Through the Island Development Company (IDC), the GOS plans to develop permanent settlements of 100-500 people on eight coralline islands over the next ten years.

The economy of Seychelles is open, with imports accounting for 76% of GDP in 1982. Following their independence in 1976, the Seychelles experienced a ten percent real growth in GDP, primarily caused by an expansion in tourism which lasted until 1979. The share of tourism-related activities grew from 14.7% of GDP in 1976 to 19.5% in 1979. Tourism began to decline in 1980 due to the recession in western Europe (which had supplied more than 62% of the tourists to Seychelles since 1977), and was further affected by an attack of mercenaries on Mahe international airport in November 1981. Between 1979 and 1982, GDP fell 8.7% a year.

The Government is concerned about the current decline in the economy and has outlined a strategy to reverse this trend through: (i) encouraging a recovery and future growth of tourism; and (ii) diversifying the economy by promoting fishing and fish exports, and by encouraging export-oriented industries.

Between 1976 and 1979, the cost of petroleum imports grew rapidly, from SR 56 million (US$7.2 million) to SR 130 million (US$19.8 million), and despite the recent declines in tourism and the volume of petroleum imports, the cost of oil imports has remained almost unchanged at SR 129 million (US$19.7 million) in 1982. However, this figure far exceeded merchandise export earnings of SR 85 million (US$13 million) in 1982; the cost of petroleum imports in that year amounted to 42% of merchandise export earnings and tourism revenues combined.

TRENDS IN GDP AND PETROLEUM DEMAND, 1976-82

	1976	1979	1982
GDP (million 1976 US$)	46.8	62.3	47.4
Population ('000)	60	63	65
Petroleum demand/capita (toe) a/	0.37	0.44	0.43
Petroleum import costs/capita (US$) a/	48.3	150.8	169.2

a/ Excludes bunkering.

seem to be lacking in thick prospective marine sections and probably have poor source rocks. The third well did show about 4,000 ft. of potentially prospective marine jurassic sediments. While the prospects for oil are uncertain, the area does nevertheless justify an attempt to encourage further exploration. The Mission recommends that a two-stage approach be followed. First, a fact-finding mission should be sent to evaluate the work done so far and determine the scope and extent of further assistance needed; depending on the findings of this mission, an exploration promotion team could be organized to prepare a promotional package for sale to the oil industry. In exploration,. the GOS should not udertake any drilling itself and, indeed, should normally not even finance geophysical surveys.

Power

4. Until 1982, all power generation came from gas oil. In 1982, all five sets at the 'B' Station (4 x 2.5 MW and 1 x 5 MW) 2/ were converted to fuel oil to reduce fuel costs. As a result, the Seychelles Electricity Corporation (SEC) has reduced fuel costs by about 20%. Currently, it is planned to retire four old sets at the 'A' Station and replace them with a new 5 MW slow speed diesel unit (fuel oil-based). Although this willi improve the firm capacity and reliability of the generation system, some old units at the 'A' station may have to be kept in operational condition until the generation system is further expanded. While future system expansion should take into consideration the possible contributions of biomass gasification and mini-hydropower, these options are likely to make only a marginal contribution, and the system will continue to rely on petroleum-based thermal generation. Plans to expand the generation system should also consider the possibility of using coal. Attempts also should be made to reduce peak demand by restructuring the tariffs for the commercial/industrial sector which has a declining block-base. For domestic users, demand related tariffs should be considered.

5. SEC seems to be overstaffed with respect to: (a) its establishment of a department in an attempt to sell services in competition with private contractors; (b) insufficient training and experience in operations and maintenance on the part of the technical staff; and (c) socio-political pressures to keep the redundant staff on payroll. The mission recommends that this situation be remedied by providing technical and economic assistance to the SEC in three areas: (i) doing a tariff study to determine an efficient tariff structure; (ii) a training program for operating diesel power stations; and (iii) developing a system maintenance plan for oil disel generators. Furthermore, the proposal by

---

2/ Firm capacity at the 'B' Station is only 7.5 MW because one unit is always under maintenance.

SEC to assign energy planning activities to an energy unit within the SEC should be reconsidered, particularly if the recommended reorganization of RDU is implemented.

Biomass and Renewables

6. Biomass currently is the only domestic alternative to import oil. 3/ However, the Mission believes the impact of biomass and other renewable energy sources on the granitic group of islands will not be significant because of: (i) the limited number of end-use options; and (ii) the limited accessibility of biomass due to the difficult terrain on Mahe. Certain applications, such as producer gas and mini-hydro schemes, however, should be evaluated to determine this potential and to find ways of substituting these for imported oil. Steam turbines using coconut husks and shells as fuel may be used on outer islands as an alternative to gasifier units. Steam turbines are not only a proven technology, but also easy to use, while the commercial viability of producer gas systems under variable load conditions is still not established. For the outer islands the contribution of biomass for power generation and crop drying is, however, more promising. To properly evaluate energy supply options, the Mission recommends that energy studies in progress within the SIEP include the establishment of an adequate data base, an evaluation of land-use options from a combined energy/agricultural perspective, an evaluation of possible energy conservation activities and studies on the feasibility of selected renewable energy sources. With respect to ongoing programs on producer gas and biogas, priority should be given to tests on outer islands.

3/ A major biomass and renewable energies study, known as the SIEP (Seychelles Integrated Energy Project), is currently underway.

this page blank

SOLOMON ISLANDS: ENERGY BALANCE, 1981
(thousand tonnes of oil equivalent)

	Fuelwood	Agricultural Residues	Petroleum Products: LPG	Motor Gasoline	Aviation Gasoline	Kerosene	Jet Fuel	Diesel	Total	Electricity	Total
Supply											
Production	46.20	26.19									72.39
Imports			0.38	6.46	0.89	1.54	3.07	33.80	46.14		46.14
International Bunkers							(2.86)	(6.08)	(8.95)		(8.95)
Domestic Supply	46.20	26.19	0.38	6.46	0.89	1.54	0.21	27.71	37.19		109.58
Transformation and Losses											
Public Power Generation								(4.91)	(4.91)	4.91	
Conversion Losses										(3.41)	(3.36)
Trans/Dist. Losses										(0.10)	(0.16)
Net Supply/Demand	46.20	26.19	0.38	6.46	0.89	1.54	0.21	22.80	32.28	1.4	106.07
Demand											
Transport											
Marine				0.68				0.79	1.47		1.47
Road				5.32				1.00	6.32		6.32
Air					0.74		0.21		0.95		0.95
Agriculture	5.55	26.19			0.15			1.41	1.56	0.04	33.34
Fishing								10.43	10.43		10.43
Timber								6.21	6.21	0.03	6.24
Commerce/Manufacturing								0.52	0.52	0.41	1.93
Govt./Public Sector				0.46		0.08		1.25	1.80	0.47	2.27
Residential	40.65		0.38			1.55		0.20	2.03	0.45	43.13

toe = 10 mn kcal
kWh = 2820 (production)
= 860 (consumption)

SOLOMON ISLANDS 1/

1. Because the Solomons is made up of a collection of distant islands, integrated energy systems are inappropriate for the country. The Solomons will, therefore, continue to rely on decentralized small energy systems to meet the bulk of the country's energy needs.

2. Although the Solomons are endowed with a diverse indigenous energy potential, it remains to be properly identified, assessed and developed and the country will continue to depend on imported petroleum (currently 37% of primary energy demand) to meet commercial energy needs, which are mainly for power generation and the enclave export sector for some time to come. Because of a shortage of trained and experienced manpower, this requires an energy plan which emphasizes manpower and institution building for the sector.

3. Considering that about 70% of the market for petroleum fuels in the Solomons is static, and that projected electricity demand in Honiara can be supplied with a wood-fired power plant, the long-run energy demand will increase at about 5.5% p.a.

Electric Power

4. Only about 10% of the country's population has access to power from the Solomon Islands Electricity Authority (SIEA). Power use is mainly concentrated in the Honiara District which accounts for 90% of SIEA's power generation of 18.5 GWh p.a. Considering the long-term economic growth prospects, a maximum demand of 5 to 6 MW in 1990 and 8 to 11 MW in 2000 can be expected for the Honiara District. The firm capacity of the two existing power stations is adequate to meet the forecast demand to 1986, provided SIEA can execute a proper maintenance and spare parts program.

5. To meet increases in power demand beyond 1986, the Government has been considering the construction of the Lungga Hydropower Project. However, Lungga (21 MW) is too large for the projected level of demand even at the end of this century. Moreover, because of the low natural head at the dam site, the bulk of the civil works must be included in the first stage of the project, resulting in a prohibitive construction cost of about US$13,000/kW for the proposed first stage of 5 MW. The mission concluded that the Lungga project should be deferred indefinitely and reappraised when the power market in Guadalcanal is at an appropriate magnitude to absorb a 21 MW plant. The government has accepted this position.

1/ Adapted from Report No. 4404-SOL, June 1983.

Economic Context

Over the past three years (1979 to 1981), the Solomons economy, whose dominant activities are forestry, fishing and agriculture, has experienced a negative real growth in GDP. The country's economic problems are fundamentally related to income disparities among administrative provinces and low agricultural productivity. GOSI expects a recovery and 5.0% growth in 1983. This will restore GDP to the 1979 level by 1985. Beyond 1985, GDP growth will depend on the country's ability to revive production in the monetized sector which declined by 9% and 4% in 1980 and 1981 respectively. This in turn will depend on a marked improvement in export prospects and the terms of trade, both of which have deteriorated during the past three years. Other critical issues in agricultural productivity, human resource development, and domestic resource mobilization must also be confronted to establish a basis for sustained growth beyond 1985. The mission has used historical relationships between GDP and energy consumption, and two GDP growth scenarios as a basis for energy demand projections: (a) a base scenario (BS) of 3.5% p.a. sustained growth; and (b) an optimistic scenario (OS) of 5% p.a. sustained growth.

6. Another option for the Honiara system with a potential for large savings in energy imports is power generation using sawmill and logging residues (from Foxwood Co.), supplemented with rice husks and straw (from Brewers (SI) Co.). About 7.5 MW of steam power generating capacity could be installed to generate 39 GWh annually by the end of the 1980s with cumulative savings of US$45-53 million in the oil import bill from 1987 to 2000. The proposed Power Development Study of the Asian Development Bank (ADB) which is scheduled to begin in 1983, will provide detailed comparative economic analysis to determine the least-cost option (including generation using coal or industrial diesel oil) for firm generating capacity requirements of the Honiara system. Following the mission's recommendations, the ADB study will include detailed feasibility and specification of the recommended option to shorten the lead time for installing the least-cost option. The availability of wood residues for power generation should be assured prior to a GOSI decision to invest in wood-fired steam power plant.

Petroleum Supply

7. The Solomon Islands are totally dependent on imported petroleum from Australia and Singapore. The size of the country's petroleum import bill is not yet critical, but any escalation in petroleum import prices could substantially increase the country's import costs and worsen the

terms of trade vis a vis her export earnings, which are mainly from agricultural products. Although a substantial proportion of petroleum imports to the Pacific countries including the Solomons are from Australia, petroleum imports to the region are priced according to Singapore import parity. Because of this, several Pacific countries generally feel that they are being overcharged. The mission investigated this and concluded that: (a) freight rates carry a premium which is higher than international standards; and (b) the total import volumes are too small (45,000 tonnes in 1981) for the country to negotiate lower price quotations. Currently the oil marketing companies (Shell and Mobil) guarantee a continuation of supplies and if the GOSI unilaterally decides on lower payments for imports, the country may face a distruption in supplies. In the short run, the country would be able to procure supplies from independent marketers at lower spot prices. Such an arrangement would not provide for long term security of supply.

8. In order to procure the supplies at lower than current costs and ensure the continuity of supplies, the mission recommends that:

(a) local storage and marketing functions should be separated from overseas supplies and transportation to allow for different companies to handle these two activities. Such a separation can be introduced without disrupting current distribution arrangements;

(b) the Governments of Fiji, PNG and the Solomons should pool their requirements and seek bids from established international majors to supply their combined petroleum needs of about 985,000 tonnes p.a. If possible, additional small islands of the region should also be included in this pool; and

(c) the three governments should also negotiate with the prospective supplier or independent shipping companies for freight rates which are in line with international standards.

These arrangements are perfectly compatible with the region's current supply logistics and give a potential supplier the incentive of large market to quote lower than Singapore import-parity prices. The mission's investigations confirm that such arrangements will be acceptable to the oil marketing companies.

Rural and Special Energy Needs

9. The major rural energy needs consist of cooking, lighting and isolated small power needs for rural services such as communications. Although methods for cooking with wood could be improved, the mission considers that this is not a priority in relation to other rural development issues. For lighting, traditional rural electrification based on small diesel sets or extension of supplies from SIEA outstations

is not appropriate. The small power demand per settlement and the extremely poor rural infrastructure make operation and maintenance of such systems in remote areas difficult (unreliability of spare parts supply etc.) The mission supports proposals by the Ministry of Transport, Communication and Government Utilities (MTCGU) to expand the country's rural telephone network by using solar PV-powered radio transceivers, and recommends that GOSI seek financing for these projects. GOSI should, however, await the results of a proposed pilot rural lighting project based on a PV system (funded by the Commonwealth Heads of Government Regional Meeting Energy Group) before deciding on more extensive use of public funds to finance similar kits for rural community lighting needs. Local retail prices for PV components are high in comparison to prices elsewhere in the Pacific. These prices can be reduced by locating a cheaper source of imports, and by removing the current import duty and surcharge on PV components.

Prices

10. There are no price controls for petroleum products in the Solomons. Prices for liquid products are set by the two oil marketing companies, Mobil and Shell, based on Singapore postings and the exchange rate. LPG prices are set according to the ex-refinery cost in Brisbane, Australia. In the mission's view, although the pricing mechanism is adequate for products supplied by Mobil and Shell, that for LPG is not, due to unreasonably high margins claimed by the importing and local marketing companies. GOSI's capability to monitor prices for petroleum products needs to be developed through training and technical assistance. SIEA's electricity tariffs are adjusted periodically to offset escalating operating costs. Some modifications in the tariff structure may be justified based on the results of the ADB Power Development Study in order to: (i) reduce or eliminate subsidies for outstation operations; (ii) enable SIEA to finance part of its own expansion program; and (iii) eliminate or modify the off-peak tariff.

Development of Indigenous Energy Resources

11. The country's potential energy resources, especially hydropower, hydrocarbons and geothermal, have not yet been systematically surveyed. The mission recommends that this be done with some urgency (except for geothermal because the identified occurrences are too distant from the main consumption centers).

Fuelwood

12. Supply problems are localized but not critical. Some shortages are reported around coastal settlements on Malaita, where natural forests have been converted into subsistence farms, livestock grazing land and

coconut groves. In the mission's view, a comprehensive program including technical assistance is required to improve the capability of the Forestry Division (FD) in such operations as reforestation, extension, and management of the natural forest for both timber and fuelwood needs. The mission also supports preliminary plans by the FD to link fuelwood replanting schemes to planned timber reforestation projects such as on Malaita, and recommends that GOSI allocate funds of about SI$100,000 annually for that purpose.

Hydropower

13. Although a number of mini hydropower projects are being developed, the hydropower potential other than Lungga is neither properly identified nor established. This is due to the lack of hydrological data on river basins in the archipelago. The mission recommends that GOSI be assisted through a 2- to 3-year technical assistance program to establish a hydrological data base on selected river basins, and that proposed technical assistance of about US$90,000 from the European Development Fund (EDF) be used to initiate the survey.

Hydrocarbons

14. Exploration for oil and gas has been limited to a few areas where seismic surveys have been done. Lack of interest in further exploration is due to the absence of legislation to regulate exploration and production operations. GOSI has drafted petroleum legislation which it expects to enact in 1983. The proposed law is not specific on regulations or the structure of preferred agreements. At this time GOSI has not considered possible contractual arrangements. In the mission's view, GOSI's desire to promote exploration activity would require technical assistance:

(a) to determine its strategy regarding agreements;

(b) to assist in the drafting of a model contract or contract guidelines;

(c) to prepare a detailed geological/geophysical information package to promote exploration activity in the potential areas; and

(d) for negotiations.

Institutions and Technical Assistance

15. The SIEA follows sound commercial principles in its operations and is a well-managed utility. SIEA's technical management capabilities could be improved by recruitment of a Senior Mechanical Engineer and a Senior Electrical Engineer, and by adhering to a better-defined schedule

for maintenance and procurement of spare parts. These measures are of critical importance and should enable SIEA to continue reliable operations in the Honiara diesel stations up to mid-1986 when new plant should come on stream. The ADB Power Development Study will further review financial aspects of SIEA's operations and the tariff structure.

16. The recently-created Energy Development Division (EDD) of the Ministry of Lands, Energy and Natural Resources (MLENR) does not have full-time staff to deal with energy matters. GOSI's first step in outlining an energy plan should be to build up a nucleus of staff for the EDD. The mission recognizes that this would be a difficult task, given the shortage in the country of technical and managerial expertise, and therefore recommends a program of technical assistance to provide short-term technical experts to enable MLENR to start on the priority tasks and also provide on-the-job training to local counterparts. The technical assistance should include the following resident staff or visiting specialists:

(a) Energy Economist/Planner (24 man-months) for the EDD to help with preparation of an energy plan, an energy pricing strategy and evaluation of energy project proposals;

(b) Petroleum Supplies Specialist (12 man-months) to assist the participating government in arranging joint supplies at lower than current import costs;

(c) Hydrologist (24-36 man-months) for the EDD to direct hydrological surveys 2/; and

17. Petroleum Exploration Specialists (12 man-months) to assist the staff of the Geology Division (GD) on promotion and regulation of petroleum exploration activity.

Energy Sector Investments

18. The main investments up to 1990 could be about US$13.5 million for expansion of the SIEA Honiara System if a 7.5 MW wood-fired steam power plant is selected, and possibly between US$5 to 15 million for detailed seismic surveys as part of a petroleum exploration activity by foreign oil companies. GOSI could, however, use one of several options to reduce their financial committments, if any, for seismic surveys. Technical assistance of about US$1.5 million will be required for various tasks.

2/ GOSI has allocated one line position in EDD to a hydrologist. This position has now been filled under New Zealand aid.

This page blank

SRI LANKA: ENERGY BALANCE, 1980
(thousand tonnes of oil equivalent)

			Petroleum Products								
	Fuelwood	Crude Oil	LPG	Gasoline-Naphtha	Kerosene-Jet Fuel	Diesel	Furnace Oil	Bitumen	Total	Electricity	Total
Primary Supply											
Production	2040									447.6	2487.6
Imports		1918.0			61.8	44.6		13.6	120.0		2038.0
Stock Change		25.0			9.9				9.9		34.9
Total	2040	1943.0			71.7	44.6		13.6	129.9	447.6	4560.5
Transformation and Losses											
Oil Refining		(1943.0)	8.0	297.3	255.6	503.1	740.4	23.8	1828.2		(114.8)
Thermal Power Generation						(13.8)	(44.7)		(58.5)	58.5	(307.4)
Transmission/Distribution Losses			(1.8)	(1.2)	(7.6)	(11.1)	(17.8)		(39.5)	(78.6)	(118.1)
Secondary Supply	2040		6.2	296.1	319.7	522.8	677.9	37.4	1860.1	120.1	4020.2
Exports				(141.9)			(166.0)		(307.9)		(307.9)
Bunker Sales				(0.7)	(96.3)	(54.1)	(310.9)		(462.0)		(462.0)
Net Supply/Demand	2040		6.2	153.5	223.4	468.7	201.0	37.4	1090.2	120.1	3250.3
Demand											
Industry/Commerce	520		3.1	36.5		50.1	201.0		290.7	72.4	883.1
Public/Other								37.4	37.4	31.2	68.6
Transport				117.0	23.7	418.6			559.3		559.3
Households	1520		3.1		199.7				202.8	16.5	1739.3

toe = 10 mn kcal
kWh = 3024 kcal (hydro)
= 860 kcal (electricity

SRI LANKA 1/

1. Developments in the energy sector will have an important bearing on the country's overall economic prospects. A large part of Sri Lanka's current economic difficulties stem from the rising cost of petroleum imports which now absorb a third of export revenues and the increasingly heavy burden of the power development program which accounts for 35% of projected government investment between 1981-85. Under these circumstances, any measures to reduce oil consumption in the near term acquire a; high degree of importance. At the same time, despite the heavy investment requirements of the Mahaweli Program, the country must begin to plan for additional indigenous energy development to further reduce its dependence on an expensive and imported source of energy.

2. Energy has only recently become a serious problem for Sri Lanka. The oil price increase of 1973 had made petroleum, which supplies a third of the country's primary energy requirements, a significant factor in the balance of payments, but a combination of slow economic growth and stringent import controls ensured that the burden of oil imports was manageable during the following years. At the same time, the addition of new hydro capacity resulted in a comfortable balance between electricity supply and demand and helped to contain the demand for oil by substituting for thermal generation.

3. Since 1978, however, this situation has changed dramatically. The marked improvement in economic performance that followed the adoption of a market-oriented development strategy under the new Government has brought with it a substantial increase in the demand for all forms of commercial energy, which rose in aggregate at 8.8% per annum in the 1978-80 period as opposed to a slight decline in the preceding seven years. Petroleum consumption has grown even more rapidly because, in the post-1977 period rising electricity demand had to met principally through increased thermal generation from oil. Thus total petroleum consumption grew at 9.5% a year during 1978-80 after having declined at an average 3.3% per annum in the 1970-77 period. Rising import volumes and a doubling of world oil prices in 1970 took their toll on the balance of payments. Between 1978 and 1981 the oil import bill more than tripled and the proportion of export earnings devoted to oil imports rose from 11 to 39%.

4. Nor has the energy crisis been confined to petroleum. Despite the addition of expensive thermal generating capacity, the supply of electricity could not keep pace with rising demand and severe power shortages ensured in both 1980 and the early months of 1981. The effects of these shortages on industrial output and economic performance have not

---

1/ Adapted from Report No. 3792-CE, May 1982.

Economic Context

Sri Lanka is a small, moderately industrialized island country with a population of about 15 million and a 1980 per capita GNP of $270. Agriculture accounts for 23% of GDP with over a third of this coming from the production of tea, rubber and coconuts. The processing of these tree crops also accounts for a third of the value added in industry (18% of GDP) and over half of the country's exports. The country's other major exports are precious stones, textiles, fish products and re-exports are precious stones, textiles, fish products and re-exported refined petroleum products which have recently become the second largest export earner after tea.

Sir Lanka's economic policies since 1977 have focussed on revitalizing the economy by dismantling controls, restoring realistic relative pricing and by taking measures to encourage domestic and foreign private investment. To lay the foundation for longer term development and provide a growth stimulus in the intervening period, the government also embarked on a large public investment program built around three "lead" projects including the Accelerated Mahaweli Development Program, by far the largest multipurpose river basin development ever undertaken in the country.

The economy's initial response to liberalization was vigorous and encouraging: 1978 and 1979 saw substantial increases in output, employment and investment. Since 1979, however, investment has had to be financed increasingly through inflationary domestic and expensive international borrowing and the country's terms of trade fell 20%. By 1980, the rate of inflation had doubled to 31%, the current account deficit rose to 19% of GDP (as against 11% in 1979), and foreign exchange reserves declined to less than nine weeks of imports by the end of the year. Recognizing that these developments constituted a severe threat to the success of its overall development strategy the government took a number of measures in late 1980 to reduce capital expenditures and contain budgetary and current account deficits.

been quantified but they are likely to be substantial. Perhaps even more important is the potential impact of a rapidly worsening external payments situation and the prospect of recurring electricity shortages on the success of the Government's efforts to attract foreign and domestic private investment, which is a key element of its new development strategy. The net effect of these developments is that energy has now become a major national concern.

5. The mission's analysis suggests that the situation is likely to worsen before it improves. For the first half of the 1980s, the implementation of a large public investment program and the commissioning of major industrial and commercial projects now under construction will result in continued strong growth in energy demand. The estimated 15% increase in commercial energy consumption in 1981 is unlikely to be repeated, but a projected economic growth rate of 5.7% per annum will still be associated with a substantially higher growth rate for commercial energy demand - an average of 8.5% per annum between 1981 and 1985. In terms of fuels, electricity consumption is projected to growth over twice as rapidly as the direct demand for petroleum products; but, because nearly all of the additional electricity demand will have to be met through higher oil-based thermal generation in this period, the economy's total petroleum requirements in 1985 will still be half as large again as in 1980. As a result, even if oil prices remain at their 1980 level in real terms, 45% of projected export earnings and 10% of GDP will have to be earmarked for importing oil in 1985. This burden will, of course, be greater if real oil prices rise in the next five years.

6. Along with continued pressure on the balance of payments, short term developments in the energy sector will be particular source of concern for national policymakers in two other areas. First, the investment requirements of the power sector - and especially for the Mahaweli hydro projects - will continue to strain the overall public investment program. Between 1982-86, budgetary investments in the power sector will amount to Rs 23 billion ($1.4 billion), which is approximately a quarter of total public investment over this period. Much of this investment is for the implementation of the Mahaweli power projects, and, given the importance of these projects, both in terms of public investment and power supply, it is worrying that their completion might be delayed because of funding and manpower shortages. This would make the already distinct possibility of recurring electricity shortages up to 1984 - which is the other main concern in the sector - an even more likely event.

7. Under these circumstances the highest priority in short term energy supply management must be attached to ensuring that the first of the Mahaweli projects, Victoria, comes on stream as scheduled in mid-1984. If Victoria is delayed form mid-to end-1984, an additional 100 GWh of thermal generation will be required in those six months at a 1980 fuel cost of Rs. 250 million ($14 million). Any further delays will have serious consequences for the cost and availability of adequate electricity in 1985. To achieve the timely commissioning of Victoria the

Government should set up a special mechanism to closely monitor progress on the Victoria site and this project should be assigned the highest priority in the allocation of manpower and funding.

8. Other supply-side options to improve the near term energy situation are limited. Three measures should be undertaken however. The first is to close down the LPG/air pipeline which the Colombo Gas and Water Company (CGWC) operates in Colombo. The pipeline's current losses - estimated at up to 70% of input volumes - cost the country $0.5 million a year in lost fuel, a loss which Sri Lanka can ill-afford at this time. Secondly, further detailed work should be undertaken to assess the viability of recovering additional LPG from the refinery for distribution in bottled form. A review of CGWC's proposal for such a project suggests that this could be an attractive investment opportunity in the petroleum subsector and merits further consideration. Finally, substantial savings could accrue from a streamlining of the current arrangements for crude oil importation which are resulting in high transport costs. The Ceylon Petroleum Corporation's (CPC) project to install a Single Point Mooring Buoy system for unloading crude oil imports appears to have a high rate of return and should be investigated further as a matter of priority.

9. Nevertheless, the main thrust of Government efforts to alleviate the country's short term energy prospects must be directed towards improving the efficiency with which energy is currently used. One of the most important conclusions of this report is that a concerted national energy conservation program, focussing initially on the industrial and commercial sectors, could begin to yield substantial energy savings in a relatively short period and at limited cost by increasing the efficiency with which these sectors currently use energy. Preliminary analysis suggests that if such a program were embarked upon immediately it could reduce the country's petroleum import requirements - through both a direct reduction in industrial/commercial sector liquid fuel use and an indirect effect through a lower need for thermal electricity generation - by $15 million in 1983 rising to $24 million by 1985, all in 1980 prices. These projected savings compare very favorably with the $10-15 million investment cost that is likely to be associated with such a program and the $0.5 million that would be required to establish it. These figures need to be confirmed through more detailed work but they serve to illustrate the high priority that should be attached to a more systematic and comprehensive effort to identify energy saving opportunities and to bring about their realization. To achieve this, the Government should establish an energy advisory and audit service to provide industry with the necessary technical information and advice in undertaking appropriate retrofitting investments and good housekeeping measures. The establishment of this service could be assisted through the provision of one or two experienced conservation specialists under a technical assistance program.

10. The Government's efforts to promote energy conservation also need to be complemented by a rationalization of energy pricing policy. The proposed change in electricity tariffs is an important step in this

direction but a number of other energy pricing issues need attention. The most important of these is the continuing general price subsidy on kerosene which is superfluous given that, in the concurrently operated Kerosene Stamp Scheme, a mechanism is already in place to meet the Government's objective of mitigating the effects of higher kerosene prices on poor households. The Government should, therefore, raise the price of kerosene to its economic cost and simultaneously increase the value of kerosene stamps thereby protecting poorer households but discouraging suboptimal kerosene use in other sectors. Similarly, the price differential between light and heavy fuel oils is not sufficient to encourage users to invest in the facilities necessary to handle and use the heavier grades even where this would be economical. Both of these measures could help to improve the efficiency of energy use and the fiscal contribution of the energy sector.

11. In the second half of the decade Sri Lanka's energy prospects are expected to improve, mainly as a result of interfuel substitution. The commissioning of the Mahaweli hydro projects in the mid-1980s and a 120 MW coal thermal station in 1989 will reduce the share of oil-based electricity generation from 25% in 1985 to 17% by 1990. The planned conversion of the cement industry to coal will also help to moderate the demand for petroleum which is projected to grow at a fairly modest 3.6% per annum over the 1986-90 period. Commercial energy consumption as a whole is also expected to grow more slowly in the second half of the decade -- at an average annual rate of 6.0% - reflecting a less energy intensive pattern of economic growth as the heavy construction and investment push of the early 1980s begins to pay off. Nonetheless, by the end of the decade, energy imports -- coal and oil -- will cost around $620 million (in 1980 prices), accounting for 45% of projected export earnings. While this figure could be reduced by an estimated $36 million (in 1980 prices) as a result of the conservation program recommended in this report, it would still entail a far higher proportion of national resources being devoted to the energy sector than has been the case in the past.

12. Even this scenario of energy prospects in the late 1980s is contingent upon early Government action in a number of policy and investment areas. First, in the power sector, preparatory work for the introduction of a coal thermal station must begin urgently. Although the station is not due to be commissioned until 19890, the long lead time for setting up such a facility and the associated infrastructure for coal imports, plus the manpower training and familiarization requirements of introducing a new source of electricity, already makes 1989 a tight schedule for power supply from such a plant. Also in the power sector, there is a need to resolve some of the uncertainties regarding the planned timing of major new power using projects, where conflicting signals are making the Central Electricity Board's (CEB) task of forecasting its future load growth unnecessarily complex and difficult.

13. Paradoxically, the long term prospects for commercial energy will be significantly affected by developments in non-commercial energy

supply, specifically that of fuelwood which currently provides over half of Sri Lanka's primary energy requirements and is the main fuel for the majority of tits population. Although data on fuelwood supply and consumption are sketchy, they indicate that a large part of the current requirements for fuelwood is met from the clearing of forests. Fuelwood demand is only one source of deforestation -- the growing requirements for agricultural land and "chena" cultivation methods being serious problem and a continuation of their trend could leave the country virtually denuded of forest cover in about 30 years. Serious local fuelwood shortages would emerge well before then. The resulting increase in the demand for commercial energy -- mainly petroleum -- would put a significant strain on both the balance of payments and domestic economic management. Current reforestation efforts fall far short of the estimated $150 million program that is required over the next 20 years to ensure a sustainable supply of this fuel in the longer term. Embarking on such a program is a high priority task for the Government. The Government should also encourage and expand the the Ceylon Institute for Scientific and Institutional Research's (CISIR) project to develop and popularize more efficient wood and charcoal stoves which could substantially reduce household fuelwood consumption in the longer term.

14. In the petroleum supply subsector, the existing imbalance between the refinery's production pattern and the mix of product demand is projected to continue throughout the 1980s. Therefore the economics of alternative refinery modification options to reduce this imbalance should be studied by the CPC and the Government. The CPC's hydrocracker project proposal is one such alternative, but further work is required to resolve some remaining technical and economic uncertainties in the analysis.

15. Finally, in the area of nonconventional energy there is an urgent need to establish clear sectoral priorities so as to guide the currently isolated and too thinly spread efforts of individual agencies. Two areas which appear to have early potential for use in Sri Lanka are the application of solar energy for crop drying and water heating and the reactivation of minihydro sites to meet the electrical energy needs of rural industries. A study to establish sector priorities and a detailed assessment of the potential of these applications needs to be carried out.

16. The analysis in this report confirms that developments in the energy sector will have a critical bearing on the success of the Government's overall development strategy for the 1980s. Successfully surmounting the challenges in the energy sector will itself require a substantial strengthening of the currently weak and fragmented institutional structure for energy management and planning. Inadequate planning and delays in decision making and program implementation are to a large extent at the root of Sri Lanka's present energy sector problems. Even now, no single agency in Sri Lanka is effectively formulating a national energy policy or coordinating the work of the various organizations that are active in the energy field. The June 1981

decision to establish a Natural Resources, Energy and Science Authority to advise the President has yet to be followed up with details on its exact role, focus and staffing even though policymakers need to take urgent action on a number of energy policy and investment issues. Some of these -- such as embarking on a concerted conservation program for industry and commerce energy prospects. A contingency program for minimizing the disruptive effects of possible electricity shortages up to 1984 must also be urgently developed. Other decisions, such as commencing preparatory work for the coal thermal station or expanding the reforestation program, will not affect the energy sector until the later 1980s but, because of long lead times, they need urgent attention if their contribution is to be realized as scheduled. At the same time the country must also begin to develop a longer term energy strategy to ensure that its energy requirements can continue to be met at the least cost. To achieve these task requires both a high level of commitment to efficient energy sector management at the national level and a core of technical staff which can provide policymakers with a continuing analysis of Sri Lanka's energy issues. Recent developments suggest that such a commitment now exists at the highest level of policymakers; what is now required is to translate this commitment into a series of operationally-oriented policy actions which will enable Sri Lanka's limited energy options to be fully realized.

Energy Sector Developments, 1980-1983 2/

Energy Supply and Demand

17. Primary commercial energy consumption increased from 1.684 million toe in 1980 to 2.075 million toe in 1982 (11% per year), compared to an 8.8% annual growth rate during 1977-1980. However, in 1983, preliminary estimates indicate that consumption declined by 8% to 1.918 million toe as a result of reduced hydroelectric generation (-25%) due to the severity and continuation of the drought, the mid-1983 disturbances in economic activity, and price increases in major oil products in July 1983.

Petroleum

18. The demand for petroleum products grew by 13% during 1980-82, compared to 9.5% during 1977-80. The net oil import bill also peaked in 1982 and consumed almost 50% of non-petroleum export earnings, compared to only 35% in 1980. During 1983, figures for the first three quarters suggest that consumption has fallen slightly and the cost of oil imports

---

2/ Adapted from Report No. 010/84, Sri Lanka Energy Assessment Status Report, January 1984.

is expected to be about 12% lower than in the previous year, partly due to improved freight management and better prices.

19. On the supply side, the detailed analysis recommended for both the single point mooring buoy and the hydrocracker projects has been carried out, with the former proceeding now to the implementation stage. The hydrocracker project has been shelved for the time being as it is not profitable. The recommendation to close down the LPG pipeline has been partly implemented, with the pipeline being reduced from 180 miles to 11 miles serving a few large users.

Electricity

20. Electricity generation increased by 11.3% annually during 1980-82, i.e. at roughly the same rate as during 1977-80, but declined to 2% during 1983. However, growth rates of hydro and thermal generation varied markedly. Hydro generation declined by about 7% per annum, from 1479 GWh in 1980 to 1206 GWh in 1983 due to drought conditions and constituted only 57% of total generation in contrast to 89% in 1980. On the other hand, thermal generation increased geometrically from 188 GWh in 1980 to 907 GWh in 1983, i.e. at almost 70% per annum. Electricity sales, estimated at about 80% of generation, increased from 1392 GWh in 1980 to about 1700 GWh in 1983 (118.6 GWh by August 1983). Private generation has been encouraged from February 1983 and is estimated at about 6 GWh per month. Two-hour power cuts are in force since November 1, 1983, but this is still an improvement over 1981 when eight-hour cuts were not considered unusual.

21. The serious supply shortfalls of 1980 and 1981 have been considerably alleviated through the addition of 40MW of gas turbines in late 1981 and the 30MW extension of the Canyon hydro station in February 1983. However, demand is still in excess of supply and the situation may worsen again in the first half of 1984 because of the extremely poor rainfall level of 1983 which has led to an estimated 25% drop in hydro generation during this year and will have a continued impact until the next monsoon. Thus, the daily two-hour power cuts in effect now will probably need to be extended in the coming months.

22. Of the power projects under construction, work on the Victoria project has proceeded satisfactorily and the project should be ready for commissioning in mid-1984. Initially, power from the project may need to be transmitted to the grid through a temporary 6 kilometer 132KV connection because the permanent 230KV line is unlikely to be ready in time. Also during 1984, 80MW of diesel plant will be added to the system in two phases - 40MW in April and 40 MW in August. For the proposed coal-fired power station, a prefeasibility report has been prepared, and detailed feasibility work is scheduled to begin in 1984. This project should be ready for commissioning around 1990. A prefeasibility study for a power system efficiency improvement and distribution rehabilitation project has also been carried out (with UNDP/World Bank assistance) and the detailed design and preparation of the subsequent investment project is underway.

Fuelwood and Other Renewables

23. In the fuelwood area, an additional IDA-assisted project has come on stream with a large component of training and technical assistance, including the preparation of a Forestry Master Plan and Forestry Department strengthening. However, there is a need to ensure that the temporary supply of wood from the clearing of the Mahaweli area does not lead to a false sense of complacency regarding the seriousness of the underlying fuelwood supply problem. As to renewables, some progress has been made to strengthen the institutional implementation capability, and to reorient efforts to more immediately relevant projects, but this is still an area where substantial improvements need to be made.

Energy Pricing Policy

24. In the area of demand management, the main changes have been the rationalization of electricity tariffs in mid-1982 which brought their structure more in line with the costs of supply. The level of tariffs was raised further in mid-1983, through an increase in the fuel adjustment surcharge from 110% to 185% of basic tariffs. Moreover, capacity charges for electricity have been trebled with a dramatic effect in terms of consumer response through the installation of power factor correction equipment.

25. Petroleum prices were raised in July 1983 to reflect higher costs and the devaluation of the Rupee. An important structural change was the virtual elimination of the general subsidy on kerosene. To protect the purchasing power of lower income households, the value of kerosene stamps, provided to about half of the population, was also raised at the same time. This increase in the price of kerosene also permitted the CPC to increase industrial diesel prices which had not been increased for fear of substitution by cheap kerosenes.

Institutional Developments

26. The major development in the institutional framework of the energy sector has been the setting up of the Energy Coordinating Team (ECT) in December 1982 in the Ministry of Power and Energy (MPE), under the supervision of a newly appointed Senior Energy Advisor to the Minister. The principal objective of the ECT is to coordinate work among the relevant ministries and prevent duplication of efforts. The ECT consists primarily of three coordinating task forces that cover the following areas:

(a) Energy Planning and Policy Analysis (EPPAN), under which an integration of all energy sector activities is attempted. EPPAN is attempting to identify the overall objectives of

national energy policy in order to define an energy strategy that meets these objectives within the established goals of maximizing Sri Lanka's development in the coming decades. The setting up of a comprehensive energy data base, including energy balances which feed into energy policy analysis and modelling, is already underway.

(b) Energy Efficiency, Demand Management, and Conservation (EDMAC) includes a number of activities that are of short-term importance in the area of energy conservation, especially in industry, but also in commerce, households, transport, and agriculture. EDMAC has also been instrumental in setting up a special cell in CEB to reduce system losses, and in reviewing electricity and petroleum pricing policies.

(c) New, Renewable, and Rural Sources of Energy (NERSE) aims at coordinating activities in the renewable energy subsector, assessing the economic and technical feasibilities of some of these technologies as they apply to Sri Lanka and promoting and financing the commercialization of these technologies.

The three task forces meet on a regular basis (approximatley once a month) and they include representatives of the major energy related ministries, departments, and parastatal organizations. The task forces also have access to a small group of economists and technical staff who have been recruited for this purpose by the MPE.

Industrial Energy Conservation

27. In the industrial energy conservation area, a number of corporations have implemented the easier and low cost efficiency improvement recommendations made by the assessment mission. In parallel, a major public awareness and training effort has been launched. The next step in this effort is a detailed training course in energy auditing for the plant managers of the 30 largest energy consuming corporations, planned for February-March 1984. If this momentum can be maintained, the necessary fasibility and preinvestment work for major industrial retrofitting and energy efficiency projects should be carried out during 1984 with the projects being implemented in the subsequent 2-3 years. In transport, smaller industries, and the household sector, progress has been slower but plans are underway to tackle these sectors in the coming 12-24 months.

Remaining Issues

28. The actions that the Government has taken have had some impact on alleviating the current energy problem but their main importance is in

laying the basis for substantially larger improvements in the second half of the 1980s. In short, much of the groundwork for effective energy sector management has been done in the last two years and the country is ready to begin the operational and implementation phase of a number of programs which will improve the energy situation in the medium term. The task now is to ensure that this momentum can be maintained, particularly during a period when overall resource availability is seriously constrained. This, in turn, requires that both the government and external assistance agencies allocate available resources only to those projects which have high, relatively certain and, preferably, quick payoffs.

29. A few policy issues also remain to be resolved. These include:

(a) Reviewing the efficiency of the existing institutional arrangements for the marketing and distribution of Liquified Petroleum Gas (LPG) and, in particular, the respective roles of the CPC and the CGWC.

(b) Reviewing the arrangements for tax collection in the petroleum sector whereby CPC's retail sales prices includes an element of government imposed taxes which are not accounted for separately in CPC accounts and are transferred to the exchequer in an ad-hoc manner.

(c) Examining the feasibility and benefits of introducing an automatic adjustment clause in retail petroleum prices to reflect movements in international prices or in the exchange rate.

SUDAN: ENERGY BALANCE, 1981
(thousand tonnes of oil equivalent)

	Fuelwood	Charcoal	Other Biomass	Crude Oil	Petroleum Products: LPG	Gasoline	Kerosene-Jet Fuel	Gasoil	Fuel Oil	Electricity	Total
Primary Supply											
Production	7,765		526							188	8,479
Imports				812	1	74	13	246			1,146
Producers' Stock decrease (increase)				62						188	62
Total	7,765		526	874	1	74	13	246		188	9,687
Transformation and Losses											
Oil Refining				(832)	5	133	41	295	358		0
Charcoal Production	(1,778)	1,778									0
Thermal Power Generation								(15)	(45)	60	0
Conversion Losses	(3,236)			(42)						(167)	(3,445)
Secondary Supply Available	2,751	1,778	526	0	6	207	54	526	313	60	6,221
Transmission/Distribution Losses										(21)	(21)
Exports									(141)		(141)
Distributors' stock decrease (increase)						55	11	40	(38)		68
Net Supply/Demand	2,751	1,778	526		6	262	65	566	134	60	6,148
Demand											
Agriculture								98		7	105
Industry	75		100		1		1	53	106	22	358
Transport						262	47	337	28		674
Households	2,591	1,686	426		5		17	33		23	4,781
Public/Other	85	92						45		8	230

toe = 10.2 mn kcal
kWh = 2530 kcal (production)
= 860 kcal (consumption)

SUDAN 1/

1. Sudan's present economic crisis is in no small measure due to crippling energy shortages in the productive sectors of the economy during the last few years. The economy has relied too little on enrgy pricing as a tool of demand management and placed too much emphasis on a physical allocation system for petroleum products. Future economic planning and decision taking must attach a higher priority to supplying energy to the productive sectors of the economy, particularly export - oriented industry and agriculture and show a greater willingness to keep energy prices in line with the economic costs of supply. At the same time, it must be recognized that Sudan will face serious limits on the extent to which it can in fact increase the overall supply of energy.

2. There are some encouraging signs for the short-term and medium-term outlook: power shortages are likely to be relieved during FY84, with a doubling of installed capacity; and domestic crude will augment petroleum supplies and export earnings from FY86. However, from a longer-term perspective, it must be recognized that Sudan is poorly endowed with indigenous energy resources in relation to its large land area. A sustained improvement in economic performance will require much better management of the energy sector and a system of foreign exchange allocation which will permit the Government to plan petroleum imports on a more rational basis. To that extent, energy pricing will assume an even greater importance than usual in restraining overall energy demand and in optimizing the distribution of petroleum products between different consuming sectors and between individual consumers within those sectors. While the impact of energy pricing on demand may take full effect only in the longer term, by initiating action now the economy will be given the maximum opportunity to adjust to a situation in which energy prices reflect the full economic costs of supply.

Options in the Energy Sector - An Overview

3. As in many African countries, fuelwood, charcoal and biomass constitute the main source of energy supply and satisfy about 82% of final consumption. Commercial energy meets the remaining 18%, largely in the form of oil (17%), all of which must be imported, although a small amount of final consumption (1%) is supplied by hydroelectricity. Sudan's options for the future are comparatively straight-forward. Energy conservation offers some scope for reducing imports, although the main potential must lie with the transport sector; also, as stated above, pricing policy needs careful and immediate attention. On the supply

---

1/ Adapted from Report No. 4511-SU, July 1984.

Economic Context

Situated in the north-eastern part of Africa, Sudan commands the largest land area on the African continent, stretching over 2,000 km from North to South and 1000 km from East to West. It is largely flat, except for a few scattered mountains. The average rainfall varies from less than one inch in the North to 80 inches in the South. Sudan's present population is estimated at around 19 million. Roughly 25% of the population is classified as urban.

GNP in FY81 amounted to about LS4334 million (US$4815) at the exchange rate of US$=LSO.90. Agriculture is the mainstay of the economy. Its share in GDP is currently around 38%, while that of industry is 13%; the balance (49%) is accounted for by the services sector. Agriculture also accounts for more than 90% of exports and 65% of employment. The economy is heavily dependent on exports of cotton. The manufacturing sector is relatively small (6% of GDP) and, apart from the processing agricultural commodities is mainly limited to textiles and cement. There have been some exports of chrome ore and further development of these deposits is taking place. The public sector generates about half the GDP.

GDP growth averaged nearly 8% p.a. from FY73 to FY78. This impressive performance, however, was not sustainable. Successive trade deficits in turn led to massive and uncoordinated borrowing abroad, a large part of it on non-concessional terms. Due to poor project implementation, some debts began to fall due before new projects came into full production. Sudan's current economic crisis is further compounded by weak infrastructure, falling agricultural and industrial outputs, critical energy shortages and an exodus of skilled manpower, mainly to the Gulf States. Since FY78, GDP has stagnated in real terms; real per capita income has declined and in FY81 stood at only US$260, placing Sudan within the UN's category of "least developed" countries.

Much of the recovery process now depends upon the extent to which Sudan can obtain debt relief and new aid commitments. Unless critical levels of imports are maintained, particularly petroleum products, domestic production and exports will be further depressed, leaving little or no scope for debt servicing. At least ten years of diligent work and extraordinary external support will be required before Sudan can expect to restore its full economic equilibrium. The Government has prepared a medium-term recovery program and consulted with donors regarding the country's external assistance requirements. Some increase in the capacity to service the debt can be expected in the longer term, through the oil revenues which should be earned from the crude oil export pipeline after 1985.

side, several measures are suggested for alleviating the fuelwood problem; furthermore, if decisions are taken now to harness more fully Sudan's hydroelectric resources, hydroelectricity could play a more important role in the long run. However, a number of new and interesting options have become available in the petroleum sector, following the discovery of oil in the southern part of the country and natural gas in the Red Sea. An export pipeline and a parallel diluent pipeline are to be constructed to transport the oil to the Red Sea; the project has been appraised by IFC. The diluent pipeline could be used to distribute products in the eastern and southern provinces; part of sudan's entitlement to the crude could be used in a refinery/topping plant at Kosti (although this would probably reduce the benefits of using the diluent pipeline to distribute products), which in turn could make it attractive to locate a power station at Kosti to supply the main grid; alternatively or in addition, some indigenous crude could be blended with imported crude at the existing Port Sudan refinery. Finally, if natural gas is available in sufficient quantities, it could be used in domestic markets; in particular, it could be supplied to power stations to supplement hydroelectric and oil-fired thermal generation.

Energy Supply

Petroleum

4. Oil: The discovery of crude in the southern part of Sudan and the construction of an export pipeline has made available certain options, among which a choice must be made. The three principal options are:

(a) Set up a topping plant at Kosti;

(b) Utilize part of the indigenous crude at Port Sudan Refinery (PSR), together with imported crude; and

(c) Set up a new refinery at Kosti or on the Red Sea to process indigenous crude, maximize the production of middle distillates and minimize the production of long residue (heavy fuel oil) wich requires further processing.

In view of the high capital costs of a new refinery, it seems prudent to pursue options (a) and (b) and to consider (c) only if much higher recoverable reserves are established; however, technical assistance is recommended for further study of the three options.

5. The construction of a diluent pipeline parallel to the crude export pipeline presents the option of using the diluent pipeline to deliver products. It is recommended that the diluent pipeline be designed for an additional pumping station at El Fau at a future date, although the benefits of using the diluent pipeline for product transport should be re-examined in light of a decision on the Kosti topping plant.

6. All bitumen is currently imported while PSR produces a surplus of long residue. The construction of a bitumen plant in Port Sudan is, therefore, an option. However, in view of the mission's projection that the surplus of long residue may disappear after 1988, it is recommended that the option of a bitumen plant be re-examined only after a decision on a new refinery is taken.

7. Natural Gas: The discovery of natural gas in the Red Sea makes available certain potential options for its utilization in domestic markets. Among other options, Sudan should consider using the natural gas in a urea fertilizer plant and -- perhaps more probably -- for power generation. Technical assistance is recommended to study both these options, including the possibility of piping the gas to Khartoum. The study should include an assessment of gas reserves based on available data, the possibility of a Government "farm-in" with total gas pricing.

Power

8. Despite the numerous studies of hydroelectric projects which have been made for the Blue Nile Grid (BNG), none have been completed beyond the prefeasibility stage and no scenario is available from which an order of merit could be prepared based on a least-cost analysis; furthermore, past planning of additions to system capacity in the BNG has been carried out with insufficient lead time to permit the optimal use of Sudan's hydroelectric potential. Technical assistance is therefore recommended to prepare, as soon as possible, a study to update the long-term power genertion development plan for the BNG to the year 2000. The study should: (a) define the economic merit order and appropriate timing for the different generating plants recommended; (b) be organized so that it can be repeated at least every two years at low cost; (c) assess the adequacy of existing studies of different generating plants; (d) define further studies necessary to proceed to feasibility and preliminary design; (e) estimate the local and foreign exchange costs of the further studies; and (f) attach a priority and timing to each recommended further study.

9. Outside the BNG, generation studies have been carried out but they are not up-to-date, they lack sufficient detail and they have not been coordinated. The Electric Power Status Report issued by the Public Electricity and Water Corporation (PEWC) in March 1982 should be repeated annually by the National Electricity Corporation (NEC) and a mechanism for coordinating past and future studies should be established.

10. Low-voltage distribution has played a secondary role in past expansion programs in the power sector; distribution systems in the BNG are therefore in poor condition and comprehensive distribution studies have not been made outside Khartoum and Port Sudan. Attention should therefore be given under next Bank-financed power project to distribution planning and investment in the Three Towns. Furthermore, technical assistance is recommended to investigate the condition of distribution systems within and outside the Three Towns, to assess the requirements

for their renovation, improvement and expansion, and to implement a power system loss reduction study.

11. To a substantial extent, the Power III project should alleviate power shortages in the BNG from the beginning of FY84; however, plans need to be drawn up for the commissioning of new generation capacity beyond Power III. The only short-term options are thermal, as there are no hydroelectric plants which could be commissioned on time to meet demand growth. If the topping plant is established at Kosti, two thermal options in particular need to be considered:

(a) Use the residual oil for power generation at Kosti and feed the power into the BNG by strengthening the transmission lines between Kosti and Sennar; and

(b) Transport the residual oil from Kosti to Khartoum for power generation at Khartoum.

Technical assistance is recommended for an urgent study of these options. In the Port Sudan area, the option of using gas for power generation could be available and technical assistance has been recommended for studying this option. With a view to the longer-term, aside from carrying out the study to the year 2000, a possible power project should consider the inclusion of feasibility studies for the heightening of the Roseires dam and for the Merowe hydroelectric project.

Forestry

12. While some surveys of Sudan's growing stock have been or are about to be conducted in selected areas — notably in the Blue Nile, Bahr-el-Gazal and El-Buhrat Provinces - with Canadian assistance, no national forest inventory has been made to provide an accurate estimate of the size of the total forest resource; consequently, there is no reliable basis for planning. As a matter ofhigh priority, a national forest inventory should be carried out, supported by overseas technical assistance, to extend the Canadian study to all provinces; the inventory would need to be implemented on a continuing basis, in order to assess the rate of deforestation over time and the degree of success encountered by afforestation measures.

13. Despite the lack of comprehensive national forest inventory, the present extent of the deforestation problem and the vital role played by fuelwood in Sudan's energy sector make it clear that urgent measures are necessary to preserve the forest resource as much as possible. The following package of overseas technical assistance, administrative action, Government budgetary support and enforcement of regulations is recommended: (a) provide technical assistance to study the feasibility, cost and economic viability of large-scale energy plantations, especially near urban areas and to set up demonstration and pilot projects; (b) provide technical assistance to study ways of improving the productivity of forests, thereby increasing the annual allowable cut relative to the

growing stock volume, through better management practices (including forest protection), the control of cutting, and the improvement and extension of silvicultural practices; (c) increase the central budget allocation to forestry, to implement the recommendations of the study under (b); (d) provide Government support and technical assistance to design, test, produce and introduce improved firewood cooking stoves, charcoal stoves and charcoal kilns; (e) enforce the requirements that abandoned agricultural land be returned to the Forestry Administration and that 15% of the land area of agricultural schemes be retained under forest; (f) carry out a program to increase public awareness of the deforestation problem, by establishing village-level committees for environmental protection; (g) encourage community forestry, through better extension services, community woodlots and homestead plantings; (h) incorporate the concept of maximum conversion of wood material into charcoal in all land clearance schemes; and (i) coordinate forestry programs with national energy policy.

Other

14. Sudan has made only limited use of energy sources other than petroleum, power and forests. Although solar and wind energy, molasses and bagasse can at best make a marginal contribution to the total energy supply in the near future, it is recommended that: (a) the Government and University of Khartoum continue to support solar energy research projects, especially for their eventual application to water heating; (b) further technical assistance be made available to design appropriate windmills and set up demonstration projects; (c) once the future of the sugar industry is known, the Government reopen discussions with the Kenana Sugar Corporation on the possible supply of molasses for ethanol production and choose a suitable agency to develop ethanol production; and (d) the detailed study of the use of bagasse for power generation proceed as envisaged under IDA's Technical Assistance II project, taking into account appropriate economic values for the costs and benefits of each alternative and determining appropriate institutional and financial arrangements for power and energy exchange between NEC and the sugar factories.

Energy Demand

Pricing

15. The prices of kerosene, diesel and fuel oil are below even the c.i.f. import values of the products. While the price of gasoil exceeds its c.i.f. import value, the margin is insufficient to cover the "inland" costs (i.e. the port, marketing, distribution and transport costs). It is recommended that, as a minimum, petroleum product prices be adjusted to reflect their corresponding values in world markets and, in addition, the "inland" costs be covered. Furthermore, in view of the excess demand for petroleum products, additional price increases would be warranted to

generate Government revenues and to keep the relative prices of different petroleum products in line with relative import costs. Although some departure from strict economic pricing might be considered for kerosene -- due -- to its social implications and its impact on fuelwood consumption -- its official price should at least cover its c.i.f. import value. A study of energy pricing is urgently recommended, which should also take into account the use of energy prices as a vehicle for taxation, resource allocation and related issues.

16. NEC's average tariff has recently been inadequate from a financial point of view and in relation to the long-run marginal cost of supply. Substantial increases in electricity tariffs are therefore required on both economic and financial grounds and are now bing implemented in two steps. However, a number of deficiencies appear to exist in the structure of electricity tariffs and there is a need for a proper tariff study. Technical assistance is recommended to support such a tariff study and the study should cover both the BNG and the isolated systems.

Conservation

17. The growth of road haulage at the expense of rail and river traffic implies an increase in the input of energy per ton-km of traffic carried, taking into account the relative fuel efficiencies of the different transport modes. A beneficial shift in the intermodal allocation of traffic could be realized if (a) rail and river freight rates are revised in relation to marginal cost; (b) the price of gasoil is raised at least to the level of its economic cost; and (c) the Sudan Railway and River Transport Corporations are reorganized to make them more competitive.

18. Within the road transport sector, the growth of private passenger vehicles has accounted for most of the overall growth of the vehicle fleet since 1970. A greater emphasis on public transport could lead to fuel savings. It is recommended that the Government: (a) continue to support the expansion of Khartoum's bus fleet; (b) rigorously apply the existing regulations concerning the licensing of vehicle imports and exemptions from import duties; and (c) consider setting a ceiling on the import of motor cars.

Institutions

The Energy Sector

19. A multiplicity of foreign donor assistance continues to take place in the energy sector; this assistance is uncoordinated and part of it maight be better directed towards essential spares and equipment rather than demonstration/pilot projects and studies. An appropriate permanent mechanism is recommended to evaluate, monitor and coordinate

this activity on a regular basis and bilateral assistance is recommended to help the Ministry of Energy and Mining (MEM) set up such a mechanism.

20. There is insufficient technical expertise in the energy sector to provide the basis for energy planning. A team of technical experts needs to be established in MEM to examine the various pricing and investment options and to make clear recommendations to enable the Government to take prompt decisions. Similarly, the establishment of energy plantations will require well-trained cadres of forestry specialists.

The Ministry of Energy and Mining

21. The main emphasis of the mission's recommendations for institutional improvement in the commercial energy sector has been given to MEM. World Bank technical assistance is already being directed at improving the performance of NEC and GPC and, furthermore, MEM accounts for many of the gaps which the mission has identified between actual performance and statutory responsibilities.

22. There are no inegrated system for controlling all ongoing activities and projects within MEM and the Minister and State Minister become involved in day-to-day operational affairs. The following areas should be examined with a view to making MEM more effective: (a) institutionalize the energy data collection process; (b) establish a mechanism for routinely coordinating the different groups within MEM and for coordinating the activities of MEM with other Ministries and relevant agencies; (c) design follow-up procedures for ministerial decisions; and (d) strengthen the secretariat of MEM with professionals from each of the energy subsectors.

23. Sudan is in the process of awarding a number of new petroleum exploration contracts and is faced or will be faced with certain "buy-in" and "farm-in" options. Technical assistance is recommended to help strengthen the staffing and expertise of the Geology and Mineral Resources Directorate in: (a) contract negotiations; (b) contract monitoring and management; (c) exercising options for "farm-in" and "buy-in"; (d) evolving a long-term strategy for development of the petroleum sector; and (e) compiling and analyzing all geological, geophysical and well-completion data provided by the contractors.

General Petroleum Corporation

24. GPC assists the Government in monitoring petroleum exploration contracts; it is also likely to become a partner with the international oil companies in petroleum exploration, through the exercise of the Government's "buy-in" and "farm-in" rights. The Government should, therefore, consider the need to define carefully and limit the contract award, management and monitoring activities of GPC which are the legitimate function of the Geology and Mineral Resources Directorate of MEM.

Forestry

25. The preservation and proper utilization of Sudan's forestry resources is essential and a national coordinated program of forestry management and development is vital. Strengthening of the Central Forest Administration (CFA) is therefore recommended. In particular, as a first step, a body should be created within the CFA to be responsible for the planning, coordination, review and monitoring of projects, especially the proposed energy plantation projects. Technical assistance is recommended to help implement these proposals (including training), to revise forest policy and legislation and to strengthen the administration of the forestry sector. Furthermore, suitable administrative procedures need to be established to coordinate forestry activities with national energy planning and policies.

Investment

26. There has been under-investment in the energy sector. Tentative mission estimates of public investment requirements for the eight-year period to FY91 -- corresponding to the `low growth' scenario for demand on the assumption that the individual investments are shown to be viable -- amount to US$1,730 million in 1983 prices or approaching US$220 million a year. Such a program -- corresponding to about 3.1% of GDP -- is not unreasonable compared with the performance of other developing countries. Specifically, it is recommended that the Government consider: (a) a topping plant at Kosti; (b) participating in the Red Sea natural gas discoveries on a "farm-in" basis and ensuring that the reserves of the Suakin structure are confirmed by additional drilling; (c) strengthening and expanding the power transmission and distribution facilities in the BNG; (d) contructing an oil-fired power station at Kosti, in the event that a topping plant is agreed upon, and (e) increasing investment in the forestry sector, notably through energy plantation programs. The unfolding debt problem and tighter constraints on scarce foreign exchange make it increasingly likely that the tentative program of energy investments may not be realizable. If half the power investment after the Power III project is postponed beyond 1991, total public investment in the energy sector could be cut from US$1,730 million to US$1,270 million, about US$160 million a year, corresponding to around 2.25% of GDP. Such a cut, it must be emphasized, would have very serious implications.

TURKEY: ENERGY BALANCE, 1980
(million tonnes of oil equivalent)

	Fuelwood	Other Biomass	Coal	Lignite	Crude Oil	Petroleum Products	Electricity	Total
Supply								
Primary Production	4.7	2.5	2.2	4.7	2.3	-	2.8	19.2
Imports	-	-	0.3	-	10.6	2.9	0.3	14.1
Exports	-	-	-	-	-	-0.2	-	-0.2
Refining	-	-	-	-	-12.8	12.5	-	-0.4
Thermal Power Generation	-	-	-0.3	-1.4	-	-1.7	3.0	-0.4
Other Transformation	-	-	-	-	-	-1.0	-0.9	-1.9
Net Supply/Demand	4.7	2.5	2.2	3.3	-	12.5	5.2	30.4
Demand								
Industry	-	-	2.1	1.5	-	4.3	4.0	11.9
Transport	-	-	0.1	-	-	5.2	-	5.3
Household	4.7	2.5	-	1.8	-	2.3	1.2	12.5
Agriculture	-	-	-	-	-	0.7	-	0.7

toe = 10 mn kcal
kWh = 2500 kcal

TURKEY 1/

1. The high level of dependence on imported petroleum is the dominant factor in Turkey's pattern of energy consumption. The share of petroleum in consumption of commercial primary energy rose from 20% in 1960 to 60% in 1980. The oil import bill grew rapidly, surpassing total export earnings in 1980, and became a major contributing factor to the 1979 economic difficulties. In order to reduce Turkey's dependence on imported oil, the Government launched a massive program in the late 1970s to increase the domestic production of electricity and lignite. This program has stretched the implementation capabilities of the state energy agencies to their limit and beyond. Resources were spread too thin, over too many projects, with resulting long delays in completion schedules.

2. Improvement in the performance of Turkey's major state energy institutions is fundamental to the success of the energy development program and the elimination of the continuing energy deficit that Turkey faces. These institutions have particularly acute problems because, unlike other industrial State Economic Enterprises (SEEs), they will be called upon to increase their efficiency while growing at rates greater than 10% per year for the next several decades. However, even in the best of circumstances, Turkey will remain heavily dependent on imported fuels, primarily petroleum. A policy goal of reducing this dependence is important in that it could increase the Government's ability to take a more flexible approach in handling other important economic issues. It is to this goal of reducing import dependence, therefore, that the report is directed.

3. The Government has concentrated most of its efforts to reduce dependence on imported oil by expanding lignite and power output. There is, however, a limit to what the State lignite and power development agencies can be expected to accomplish, even if all the proposed institutional reforms are carried out quickly and effectively. It is, therefore, quite possible that lignite and hydro power production may grow too slowly to meet the full requirements of a dynamically growing economy. If this happens, recourse would have to be made to an even greater expansion in energy imports than is currently envisaged. In order to reduce Turkey's dependence on imported energy sources, the Government should put a higher priority on a complementary approach to the development and efficient use of its energy resources in the future than it has in the past.

4. One of the most important elements of such an approach is the expansion of efforts to develop other known primary energy resources, particularly through the expansion of programs to increase the recovery

---

1/ Adapted from Report No. 3877-TU, February 1983.

of oil from proven reservoirs, the exploitation of identified geothermal fields, and the more extensive use of forestry resources and wood plantations for fuelwood. Such developments would require an expansion of the financial and technical resources currently committed to these fields.

5. A second important element is the expanded enlistment of the skills and resources of the private sector, both domestic and foreign. The local private sector could develop the smaller projects that the state enterprises are unable to consider because of a shortage of staff. The foreign private sector should be encouraged particularly in such fields as petroleum and geothermal where their expertise is needed to speed up the exploration for development of these resources.

6. The third element of the proposed approach is the encouragement of greater efficiency in the use of existing energy resources. This includes instituting pricing and other policies that encourage greater efforts to reduce energy consumption, establishing institutions that can provide technical assistance to industry in energy savings and by requiring state enterprises to institute energy saving programs. While none of these approaches alone will solve the problem of the high dependence on imported energy resources, together they will be able to make a substantial impact on the problem.

Demand and Supply Projections

7. The demand and supply projections for major energy products prepared by the various concerned ministries were reviewed in October 1981. The resulting demand projections used in this report and, based on the assumption of a moderate level of economic growth averaging 4.5% to 1985 and 5.0% thereafter, show electricity growing by 200% between 1980 and 1990, to 60,000 GWh; lignite demand by thermal power plants growing by almost tenfold to about 50 million tons; fuelwood and biomass demand growing by 14% to 36 million tons; and petroleum demand growing by 110% to 30 million tons. If some products (such as fuelwood or lignite) are not available, demand may spill over into other energy substitutes. Demand would, of course, grow substantially faster in response to a more rapid rate of growth of GNP.

8. To resolve its energy difficulties, Turkey has concentrated its efforts on the expansion of its domestic energy production through the development of its hydro and lignite resources, while attempting to restrain the growth in petroleum consumption. The implementation schedules for the major power and lignite projects were, therefore, also reviewed. The results indicate that even if the Government's proposals for reforming its energy institutions can be implemented, an optimistic estimate of net available electricity in 1985 and 1990 would be 37,300 and 60,500 GWh respectively, and 31.7 and 70.7 million tons lignite, respectively; these were used as the base case supply estimates for the energy balance projections.

9. The energy balance based on the above demand and supply projections shows that sufficient power could be produced and to eliminate imports in 1990. However, there would be shortfalls in lignite production of about 9 million tons in 1985 and 7 million tons in 1990, shortfalls that presumably would have to be made up with additional fuel oil imports. Energy import levels needed to balance demand requirements would range from 28.4 million tons of oil equivalent (toe) in 1990, under the most favorable scenario, to 32.9 million toe in a less favorable, but quite possible scenario of a 20% slippage in the lignite and power investment program and a low availability of hydro electric power due to substantially lower than average rainfall. A higher level of economic growth would, of course, lead to substantially higher levels of demand. An increase of an extra 1% in GDP growth per year until 1990, would, even with a low elasticity of demand of 1.2, increase total annual energy consumption by about 5 million tons oil equivalent, all of which, presumably, would have to come from imports.

10. The need for such a high level of energy imports would put a severe strain on Turkey's overall ability to import sufficient goods to keep the economy growing smoothly. This would have serious implications for economic growth that will not be analyzed in this report. The issue, therefore, is whether the most severe effects of the possible higher levels of demand for energy imports would cause energy supply shortfalls and imposition of emergency measures that could disrupt the growth of the economy, or whether the constraints on the economy could be reduced through long term strategies and tactics that could minimize energy import requirements for expanded energy imports.

Increasing the Production of Energy

11. The above estimates of the levels of energy output of the state energy agencies are contingent upon rapid improvement in the mobilization and distribution of investment resources for priority projects and on the improvement of the capabilities of the energy SEEs to implement the projects. The problems of the energy SEEs are particularly pressing, since these institutions will be called upon to increase their operating efficiency while increasing production at better than 10% per year over at least the next decade. The implementation of an effective reform program for the energy SEEs, therefore, should be seen as one of the Government's top priorities. Without action on this front, little or no progress can be made in resolving the country's energy difficulties.

12. The Government is currently revising the basic laws under which all SEEs operate, with the aim of removing the constraints on improving their efficiency. In addition to changing these laws it it recommended that: (a) in order to create a stable professional management, senior mangers should be appointed for fixed terms; (b) to assure adequate delegation of authority to management along with full accountability, the appointment contracts should be accompanied by annual "State Economic

Enterprise Program Contracts" between the Ministries of Energy and Finance on the one hand and the management of the SEEs on the other; and, (c) to stop the losses of professional staff, the salary structure of management and engineering staff should be disassociated from that of the civil service and aligned closer to that of the private sector. In addition to implementing these reforms, however, a series of measures, the most important of which are discussed below, will be needed to improve the performance of specific energy subsectors.

Lignite

13. Almost all of the planned new thermal plants would be lignite fired. This places a heavy burden on the Turkish Coal Authority (TKI), the Government owned coal and lignite mining enterprise to expand its lignite production facilities, and TKI has embarked upon an extremely ambitious program to meet this growing demand for lignite. From the 15 million tons produced in 1980, production in 1990 is planned to rise to 70 million tons, a more than four-fold increase, to be accomplished through the development of eleven large open pit mines and two large mechanzied underground mines. However, TKI is understaffed and, therefore, is technically not capable of undertaking the preparation, implementation and monitoring activities that are required for such a large expansion program. Thus, TKI is faced with the prospect of having to follow through on many projects with insufficient technical staff and inadequate financial resources to complete them. To resolve its short term staffing problems while building up its own internal capabilities, TKI will have to rely heavily on outside assistance for project preparation and project implementation and management. To supplement its limited in-house capabilities to develop its lignite resources rapidly, TKI could use foreign contractors to develop some of its proposed projects on a turnkey basis, if sufficient foreign exchange were made available. Otherwise it will have to scale down its program to a more manageable level commensurate with its available staffing and financing resources, or face continued unforseen technical problems, unprogrammed project delays, and cost overruns.

14. What TKI lacks is a coordinated program for maximizing the efficient use of its limited managerial and financial resources. In order to develop a realistic program, it is recommended that revised estimates be made of construction and operating costs of the various lignite mines and thermal power plants for all mine mouth power complexes that are in the early stages of development. A ranking should then be made of the economics of the different units. This work should be done with the aid of outside financial assistance. Based on this ranking, explicit priorities should be set for completing the construction on only those projects for which financing and staffing and implementation capacity can reasonably be assured.

15. The potentially high cost of some lignite-based power projects raises questions about whether their development for power is economically justifiable and competitive with other power development

options. This is particularly true for the development of Elbistan B, C, and D. A detailed cost comparison between the alternatives of additional developments at Elbistan and a shift to imported coal for power needs in the 1990s and beyond should be made to determine the least cost approach.

Coal

16. Coal prospects and problems are substantially different from those of lignite and should be treated separately. Production can be increased only marginally, even under the best of circumstances. Large scale mechanization is impractical at most under-ground mine faces. The industry is plagued by excessive employment and deteriorating capital equipment, and costs are above the alternative cost of importing. Efforts should, therefore, be directed at reducing costs through improving operational efficiency. A comprehensive study is needed to determine the best way to accomplish this. Until this study is completed TKI should concentrate its energies on lignite production since this is where the major expansion in output will come from. One way of ensuring this might be to have TKI's hard coal operations could be segregated to a toally separate profit centre with its own fully independent management. If need be, to accomplish this, hard coal and lignite operations should be split up and separated into fully independent institutions.

Electricity

17. The Government's planned power development program calls for a tripling of installed generating capacity in the decade of the 1980's, reaching 15,000 mw by 1990. About half would be in hydro and half in thermal. This program will require the Turkish Electric Authority (TEK) the Government owned power utility, to bring on stream three times more capacity in the 1980's than it brought on in the 1970's. A revised investment program is urgently needed for the power sector. It will need to be based on a more realistic demand forecast. It should also take into account the manpower constraints in the subsector, so that the available scarce human and financial resources can be focused effectively upon a smaller number of projects. Investment in upgrading and expanding of distribution and transmission facilities and particularly in repair of major urban facilities should be given high priority. They have both high returns and can increase available electricity supplies quickly.

18. The process by which new projects are chosen for inclusion in the country's long term power development program needs to be revised before new projects are included in the next five year plan. One problem is that in calculating the economic costs and benefits of power, the General Directorate of State Hydraulic Works (DSI), TKI, and TEK use different parameters for costing hydro power, lignite, thermal power and transmission investments. Different discount rates, investment costs, inflation rate and base case comparators are used for each economic feasibility study. These inconsistencies can often lead to suboptimal choices in the priorities among competing projects. It is recommended

that this least cost power development planning model be revised and updated.

19. The ministries concerned with fuelwood production have been slow in recognizing the potential ecological and economic consequences of future shortages of forest resources and fuelwood. For example, the General Directorate of Forests (OGM), has put priority on the development of industrial wood resources almost to the total exclusion of fuelwood considerations. Its current plan calls for a decline of 25% in the volume of fuelwood supply coming from existing official sources over the next 15 years, and proposes to substitute lignite, coal and LPG as alternative energy resources for cooking and heating. It is clear, however, that under the present circumstances such a policy would go against the tide of new energy realities. For the development of fuelwood resources, a comprehensive plan for reducing production shortfalls should be prepared as soon as possible andd appropriate funds allocated towards achieving reasonable production targets. Projects in the area of coppice rehabilitation, energy plantations and village woodlot development should be given a high priority within the overall energy investment program.

Geothermal

20. Geothermal resources can be used for both power and space heating. In spite of promising geological conditions the development of these resources has been given an extremely low priority; as a result, little has been accomplished to demonstrate the importance of their potential. Although the basic research work has been completed for some time, at present there is no organization dedicated to the development of this resource. As part of a realistic development program to develop these resources, consideration should be given to allowing the private sector, either local or foreign, to obtain concessions to develop some of the known reserves. The discussions currently in progress with Union Oil on a possible exploration agreement are an encouraging step in this direction.

Private Sector Inititatives

21. Even after taking into account the increase in energy supplies that can reasonably be expected to be provided by improved, more efficient energy SEEs, there will still be a need for more energy production. One important way that the Government can help increase production is by encouraging the participation of private enterprises, both local and foreign, in the development of Turkey's energy resources. The private sector could make important contributions in the expansion of lignite production and the exploration and development of petroleum resources. It could also make a smaller, but still important, contribution to power generation, geothermal development and fuelwood production. The following is a summary of the principal recommendations for encouraging private sector participation.

(a) In the lignite subsector, the Government should return smaller mines to the private sector as quickly as possible to increase the supply of lignite to the household and industrial sectors. It should also consider granting concessions or long term production contracts to private firms for the larger mines for which TKI has no current development plans. Since TKI is unlikely to be able to develop all nine major projects that it is planning during the 1980s, consideration should be given to opening the development of one of these projects to foreign competitive bidding. If successful, this could bring additional foreign capital as well as foreign expertise and training to the Turkish lignite industry. For the lignite mines owned and operated by TKI, the government should encourage the expansion of competively bid, long term contracts for the removal of overburden by the private sector, consistent with TKI's firm financial program for purchasing its own equipment. This would give the private sector the incentive to purchase the heavy equipment required to do the work more efficiently.

(b) Foreign participation in petroleum exploration is potentially of enormous significance to Turkey, with its prospect for early foreign exchange savings through expanded production and the transfer of skills and technology. Encouraging progress has already been made in this area. The promotion of exploration activities by foreign companies should focus on: (i) clarification of the policy framework within which foreign companies must operate, through the passage of the new petroleum law; (ii) the opening of prospective acreage where TPAO is not currently active; (iii) revision of the legal, contractual and administrative framework, with particular focus on key areas such as the remittance of capital and profit, pricing and fiscal arrangements; and (iv) development of the skills needed to actively promote and negotiate new exploration contracts.

Efficiency in Energy Usage

22. With the supply of energy resources severely limited and the investment cost of expanding these resources high, it is imperative that action be taken to influence the users of energy. Clearly, increased efficiency in the use of energy must play an important role in reducing the pressure on existing resources. There are three ways that the Government can promote energy efficiency. The first is through appropriate energy pricing policies. The second is through requiring high energy consuming industries within the state sector to implement programs to reduce energy consumption. The third is through exhortation, information and incentives for the private sector and through creating a climate under which energy efficiency will be considered by every energy user.

Pricing

23. The Government's pricing policy has been based on two major principles. First, that energy producing and distributing enterprise should recover their costs; and second, that relative energy prices should be set to encourage the substitution of domestic fuels for import. To these a third principle should be added: the principle that energy princing should reflect opportunity costs, that is, the real cost of producing or importing additional amounts of energy in the future. Therefore, for as long as there is going to be a shortage of foreing exchange for importing the required amount of energy and international accounts are balanced by a system of import duties, import restrictions and export subsidies, the opportunity cost of imported energy will be higher than current cif prices, and the price of imported fuels should be raised accordingly. The application of these basic principles leads to the following conclusions:

(a) The prices of petroleum products should be raised in order to keep the growth of oil import demand to economically sustainable levels. To reduce the strain on the balance of payments, the tariff on oil and oil products should be raised at least sufficiently to eliminate this bias implicit in the import system. Retail price increases of 25%-30% would appear reasonable on the basis of existing information. If the price increases that are required are impractical in the immediate future, the Government couldachieve the goal by announcing apolicy of gradually increasing prices in real terms over a period of three to five years. If strictly carried out, this announced policy could influence present investment planning decisions, since these decisions are generally made on the basis of expectations about future prices.

(b) Lignite prices should be raised to reflect reasonable production costs (including a reasonable return on investment). At present, lignite prices do not cover production cost for most mines. While the Government may wish to subsidize household consumers on income distribution equity grounds, it should have no similar basis for subsidizing power and industrial users. These consumers should be charged the full economic cost. If the Government subsidizes household consumers, it should reimburse TKI for the price differential. This does not mean that prices should be automatically set on a cost-plus bais. Many of the new mines may be only marginally economic compared with other energy sources, and a guarantee of cost plus returns may lead to cost ineffectiveness in TKI. Therefore, prices for each mine should be agreed upon in advance, based on a reasonable target for operating efficiency, with appropriate escalation clauses and contingencies. The ability of each mining project (particularly new ones) to contract for its output on the basis

of price comparisons with domestic and imported alternatives would provide an important indication of the economic viability of the project.

(c) Electricity prices are substantially below opportunity costs, which, for this resource, are indicated by the long run marginal cost (LRMC) ofsupply. The present bulk and retail tariffs should be restructured to reflect the LRMC, including a reasonable return on investments valued at replacement cost. Energy intensive industrial users, such as aluminum and ferro-chrome producers, that now get preferential rates, should be charged the same rates as other bulk consumers; TEK should not be forced to subsidize them. TEK should also be allowed to increase its tariffs in a timely manner to reflect inflation and increases in fuel costs.

(d) Fuelwood prices at forest village depots appear to be lower than necessary to encourage optimum production and distribution. Higher prices could provide the funds required to expand investment in forestry projects.

Institutional Changes

24. In addition to establishing realistic prices to allow the market to work more effectively to bring about conservation in the private sector, the GOT can also encourage the more efficient use of energy through the provision of the necessary technical information and assistance to energy users. This should be accompanied by a promotion and education campaign, and the formulation of an accompanying regulatory framework, such as building codes, traffic regulations, environmental controls, etc. For the majority of energy users, who cannot be expected to acquire their own in-house capability, the GOT should establish vigorous energy efficiency programs, to be coordinated by an organization exclusively devoted to this work. One possible way of achieving this would be to upgrade and expand theexisting energy efficiency unit within the EIEI of the Ministry of Energy. The proposed organization should develop a comprehensive program of promotion, energy surveys of individual plants and buildings, setting of efficiency targets, training, monitoring, and reporting to the Government on progress made on an annual basis. As an initial goal, this organization should be given the resources to perform an energy survey ofthe largest 100 energy users within three years.

25. While the proposed organization will constitute the backbone of the energy efficiency program and would be responsible for monitoring its progress, the implementation of specific measures would still be the responsibility of the individual energy producing and consuming units. Thus, in the power subsector, TEK should set up a special unit torevise and implement its load management program, with a view of reaching the

target of balancing supply and demand and of providing the industrial sector with the quality of electricity that it requires to operate efficiently. In addition, TEK should review its operation, maintenance and spare parts stocking procedures to ensure that short term demand considerations do not adversely affect long term operating capabilities. Energy audits should be carried out at all thermal stations. Furthermore, investment in rehabilitation of transmission and distribution facilities should be substantially increased with the objective of reducing power losses.

26. In the public industrial subsector (including refineries), the management of most SEEs tend to be relatively unresponsive to energy price increases in their day to day operating decisions; they have failed, for the most part, to place strong emphasis on programs designed to find ways to reduce energy consumption in operations. To increase energy conservation consciousness, General Managers should have improvement in the efficiency of energy use as one of their operational targets. Each SEE should be required to set up a special department to measure, monitor, and make improvements in energy use. New investment proposals should include an analysis of the energy consumption implications and the expected energy efficiency coefficients. Given the possibility of continuing energy shortages and the high cost of power from fuel oil fired power plants, there should be no new investments in energy intensive industries such as aluminum and ferro-steel unless such investments can be justified when evaluated with energy costs based on the real opportunity cost of the energy consumed.

Planning

27. To be useful for policymakers, the planning process needs to be institutionalized and the staffing strengthened, possibly within the Ministry of Energy and Natural Resources, so that energy sector plans can be revised annually. The revisions would use updated estimates of critical parameters, including those of project completion dates for added productive capacity, those of energy import capacity, and those of growth in demand by major consuming sectors. First priority should also be given to reevaluating all major new energy projects, particularly for lignite development. Attention should also be given to consumption priorities and the appropriate distribution of the limited lignite supplies available among power, industry and household consumers, instead of allowing the implementation of such critical policies to bo by default to TKI and TEK. Most importantly, however, is that a strengthened Energy Planning Secretariat would be able to review the full range of options available to the Government to meet the energy needs of each consuming sector.

28. Clearly, Turkey's energy problems will be long lived. They must be tackled on many fronts simultaneously, as on one set of actions will be adequate to resolve them. Energy pricing and efficiency in

energy use at all levels of private and public sector activity will be important in reducing the growth rate of demand. However, in the long run, the most critical requirement for resolving these problems is that the efficiency of the energy producing institutions be improved so that they may operate at maximum efficiency and expand output at the rates required.

UGANDA: ENERGY BALANCE, 1980
(thousand tonnes of oil equivalent)

	Non-Commercial Energy	Commercial Energy										
	Fuelwood	Fuel-wood	Charcoal	LPG	Gaso-line	Aviation fuel	Kero-sene	Diesel a/	Fuel Oil	Electri-city	Total	Total
Primary Supply												
Production	3,662	1,121	-	-	-	-	-	-	-	159	1,280	4,942
Imports	-	-	-	1	89	13	48	73	23	-	247	247
Total	3,662	1,121	-	1	89	13	48	73	23	159	1,527	5,189
Transformation	-	(738)	177	-	-	-	-	-	-	(106)	-	(667)
Secondary Supply	3,662	383	177	1	89	13	48	73	22	54	1,527	4,552
Transmission & Distribution Losses	-	-	-	-	-	-	-	-	-	9	-	9
Exports	-	-	-	-	-	-	19	14	-	24	57	57
Net Supply/Demand	3,662	383	177	1	89	13	29	59	22	21	794	4,456
Demand												
Residential	3,267	146	112	1	-	-	29	-	-	7	295	3,562
Commercial	351	96	65	-	-	-	-	-	-	6	167	518
Industrial	44	141	-	-	-	-	-	1	22	8	172	216
Transport	-	-	-	-	89	13	-	58	-	-	160	160

toe = 10.2 mn kcal
kWh = 2550 kcal (production)
= 860 kcal (consumption)

a/ Primarily automotive

UGANDA 1/

1. During 1980, per capita energy consumption in Uganda is estimated to have been 0.35 toe, of which only 0.06 toe was commercial. This commercial energy consumption, while exceptionally low by world standards, is comparable to estimates for some other low-income countries in Sub-Saharan Africa. In Uganda's case, the low level of commercial energy consumption reflects not only the country's low per capita income, but also the dominance of the subsistence sector and the significant decline in the industrial and transport sectors during the 1970s. For the same reasons, energy consumption is concentrated in the household sector and supplied primarily from woodfuels. Electricity, which is the major focus of public involvement in the energy sector, has never supplied more than 4% of commercial energy consumption. In terms of primary supply, 84% of Uganda's commercial energy was domestically produced in 1980, with the balance coming from imported petroleum products. About 7% of the net supply of commercial energy was consumed outside Uganda, including electricity exports to Kenya and unofficial sales (smuggling) of petroleum products to most neighboring countries.

2. The impact of recent improvements in Uganda's economic performance on commercial energy consumption has so far been constrained by higher energy prices and the shortage of foreign exchange with which to import petroleum products. As a result, the declining trend of commercial energy consumption, which has been evident since 1970, continued through 1982. However, even allowing for further improvements in energy efficiency, this trend is now expected to be reversed. Given the many uncertainties in the Ugandan situation, the mission considered a range of illustrative energy demand projections. Under the base case, commercial energy demand rises by 6.3% per annum through 1985 and 4.7% per annum from 1985 to 1990. With even more pessimistic assumptions on the pace of recovery (the low case), the growth rate of commercial energy demand averages 4.8% per annum over the remainder of the 1980s. To meet this demand is the basic challenge facing the energy sector today.

Energy Efficiency

Conservation

3. The efficiency of energy use in Uganda is extremely low. Some degree of improvement in energy efficiency will follow automatically, as rehabilitation proceeds and capacity utilization increases. However, additional savings should also be achieved by implementing relatively

---

1/ Adapted from Report No. 4453-UG, July 1983.

Economic Context

Uganda has an enviable reserve of natural wealth, with highly favorable soils and climate for agricultural production, a rich mineral base to support the industrial sector, and ample water and forest resources for energy development. At Independence, in 1962, Uganda was one of the strongest and most promising economies in Sub-Saharan Africa. The economy continued to perform well throughout the 1960s, supported by a well-developed transport system and an exceptional supply of skilled labor. The economy was and is dominated by agriculture, which provides livelihood to about 90% of the population (13 million in 1961) and has supplied almost all of Uganda's exports in recent years.

By April 1979, when the military regime was overthrown, the Ugandan economy was in ruins. While there was at that time high hopes for rapid economic recovery, initial progress was constrained by the unsettled political situation, administrative and manpower constraints, and a severe shortage of foreign exchange. Little progress was made on policy or institutional reforms during 1979 and 1980. In mid 1981, the Government introduced a major package of policy reforms including devaluation and related price adjustments and has followed this with further measures over the past two years. This program, supported by stand-by arrangements with the IMF, is intended to stabilize the economy and eventually revive investment and production through restoring a measure of confidence in the currency, reducing price distortions and improving fiscal and monetary discipline. Overall GDP is estimated to have grown on average by 5.7% per annum in 1981 and 1982.

simple and cheap energy conservation measures, especially in the industrial and transport sectors. These conservation measures would have an immediate impact on the energy situation, by reducing the growth of petroleum import requirements and the demand on generation capacity at Owen Falls Power Station. In the industrial sector, the Mission recommends that:

(a) fuel-firing techniques in boilers and furnaces should be improved through operator training and provision of appropriate monitoring instruments;

(b) power-factor correction equipment should be installed and properly utilized;

(c) various investments in energy-saving equipment should be undertaken, including recuperators on furnaces and kilns, effluent heat recovery plant and recovery of condensate;

(d) new and more efficiency boilers, already imported, should be installed as soon as possible; and

(e) general energy management and housekeeping techniques should be improved.

Similar energy savings can be made in agro-industrial plants, through improving boiler efficiency in tea-drying factories, improving kiln design and burning efficiency in the brick and kiln industry, improving barn design and increasing barn size for tobacco curing, and possibly using brick hearths for fish smoking.

4. The mission estimates that diesel fuel consumption in rail and road transport could be reduced by 5% to 10% with appropriate conservation measures. These include:

(a) better maintenance procedures, workshop facilities and availability of spare parts;

(b) installation of diesel-testing equipment (some of which has already been imported) and proper tuning of engines; and

(c) training of drivers and mechanics.

Improvements in railway track conditions and grades, as well as road rehabilitation, would also contribute towards better fuel efficiency in the transport sector.

5. Energy efficiency in households and commercial establishments, especialy for woodfuel stoves, is also low. The most common stoves at present are the fuelwood-burning three-stone fire and the charcoal-burning metal stove (sigiri). Higher efficiencies could possibly be achieved with burnt-clay stoves. However, for these stoves to be acceptable to the consumer, they must be portable, easy to use and low cost. Particular attention needs to be given to the development of simple and non-customized designs which utilize local materials, and to the practical problems of stove manufacture and marketing. A number of countries in the region have recently started programs to improve stove efficiency and Uganda should follow these programs closely. To date, progress has been limited and even the potential for achieving higher levels of stove efficiency in everyday use remains unclear. Nevertheless, further development and promotion of better stove designs is justified by the potential impact on demand for woodfuels. Further savings of wood could be realized by improved charcoal production techniques. Courses should be organized in earth kiln production, and brick and metal kiln production should be revived and applied where appropriate. Alternative fuel options should also be investigated, including briquetting of charcoal powder/fines, sawdust and crop residues, and compressed and pre-dried wood.

6. Present losses on power transmission and distribution offer considerable scope for energy conservation. Urgent rehabilitation works are scheduled with British (ODA) and IDA assistance. However, additional rehabilitation will be required to reduce distribution losses to acceptable levels, and the need for such works are included in the terms of reference for the proposed study into uprating and rehabilitating Owen Fals Power Station. Improvements in power factors, especially for major industrial consumers, will also help to reduce distribution losses.

Substitution

7. The feasibility and economic viability of proposals for fuel substitution in industry should be studied on a case-by-case basis, taking into account projected production levels and the associated costs of energy investments. The mission's preliminary findings suggest that there are several industrial and agro-industrial plants in Uganda for which there is a strong economic justification, as well as financial incentive, for fuel substitution. The most promising option is the substitution of fuel oil by woodfuels, for example, in the cement industry and for tea drying and coffee roasting. However, a basic prerequisite would be a guaranteed source of woodfuel supply, either from the establishment of plantations or designation of specific forest areas for commercial management. Other promising forms of energy substitution include switching to heavier grades of fuel oil and the use of in-house agricultural wastes such as bagasse and coffee husks. In general, the mission doubts that major boiler conversions to electricity would be economically justified before the addition of power generation capacity from a new hydro station, which would be in 1991 at the earliest. Similarly, electrification of Ugandan railway system is unlikely to be justified in the near future because of low traffic densities. However, the Government's plans to extend the power transmission network to isolated local centers, presently supplied by diesel operators or which are without electricity supply, are considered justified. This extension will substantially reduce the costs of supply and provide an additional energy option for households, agro-industries and water pumping stations.

Energy Supply Options

Hydroelectricity

8. Uganda is well endowed with hydroelectric potential, especially along the Victoria Nile. According to the base-case demand projection, additional generating capacity will be required by 1986 to meet Ugandan demand and existing export contracts. The only capacity which could be added in time to avoid significant shortfalls in supply is the rehabilitation and uprating of Owen Falls Station, which could add about 60 MW in rated capacity. Already, the timetable for project preparation and implementation is tight. It is therefore essential that the proposed feasibility study be started immediately. The next addition to capacity

to meet projected demand will be required towards the end of the decade. Since the period required for project preparation will be about two years and for construction about five years, planning for the next station must be started now. In this context, an immediate priority is preparation of a least-cost power development program up to the year 2000. The program should be based on a detailed demand forecast taking into account the prospects for economic recovery, fuel substitution possibilities, additional exports and extension of the transmission system. Proposed terms of reference for these two studies were drafted and discussed by the mission with the Ministry of Planning and Economic Development (MPED), the Uganda Electricity Board (UEB) and the British ODA, which subsequently agreed to finance these two studies.

Petroleum

9. At the present time, Uganda imports all of its requirements of petroleum products. There are signs that Uganda could have some petroleum resources in the lake Albert area and further work to assess the extent and economic viability of these resources is justified. Technical assistance is already being provided by the Commonwealth Fund for Technical Coorporation and IDA to help prepare petroleum legislation, undertake airbag and gravity surveys (jointly with other countries in the region) and complete a petroleum exploration package. This package can then be used to determine the interest of oil companies in further exploration and development.

10. Development of domestic petroleum resources is a long-term and still uncertain prospect. At least for the 1980s, Uganda will remain dependent on imported petroleum products and the main objective should be to minimize the costs, particularly in foreign exchange, of these supplies. Significant progress in this regard has already been made during 1983. Even so, the Government still needs to take a more active role in monitoring petroleum imports, based on an informed understanding of changing market and regional conditions, to ensure that an appropriate mix of supply options is maintained. The mission's recommendations are as follows:

(a) diversify supply sources. The cheapest source of petroleum products for Uganda is direct imports from the Middle East. The next best option is usually processing crude through the Mombasa Refinery, although purchases on the Kenyan market occasionally become more economic. During 1983, the oil companies have stopped buying products on the Kenyan market and some have started importing directly from the Middle East. This shift is proving beneficial to Uganda. Further adjustments in supply sources should be made, as and when appropriate, to take advantage of changing cost relationships.

(b) reduce transport costs to the Ugandan border. Presently less than 10% of petroleum products are transported from Mombasa to the Ugandan border by rail. However, this is by far the most

economic option and the Ugandan Government should do all it can to ensure that better use is made of the railway. This will require the allocation of rolling stock for transporting petroleum products in Kenya and Uganda, and some rehabilitation of railway infrastructure. But the more binding constraint is the influence of vested interests in the allocation of freight traffic to trucking, and this will be difficult to break;

(c) develop alternative supply routes. The Government is presently arranging with Shell to carry out a trial run for importing petroleum products through Dar es Salaam and on by railroad to Mwanza and thence by lake ferry to Jinja. It would appear that the costs of this route are similar to those of using road transport through Kenya. The mission supports this initiative; and

(d) maintain a product stockpile. Uganda should maintain a "minimum safety stockpile" of petroleum products. There would appear to be no general shortage of storage capacity at the present time. The actual level of stocks has also been increased in recent months from one to four weeks' consumption. This level of stocks would seem to be adequate to provide protection against disruption in supplies.

Woodfuels

11. There is evidence that Uganda's wood capital is being eroded. In certain areas, where population densities are high or the available land is being converted to agricultural uses, the accessibility of woodfuels has already been seriously affected and there is a danger that local wood supplies will soon be depleted. The mission therefore recommends that the Forestry Department undertakes an inventory of tree stocks on a district-by-district basis. This inventory should be complemented by a survey of consumption trends and projections for all wood products to help pinpoint the areas of immediate shortages. Measures can then be pursued to help remedy this situation. In particular, the Government should:

(a) encourage farmers to introduce trees into the cropping system. Appropriate agro-forestry practices should be taught in agricultural and forestry colleges and at Makere University. Extension workers should be trained in agro-forestry and farm tree management so that they can provide practical advice to farmers. At present, the extension system in Uganda is basically non-operational and it will have to be substantially strengthened and reorganized to become effective;

(b) assist in the planning and execution of urban and peri-urban plantations. Legislation may be required to permit plantation development, if there are not already forest reserves in the vicinity. Private individuals may invest in woodfuel

plantations as the most profitable use of land at present urban prices for fuelwood and charcoal. The Government could encourage this investment by providing inputs (for a charge) and management assistance;

(c) assist industries to establish industrial plantations and woodlots as an alternative energy source. This could be done by providing technical help and leasing out areas of forest reserves as has been done in the case of the tobacco industry. If necessary, the Government could also provide inputs and financial support;

(d) expand forest plantations to provide the raw material for sawnwood and panel products and, most importantly, for woodfuels and poles. The output per unit area could be increased up to five-fold by converting from natural forests to plantations. This should at least be done around the perimeters, to prevent encroachment;

(e) improve the management of natural forests and woodlands, by cutting out unwanted trees for charcoal production or fuelwood and controlling the legal and illegal use of commercially valuable trees. Line planting should be reintroduced to boost natural regeneration and more forest areas should be included within the management plans; and

(f) give special emphasis to the needs of low-potential agricultural areas, such as Karamoja, where there is an acute shortage of wood and ecological conditions are fragile. It is essential to establish a protective barrier of trees to prevent desert creep and with browse or feed trees it may even be possible to sustain a higher animal population as well. The establishment of trees is the most difficult problem and micro-catchment techniques with solar electrical fences should be tried.

Sufficient seeds, cuttings and seedlings must be available in the right place at the right time to undertake an expanded planting program as proposed above. Related back-up requirements include trials on tree species, the acquisition and distribution of indigenous and exotic tree seeds, the establishment of seed stores and nurseries, and the development of seed orchards and a tree-breeding program.

Other Indigenous Energy Sources

12. In western Uganda there are a number of areas which show promising geothermal potential. A UNDP study, completed in 1971, concluded that further surveys and exploration of this potential was justified. However, the mission does not consider this an immediate priority, given the present resource constraints and the availability of sufficient hydroelectric capacity to meet the country's power

requirements for many years to come. The mission has also looked at new renewable energy options and concludes that these are unlikely to have a significant impact on Uganda's overall energy situation during the 1980s or even over the longer term. However, some could make a contribution in specific applications (e.g., solar drying and water heating), in certain industries (e.g., use of bagasse by the sugar industry) and in isolated areas (e.g., biogas). Further development of these renewable energy options is justified. The Government should consider providing special tax incentives to encourage use of solar heaters in new and existing buildings, especially in areas not served by UEB's transmission network.

Energy Prices and Pricing Policy

13. Retail prices for all energy sources in Uganda declined in real terms during the 1970s. This led to waste and inefficient use, reduced the sector's contribution to public revenues, and encouraged smuggling of petroleum products to neighboring countries. Since 1981, the Government has increased petroleum prices substantially, at least in line with the devaluation of the Ugandan shilling and by as much as 2,200% in the case of kerosene. However, the potential for profitable smuggling has not been fully eliminated and there are still significant price distortions among products. Comparable adjustments have not been made in domestic electricity tariffs and they are now well below the long-run marginal cost of supply. Woodfuel prices, which are not officially controlled, have risen (in real terms) over the past two years, reflecting the increased prices of alternative fuels, higher transport costs, security bottlenecks and the steady depletion of the most accessible and economic forest resources.

14. The economic costs of available energy sources for selected uses were estimated by the mission. Electricity produced from hydro-capacity is the least-cost form of energy for lighting in urban areas. In other uses, the comparisons between electricity and woodfuels are highly dependent upon the economic value of land used for wood production and transport and distribution costs. For the major population centers in southern Uganda, where the surrounding land is suitable for production of medium-value crops and where supplies from more-distant low-value land involve substantial transport costs, electricity probably remains the most economic energy source for household cooking. For urban areas in the northern part of the country, and in most rural areas, woodfuels would become a more attractive option. Similarly, woodfuels are also more attractive in non-household uses, where transport costs are generally lower and the end-use conversion efficiency higher than in household use. However, in all uses, both electricity and woodfuels are substantially more economic than petroleum.

Electricity Tariffs

15. Uganda's present electricity tariff structure and levels are based on historical factors, and do not adequately reflect the costs of installing and operating additional generating capacity to meet projected demand. Domestic tariffs have been increased by 240% over the past three years in order to maintain the financial viability of UEB. However, a more general review of tariffs according to economic principles is required and should be undertaken immediately after the preparation of the long-term power development program. The Mission estimates that the long-run marginal cost of power in Uganda is at least US cents 5/kWh, or Ush 5 to 10/kWh depending on the exchange rate used. By comparison, the average yield from the present tariffs during 1983 will be about USh 1/kWh. The Government should raise tariffs to a level that corresponds to the economic cost of power as soon as is practicable, and at least by 1991 when the next hydroelectric station will be required. The burden on the poorest households could be alleviated through introduction of a "lifeline" low tariff rate for essential uses, particularly lighting. The Government should also adjust the tariff structure by eliminating the element of regressive tariff rates for additional blocks of consumption and increasing maximum demand charges to encourage improvements in power factors.

16. The rates for the sale of power to Kenya were last raised in 1980 and provide an average yield on the first 30 MW of only US cents 0.66/kWh. In the past, when Uganda had substantial surplus capacity, sales to Kenya at low rates were justified as extra income from power supplied at zero marginal cost. However, once Uganda's surplus capacity is fully absorbed by domestic demand, power supplied to Kenya will have an opportunity cost equal to the long-run marginal cost of installing new capacity discussed above. Even with these costs fully reflected in the export tariffs, Ugandan power would remain a low-cost source of supply for Kenya.

Petroleum Prices

17. For petroleum products the most accurate indication of economic cost is the import-parity price for supplies obtained from the Middle East market valued at the shadow exchange rate (USh 200 per US$). Even after the latest increases, the retail prices of fuel oil, kerosene and auto. diesel are substantially lower import-parity prices; the retail prices of gasoline are higher than import-parity prices. These distortions arise primarily from three basic factors: (a) the overvalued "window one" exchange rate used in the price formula for petroleum products; (b) the cross-subsidization of products at the Mombasa Refinery; and (c) differences in effective tax rates. The mission therefore recommends that the Government continues to adjust petroleum prices whenever there is a major change in the exchange rate. Under present conditions, it might be preferable to fix the exchange rate used in the price formula above the prevailing "window one" rate to anticipate future depreciation of the Ugandan shilling and thereby avoid more

frequent price increases. The Government should also realign the taxation structure to offset the cross-subsidization of products. This implies relatively higher tax rates on fuel oil in particular, but also on kerosene and automotive diesel; tax rates on gasoline could possibly be reduced, especially if the Ugandan shilling depreciates further. Taxes on petroleum products make a major contribution to government revenue. Therefore as the official exchange rate tends towards the shadow exchange rate, it may be necessary on revenue grounds to raise retail prices above import parity (as has already occurred for gasoline). This would also help discourage smuggling and the uneconomic use of petroleum products within Uganda.

18. Under the pricing formula, the oil companies receive a margin (for operating expenses, capital costs and profits) computed as 22% of the value of gasoline, kerosene and auto diesel delivered to Kampala (excluding customs duty). The oil companies generate revenue from other products as well and are able to allocate profits between Kenyan and Ugandan affiliates, especially for products purchased on the Kenyan market. Therefore, the Ugandan Government is not able to asess the actual level of profitability of the oil companies operations in the country, nor is it possible to ascertain precisely the use of the foreign exchange allowance. The use of a fixed percentage margin for operating expenses, independent of crude prices and import volumes, would also seem inappropriate. The Government should take measures to ensure that the component of the margin currently allowed for "rehabilitation and development of assets in Uganda" is used for the purpose intended or reduced accordingly. More generally, the mission recommends that the Government reviews the formula for reimbursement of all operating and capital expenditures with the oil companies.

Woodfuel Prices

19. In the woodfuels subsector, the Government's major concern is the high level of retail prices, especially for households, in Kampala. Obviously, woodfuel prices will come down as transport and security around Kampala is improved and this is a priority of the Government. The official stumpage fee, which is presently only USh 200/m^3, should also be reviewed. At present, the fee does offer an attractive financial return on fuelwood production from land with low economic potential. However, large amounts of such land are unlikely to be available near to urban areas such as Kampala. There is therefore a strong case for raising the stumpage fee to reflect more fully the economic value of wood as a fuel. An initial adjustment to at least USh 1,000/m^3 for forests serving urban areas would seem justified. This is unlikely to have any significant impact on retail prices, as the stumpage fee is a relatively small component of total costs and the increase would be partially absorbed by a reduction in the "windfall" profits of distributors. Provided the Government uses the revenue generated to strengthen its tree planting and management program, the overall impact on supplies will be positive over the longer term. In the final analysis, the only effective way to reduce retail prices for woodfuels in Kampala is to improve supply.

Institutions and Manpower

20. The energy sector in Uganda suffers from severe manpower and resource constraints. In many respects, these are country-wide problems. However, they have been compounded in the energy sector by a weak and poorly coordinated institutional structure. In particular, no one institution (or clear hierarchy of institutions) has been given primary responsibility for energy planning and policy formulation. Indeed, as yet, there has been very little recognition that energy concerns warrant a sectoral approach. As a result, day-to-day management is left to a plethora of separate entities, while higher-level policy decisions have been taken without due regard for their impact on sector performance and development. The mission considers that it would be premature at this time to try to tackle these problems by establishing a separate Ministry of Energy. Instead, a more modest and phased program of institutional development is proposed.

Sector Coordination and Planning

21. Broadly speaking, the mission proposes a three-tiered organizational structure: day-to-day management would be left to the subsector institutions as at present, sector planning and policy formulation would be coordinated by an Energy Department in the Ministry of Power, Posts, and Telecommunications (MPPT), and higher-level policy making would be the responsibility of an Inter-Ministerial Policy Committee. Initially, the Energy Department would comprise an Energy Secretariat and a small Energy Efficiency Section only. The Secretariat would support the Inter-Ministerial Policy Committee and formulate proposals for Cabinet consideration. It would also begin work on monitoring energy trends and help develop an integrated approach to energy issues. The Energy Efficiency Section would be responsible for coordinating the activities of the many public and private organizations involved in energy-efficiency activities. The Section should also propose, through the Energy Secretariat, appropriate policies for promoting more efficient use of energy in the economy. Eventually, the Energy Department could be expanded to include separate sections responsible for coordinating subsector activities. However, manpower and budgetary resources for this are simply not available at the present time. Instead, it is proposed that the Government identify suitable staff and begin training them, within the existing institutional structure, to form the nucleus of an expanded Energy Department at some future date. In the meantime, these staff can make a contribution through their normal line responsibilities as well as in liaison with the Energy Secretariat.

Subsector Management and Development

22. The institutional structure for energy management and development at the subsector level is largely in place and has performed remarkably well given country conditions. However, the mission has identified the following weaknesses which need to be addressed on a priority basis:

(a) UEB should strengthen its development planning capacity. At the moment, UEB is well staffed with operational personnel and engineers but has no economists to help analyze the viability of future investment proposals;

(b) UEB's billings have often been delayed by computer malfunctions and breakdowns. As similar problems are faced by other parastatal bodies, the Government should consider establishing a central computer center, possibly managed and serviced by the supplier;

(c) there is an urgent need to strengthen the Government's capacity to monitor developments in the petroleum subsector and to negotiate effectively with the oil companies. The Bank of Uganda has recently established a petroleum desk and this should be strengthened to assume primary responsibility for overseeing petroleum importing and marketing;

(d) there has been inadequate attention given to woodfuel issues in the past. Until a separate woodfuels section can be established in the Energy Department, the Forest Department should assume responsibility for coordinating woodfuel production activities. Activities relating to the utilization of woodfuels, including charcoal production techniques and stove designs, shyould be handled separately by the proposed Energy Efficiency Section in the Energy Department, the National Research Council and Makerere University;

(e) the Geological Survey and Mines Department (GSMB) is already well staffed with technical personnel to take responsibility for promoting and regulating petroleum exploration, but requires two or three legal and commercial staff to help draft and negotiate prospective agreements with foreign oil companies; and

(f) the National Research Council should take the lead in coordinating the development of new renewable sources of energy. Much research in this area has already been done both in Uganda and under similar conditions in neighboring countries. The priority now is to evaluate this research, identify appropriate areas for development and propagate the use of practical techniques which are economic and acceptable to consumers. Support for public and private concerns interested in marketing the necessary equipment and other promotional activities (e.g., demonstration centers, tax incentives for conversion and building code provisions) should be considered.

23. In terms of numbers, the manpower requirements related to the mission's proposals are deliberately modest. Initially the only

requirements are for two additional economists to form the Energy Secrertariat, two engineers and two economists for the Energy Efficiency Section, two economists to strengthen the development planning capacity of UEB, and two or three legal and commercial staff in GSMD to deal with petroleum exploration promotion. The real priority now is not so much more manpower (which is not readily available in any case), but better utilization of the available manpower. This touches on issues of working conditions and wage levels which go beyond the scope of this Report. However, it also involves retraining of staff who have not used their skills effectively in recent years, development of some new and specialized sills not previously emphasized (e.g., energy planners, agro-forestry experts and petroleum specialists), reorientation of training programs to focus on energy issues, and judicious use of external technical assistance. Priority tasks were identified by the mission which could be assisted by technical assistance. Follow-up support and long-term technical assistance will also be required in a number of these areas (e.g., training). Identification of these requirements, and preparation of appropriate action programs, should be an integral part of the initial technical assistance program.

Investment Priorities and Resource Requirements

24. Substantial energy investments will be required over the next decade to rehabilitate existing assets and provide for expansion. Some of these investments (e.g., in petroleum exploration, woodfuel plantations, and the development of more efficient woodfuel stoves and new renewable energy sources) can be undertaken by the private sector, and the Government should encourage this. However, many of the investments will have to be made by the public sector. Priorities identified by the mission for public investment during the remainder of the 1980s include:

(a) electricity. The immediate priority in the power subsector is to rehabilitate and upgrade the existing generating, transmission and distribution systems, to meet the expected growth in demand through 1990. The total cost of these investments is estimated at US$37 million. An additional US$14 million is provided for extending the transmission system. It is also important to begin planning now for construction of a second power project to meet projected demand during the 1990s. The location, scale and timing of this project will be determined by the proposed power development study. However, it seems likely that, without additional exports, a second project of 60 MW (51 MW of firm capacity) would be adequate to meet domestic demand and existing export contracts through 1995. This would cost at least US$72 million. A much larger station of up to 240 MW (160 MW of firm capacity) could be considered if additional export contracts for 120 MW could be signed in advance. However, this would cost an additional

US$177 million, equivalent to 45% of the 1983-90 investment program. Such a larger project would only be viable if other countries in the region benefitting from this investment repay Uganda through economic tariffs for the electricity purchased. Furthermore, the Government should only consider this investment if suitable financing can be found to avoid significant net foreign exchange outflows in any year, even during construction.

(b) petroleum. The only major public investments anticipated in the petroleum sector during the 1980s are for preparing an exploration promotion package. This will cost about US$2 million and be complete by 1985. It is anticipated that any additional costs incurred by the Government would be fully covered by prospecing fees and royalties paid by the oil companies. If the package fails to attract oil company interest, the Government should not commit its own resources for further petroleum exploration, at least during the 1980s;

(c) woodfuels. The major priority in the woodfuels subsector is to strengthen the Forestry Department's planting and management program. The resource requirements for this program over the remainder of the 1980s are estimated at US$20 million; and

(d) energy efficiency. The mission has identified a number of conservation measures in the industry and transport sectors which would contribute to a general improvement in energy efficiency. The related investments (largely in the parastatal sector) would cost an estimated US$8 million over the next two years. No explicit provision has been made for industrial conversions as these generally require further study on a case-by-case basis.

25. Including the larger option for the second power project, the total resource requirements of this public investment program over the next eight years is close to US$400 million (at 1982 prices), of which 85% is in foreign exchange. This is equivalent to 15% of the projected investment in the economy. On an annual basis, the foreign exchange cost works out to about US$40 million, or 5% of the projected imports of goods and services over the period. This is considered manageable, provided the bulk of investment costs is covered by concessional financing. In fact, the real impact of these investments on the balance of payments will be substantially less, because of the direct foreign exchange earnings/savings they generate. Similarly, the various price adjustments for electricity and petroleum products proposed by the mission would reduce, if not eliminate, the need for investment resources from the government budget. Even so, relative to what has been done in the past and the existing pipeline of aid commitments for the energy sector, this is an ambitious program. If the necessary resources cannot be mobilized, the government will have to accept some reduction in coverage and implementation delays. It is equally important that both the Government

and donors make best use of available resources by giving priority to the most pressing requirements of the sector, rejecting low-priority investments (evenn if this means sacrificing tied external assistance) and avoiding duplication of external financing efforts. As allowance has already been made for investments from private sources, and given Uganda's need for concessional assistance, most of the external financing will have to come from official sources. Large investments, such as for the second power station, will have to be financed by a consortium of donors, possibly supplemented with judicious use of suppliers' credits.

Regional Cooperation

26. The mission has identified a number of issues directly related to the energy sector in Uganda which have a wider regional significance. These issues include:

(a) the potential development of hydroelectric capacity in Uganda for exports to other countries in the region;

(b) the operations of the Mombasa Refinery and its impact on petroleum supplies and costs;

(c) the use of alternative transport modes and routes for transporting petroleum products to Uganda; and

(d) the exploration and possible future development of petroleum resources.

There would seem to be economic advantages for both Uganda and other countries in adopting a regional approach to these issues. Urgent joint action is required to reduce short-term economic costs (e.g., petroleum transportation) and to provide a basis for longer-term planning (e.g., electricity exports). For Uganda, the mission recommends that the proposed Inter-Ministerial Policy Committee takes the lead in regional discussions relating to the energy sector.

ZAMBIA: ENERGY BALANCE, FY 80/81
(thousand tonnes of oil equivalent)

	Fuelwood	Bagasse	Coal	Coke	Petroleum	Electricity	Total Commercial Energy	Total
Primary Supply								
Production	2000	32	366	-	-	2574	2940	4990
Imports	-	-	-	60	748	-	808	808
Total	2000	32	366	60	748	2574	3748	5798
Transformation								
Oil Refining Losses	-	-			-44		-44	-44
Thermal Power Generation					-13	4	-9	-9
Exports					-47	-840	-887	
Transmission and Distribution Losses						-348	-348	
Net Supply/Demand	2000	32	366	60	644	1390	2460	4492
Demand								
Mining	120	-	192	60	238	1030	1520	1640
Industry/Commercial	-	32	174	-	116	250	540	572
Transport	-	-	-	-	225	-	225	225
Agriculture	-	-	-	-	6	-	6	6
Others/Households	1880	-	-	-	59	110	169	2049

toe = 10 mn kcal
kWh = 2520 kcal

ZAMBIA 1/

1. Zambia's commercial energy demand depends largely on the needs of the copper mining sector, which is the main foreign exchange earner for the economy, but which is going into decline due to declining ore grades and increasing production costs (15-20% per annum) and also the depressed state of the international price of copper. In 1981, the copper mining sector alone consumed (out of the total energy demand in the country) over 74% of electricity, 52% of coal, 94% of fuel oil and about 24% of diesel oil.

2. Although Zambia has abundant resources of hydropower, coal and woodfuels, liquid fuels (which are imported in the form of spiked crude and refined in Zambia) remain important to both mining and non-mining activities. In 1981, total energy consumption including traditional fuels amounted to 4.5 million tonnes of oil equivalent (toe) of which imported petroleum was 16.5% and imported coke 1.3%. Hydropower accounted for 31% and coal for 6% (of total energy consumption) while traditional energy, largely firewood, charcoal and bagasse, accounted for 45% (equivalent to 2.03 million toe) of total energy demand.

3. The country has no known petroleum deposits and all petroleum products must therefore be imported. Even though the total volume of petroleum imports has been declining by 1.7% per annum (from 731,000 tonnes in 1976 to 683,000 in 1980), the cost of these imports has been increasing rapidly. In 1981, the petroleum import bill was estimated at US$240 million, equivalent to 17.9% of total imports and 19.4% of merchandise exports. As a consequence of declining foreign exchange earnings (principally from copper), and rising costs of petroleum imports, the balance of payments deficit on current account has been increasing. It reached $617 million in 1981; and payments arrears were about US$504 million.

4. Zambia's energy situation has been worsened by problems in the mining sector as well as by inadequate energy planning and policies, coupled with shortages of skilled manpower and management expertise. It is essential, therefore, that measures taken to deal with the energy problems are closely linked with those dealing with the other problems in the economy. The following measures are considered urgent in the energy sector:

(a) reduce the cost of petroleum imports to the economy by reducing fuel own-use/losses at the refinery as well as improving refinery utilization through finding new markets;

1/ Adapted from Report No. 4110-ZA, January 1983.

Economic Context

Zambia, located in South Central Africa, is landlocked between Angola, Mozambique, Malawi, Tanzania, Zaire and Zimbabwe. It has a total area of 752,600 square kilometers and a population of about 5.65 million (1980 estimate) which is growing at about 3.3% per annum. About 40% of the population is urbanized. The most populous of the eight administrative provinces are the Copperbelt and Central provinces, where internal migration has been towards urban centers.

Mining remains the dominant influence in Zambia's economy and currently copper is the main foreign exchange earner. In 1980, mining contributed about 90% to the foreign exchange earnings and 18% to GDP (in current prices). In 1982, the contribution to revenue budget by the copper mining industry was about $1.2 million or 0.1% of the total budget of $978 million. Events during the past decade have emphaized Zambia's vulnerability to regional economic and political disruptions. During this period, political instability, particularly in Zimbabwe and Mozambique, the continuous fall in copper prices and rising copper production costs (15-20% per annum) have adversely affected the economy. The Government is concerned about this and recognizes that, along with diversification of the economy to lessen Zambia's dependence on copper mining, improvements in the energy and transport sectors are also necessary.

(b) promote the substitution of fuel oil by coal and/or electricity particularly in the copper mines, and reduce cost of energy use in copper production;

(c) increase the efficiency and quantity of coal production;

(d) improve the effectiveness of the power distribution system in urban and rural areas;

(e) improve the transport system, particularly the railways for carrying coal and petroleum products;

(f) rationalize pricing policies and improve the efficiency of energy use;

(g) establish technical assistance programs to provide efficient and skilled manpower and managerial expertise; and

(h) reorganize the institutions in the energy sector to promote efficient production and management of energy resources.

5. However, the ability to implement some of these measures will be constrained by the country's precarious financial situation which has resulted primarily from the depressed price of copper. Priority must therefore be given to those actions that have a large and quick pay-out and could stimulate growth in the other sectors of the economy.

Energy Supply/Demand Issues

The Refinery and the Reduction of Petroleum Import Bill

6. Zambia is not a petroleum intensive economy. Per capita petroleum consumption of around 0.12 toe in 1981 is lower than most middle-income countries with about the same per capita income levels (for example, Honduras 0.17 toe and Bolivia 0.18 toe). It could be lower still but for the technical limitations of the refinery. This refinery, located in Ndola, currently operates well below design capacity due to market limitations and therefore has a high own fuel use/loss of about 6% as compared to less that 4% in refineries of similar size and configurations. 2/ It has no secondary conversion capabilities to enable it to meet major changes in patterns of product demand or to substantially reduce or eliminate the output of fuel oil, which the government has insisted must be used by the copper mines 3/ even though this is uneconomic compared to use of other fuels such as coal or electricity. When output adjustments are necessary in the refinery because of changes in demand, they are handled by spiking the crude feedstock with lighter products. 4/ In addition, the refinery must carry out by itself may ancilliary services such as transport of staff, maintenance of houses, etc., leading to a relatively large total staff.

7. A two-pronged approach is necessary to reduce the petroleum import bill. First, efforts must be continued to explore for oil and gas, since the mission considers that, on the basis of available data,

---

2/ A study on how to reduce such own fuel use/loss at the current operating level has recently been completed by the refinery and is to be implemented.

3/ The production of fuel oil and subsequent use by the mines was economic when the international price of crude oil was about one tenth the current price. With the increase in crude oil price, production of fuel oil is not economic. Currently there are no other major users of fuel oil in Zambia and export potential is almost non-existent.

4/ Spiked crude feedstock is crude oil blended with refined lighter products, and in this case naptha, kerosene and diesel oil.

discoveries cannot be ruled out. 5/ Second, the more urgently, means must be found to reduce the production and consumption of fuel oil, particularly in the mines, by substitution of other cheaper fuels. There are three main options to reduce or eliminate fuel oil production:

(a) increase the level of spiking in the refinery feedstock (the current level is 43%). Although designed to process Iranian Light (Agha Jari) crude oil spiked up to 25%, test have shown that the refinery can accomodate up to 55% spiked crude if the throughput is at least 660,000 tonnes;

(b) close down the refinery and import refined petroleum products through the Tazama (Dar es Salaam to Ndola) pipeline now used to supply the spiked feedstock. The Tazama pipeline was originally designed for refined petroleum products and was converted to supply crude oil when the refinery was built in 1973. It can easily be reconverted to its original use;

(c) upgrade or modify the refinery to produce either less fuel oil and more middle distillates from whole crude oil, or eliminate the production of fuel oil.

8. As long as the spiking level does not exceed the 55% of feedstock and there is a minimum throughput of 660,000 tonnes, with the proportion of the distillate yield to the input feedstock not exceeding the design conditions, Option (a) will not involve any significant additional investment either in the refinery or elsewhere in the economy to meet expected increases in the demand for middle distillates and will not increase the production of fuel oil. This could result in an overall reduction in the volume of petroleum imports. However, beyond the spiking level of 55% minor modifications of the refinery will be necessary; this could include installation of a prefractionating column at an estimated cost of about $10-15 million.

9. Option (b) will mean that the mines (and other users) will have to use coal and electricity instead of fuel oil. This was the situation before the commissioning of the refinery in 1973/74. Based on 1980/81 product consumption, and other things being equal, this option could save the government foreign exchange of about $27-35 million annually in petroleum import costs. 6/ However, to implement this option, the following other investments are necessary: (i) $1 million to reconvert the Tazama pipeline to transport refined products rather than crude oil; (ii) $2-5 million to build additional storage facilities at about $39-50

5/ A Bank petroleum exploration promotion loan of $6.6 million was signed in May 1982.

6/ Also see para 12 and 13 below.

million for the copper mines, the Maamba Colliery, the Railways and the electric power system.

10. Option (c) will require the mines to use coal or electricity, and also imply investments (iii) under option (b). However, the refinery modification, costing $80-120 million, could produce savings in foreign exchange of about $26-40 million per year in the petroleum import bill alone by reducing or eliminating spikes in the imported crude oil and by reducing the refinery's own fuel use/losses. The refinery could also be modified to produce lower volumes of fuel oil from whole crude oil.

11. Although both options (b) and (c) will enable the government to achieve substantial savings 7/, both require commitment of additional investments in either the refinery or in other sectors of the economy. The mission therefore favors option (a) which appears to involve the least amount of investments in the short term and, given the funds externally, recommends that this option be implemented in the interim while further detailed cost benefit analyses and ranking of the a study of the economic viability of alternative fuel substitution in the mines and on decisions to rehabilitate the copper mines in order to reduce production costs and re-establish the growth of copper production. A refinery modification study is currently in progress to do this. 8/

Fuel Substitution and Energy Use in the Copper Mines

12. The mission studied energy use in the copper mining and smelting operations and concluded that, allowing for the age of equipment and the fact that the prices of all energy products to the mines are subsidized, energy use in the mines is reasonably efficient. However, with modest investment, the volume of diesel oil used in the mines could be reduced by 10% by converting some of the earth moving equipment to run on (cheaper) electricity. The mines are already experimenting with modified equipment.

13. The copper mining companies consider (and the mission agress) that electricity or coal can be substituted for fuel oil. If coal is to be substituted, this will require additional investments of about $14 million in the copper mines, about $15 million in the Maamba coal mines and some investments in improving the efficiency of the railway

---

7/ The local cost of the replaced fuel (coal is $15 million or electricity $2 million) must be deducted from these savings.

8/ This refinery modification study will evaluate the least cost options and the implications that any modification of the refinery will have for the petroleum demand mix for the country.

system. 9/ Estimated annual fuel savings to the mines are about $9.5 million. 10/ If electricity is to be substituted, the mines will be required to install smelters at a cost of $40-60 million, but estimated annual fuel savings to the mines are about $22 million. 11/ Also the mines are evaluating the economic viability of using an oxygen flash furnace to replace both fuel oil and coal. Estimated capital investment is about $160 million, and estimated annual fuel savings to the mines are about $38 million. However, the mission believes that it will be difficult for the mines to raise sufficient funds (in the short term) to finance the oxygen flash furnace option.

14. Preliminary analysis shows that the substitution of electricity for fuel oil in the mines requires the lowest investment and appears to have a high benefit/cost ratio. However, the mission recommends that all the fuel substitution options should be reviewed in detail during the refinery modification study.

Electricity

15. Hydropower is the most important domestic energy resource: the potential is estimated at 4,000 MW. Installed hydroelectricity capacity in Zambia of 1,608 MW is well in excess of the current combined domestic and export demand of 1,308 MW and, based on the mission's demand forecasts, including possible electrification of the mines, will meet Zambia's needs to 1995. It will also provide exports of 500 MW to Zimbabwe until 1986/87 and 400 MW until 1990. For domestic power needs, therefore, new investments in Zambia are not urgent. However, if Zimbabwe needs to increase its power imports, thus providing Zambia with additional export earnings at a profitable rate, decisions on the joint development of the river Zambezi for power projects must be made in the medium term. For this, a least cost power development program is necessary, and the Government plans to seek financial assistance for the United Kingdom for this study, which the mission supports.

16. Currently, system losses are high. In the interconnected system (of Zambia Electricity Supply Company, ZESCO and the Copper Belt

---

9/ Total investments in the Maamba Colliery are about $30 million to maintain production and efficiency. 50% of this is estimated to be due to the increase in coal demand by the copper mines (see para 21). The Zambia Railways (ZR) estimates that about $10 million is required to improve the efficiency of its operations.

10/ The difference between the current subsidised cost of 150,000 tonnes of fuel oil to the mines ($24.5 million) and the cost of 240,000 tonnes of substituted coal ($15 million).

11/ The difference between the cost of power at about $3 million per year and fuel oil at $24.5 million per year.

Power Company, CPC) losses are estimated at 3.5% in transmission and 18.2% in distribution. In the rural areas, total losses on the transmission lines and the distribution system are about 20%. This is largely due to lack of funds, especially foreign exchange, for proper maintenance. Vehicles are old and equipment and spares purchases are insufficient. In particular, ZESCO's ability to maintain the power system is being eroded and will continue to deteriorate unless its financial position improves. This can be achieved through increases in tariffs to adequate levels. ZESCO estimates that it needs about US$40 million to purchase spare parts for maintenance and US$37 million to pay outstanding bills to contractors. Non-payment of electricity bills (especially by government ministries and parastatal organizations) amounted to over US$8 million in 1980. Such bills should be paid immediately. Also, ZESCO is short of adequate technical and management expertise. To upgrade and strengthen its management, ZESCO will have to provide improved working conditions for its staff. It has been difficult to attract and retain capable Zambians because its salaries and work incentives are not competitive. The mission recommends that ZESCO be assisted through an external technical assistance program to establish an adequate training program to train engineers and managers and also develop an appropriate salary and incentive structure for its staff.

Rural Electrification

17. An important social program for the Government, rural electrification is poorly planned and implemented and has been causing operating losses to ZESCO of US$5-8 million annually since 1978. The rural electrification program comprises two elements: (a) replacing the isolated diesel generation units serving remote townships by direct connection to the national grid; and (b) a government directed rural electrification program to include new areas. In both cases, the transmission distances are long (typically 50-100 km from the grid) because the rural settlements are widely scattered; moreover, neither program appears to have been evaluated according to either financial or economic criteria. The mission recommends that before making further investments, a comprehensive rural electrification study be prepared which would establish priorities based on the economic cost of specific investments. In view of ZESCO's difficult financial position, the Government should not require ZESCO to finance with its own resources any further investments in rural electrification which ZESCO would not otherwise undertake.

18. The mission also recommends that attempts should be made by all the parties concerned, including the Bank, to resolve the outstanding issues relating to the Central African Power Company (CAPC). This organization is jointly owned by the governments of Zambia and Zimbabwe and its main responsibilities are for power generation on the Zamberzi and the transmission of power to Zambia and Zimbabwe. Although CAPC plays an important role in power development, there are differences of opinion between the two governments on the role of CAPC and how its services should be financed. It is essential that an independent and effective institution be established for the equitable sharing of the

Zambezi waters for power development to the benefit of both Zambia and Zimbabwe.

Coal

19. Currently, coal is mined at Maamba in the mid-Zambezi basin where proven reserves are about 58 million tonnes. Coal deposits have also been identified in the Luangwa valley in the Northern Province and in the Western Basin, but these reserves have not been explored. Although not of immediate priority, the mission recommends that a full evaluation and inventory of the coal resources is necessary to ascertain the total coal potential in the country. At the designed production capacity for the mines of 1.2 million tpa, proven reserves at Maamba are sufficient for about 33 years. 12/ The current production rate at Maamba is 610,000 tonnes per year (610 ktpa) or about 51% of the designed rate. The major consumers of coal are the copper mines (326 ktpa), the cement factory (98 ktpa) and the fertilizer plant (64 ktpa). The demand for coal is expected to increase by 9% in 1982/83 due to expansion of the fertilizer plant, cement factory and the pulp mill.

20. To satisfy increased demand, and particularly if coal substitution is preferred for copper smelting, the Government must improve the mining operations at Maamba. The cost of producing coal at Maamba Colliery is high (about US$47/tonne at the mine head), despite the fact that open pit mining conditions are relatively easy. Several factors are responsible for this. The major ones are shortage of experienced management and skilled manpower, poor maintenance and lack of foreign exchange to purchase necessary spare parts to replace and maintain equipment. The mission estimates that the Maamba colliery will need about US$30 million for a full rehabilitation which will enable it to increase production to the design capacity of 1.2 million tpy of coal. Such rehabilitation may take 3-5 years to complete.

21. The railway systems for transporting coal between the mines to the main trunk line and also to the copper mines at Ndola, a distance of over 300 km, are in poor shape. In 1980/81, over half of the coal requirements of the copper mines were hauled by road from Maamba to Ndola, thus adding considerably to transport costs and energy consumption. The rehabilitation of the tracks between the mines to the main trunk line and purchase of rolling stock and wagons are estimated by ZR to cost about uS$10 million. Further analysis of the cost may, however, reduce this figure somewhat. 13/

12/ The run-of-the-mine production capacity is 1.5 million tonnes per annum. The washed coal production is 1.2 million tonnes per annum.

13/ This amount is in addition to the rehabilitation program currently in progress.

Firewood and Charcoal

22. Firewood and charcoal are the major household fuels in the rural and urban areas. The main cause of localized woodfuel shortages is excessive cutting of trees for charcoal production. This affects mostly the densely populated areas, particularly along the "line of rail."

23. Although supplies of woodfuels to the more widely scattered rural population are adequate, the consumption of charcoal by the urban centers in the Copperbelt and Lusaka provinces has increased the threat of widespread deforestation in the surround woodlands. The issues are how to maintain an adequate and reasonably priced supply of charcoal to urban households and how to recuce the demand for charcoal through substitution by other cooking fuels such as electricity. In the mission's view, charcoal and firewood will remain the main source of fuel for cooking in most households until 2000. Therefore, unless extensive programs are immediately undertaken in the affected provinces, these traditional fuels will become increasingly scarce and expensive with serious effects on low and middle income urban households. The mission recommends that ZESCO and the Zambia Oxygen Company (ZAMOX) 14/ should explore the possibility of implementing an effective program to encourage the use of electricity and LPG in urban households so as to further reduce charcoal and firewood consumption.

24. The mission supports the Government's general approach to solve the woodfuel problem which includes:

(a) promoting fuelwood plantation schemes such as the woodfuel project in areas surrounding Lusaka and the Copperbelt to supply charcoal burners and improve the supply of woodfuel in the urban areas 15/;

(b) improving the traditional earthern kiln charcoal production methods. thereby reducing overall wood requirements for carbonization; and

(c) encouraging ongoing research in the University of Zambia (UNZA) to improve the efficiency and affordability of the local charcoal stove, known as the Mbabula.

25. However, it is necessary to strengthen and better define current projects for:

(a) demonstration of improved charcoal kilns and stoves;

14/ The use of LPG should be encouraged only if the refinery remains in production.

15/ And also the supply of woodpoles for use in the mines.

(b) providing credit for smallholder tree farming schemes sited around the Forest Department's (FD) plantations to supply wood to the charcoal producers; and

(c) reintroducing the short training course for "Ndunas" (volunteer forest guards), seconded by rural or district councils to improve forestry extension programs in the central province.

Other Energy Sources

26. The Government of Zambia (GRZ) has supported solar, wind and biomass research at the University of Zambia (UNZA) and the National Council for Scientific Research (NCSR). However, it is necessary to develop a technical unit for planning and implementing rural and renewable energy projects as part of the institutional framework for overall energy planning. In the mission's view, the Technology Development and Advisory Unit (TDAU) at UNZA, with some additional technical assistance, could effectively assume this role as it is currently involved in the design and adaptation of solar heaters and driers for agricultural products such as fish, vegetables, etc. It is also necessary that TDAU and UNZA should have sufficient funding to increase their competence in evaluating the economics of various technical options relevant to the energy needs in the rural and agricultural sectors.

Ethanol

27. IFC had agreed to finance a project to produce 11.5 million liters/annum of ethanol from molasses at a capital cost of about US$20 million. The ethanol would be blended with regular gasoline (87 octane) to substitute for premium gasoline (95 octane). This volume of ethanol could replace about 10.4% of premium gasoline demand by 1983/84 and about 9.5% by 1990. IFC's calculations for this project show an economic rate of return of 13% and were based on the following assumptions:

(a) 17,000 tonnes of molasses, additional to 5,000 tonnes currently surplus, will be available and can be valued at zero opportunity cost;

(b) the ethanol will save about 16% in refinery fuel/loss (consisting of 6% refinery fuel; 7% in LPG and 3% additional fuel savings);

(c) future increases in the real price of naptha will be 2% per annum; and

(d) that the ethanol will enhance the octane rating of regular gasoline by a ratio of 1.3:1.

Conditions in Zambia now are such that due to reduced gasoline consumption concerns have been expressed by the Government about the low level of gasoline production in the refinery and consequent inability to absorb ethanol supply. Therefore, the decision to go ahead with this project has been shelved.

Pricing Issues

28. Prices for all forms of energy are controlled by the Government and do not reflect opportunity costs. 16/ Kerosene and all other fuels used in the copper mines (coal, power, fuel oil) are subsidized.

Petroleum

29. Petroleum prices ex-refinery, marketers margins, transport costs and retailers' margins are all determined by the Government. In determining these prices, the overriding factors are not the opportunity costs of these products but rather the revenue needs of the budget and the political and social desire to keep the prices of kerosene, diesel oil and fuel oil low. To achieve this the products are differentially taxed and cross-subsidies applied, resulting in price distortions. In the case of kerosene, the rationale for the subsidy is the assumption that this fuel is used mainly by the rural population although a significant quantity of kerosene is actually used in industries, 17/ where it replaces the relatively higher priced diesel oil. The subsidy 18/ on fuel oil was a concession to the mines who were compelled to switch from coal to fuel oil when the refinery was commissioned. premium and regular gasoline and diesel oil are heavily taxed to compensate for the subsidy on fuel oil. A further problem is that since no pricing

---

16/ In late 1982, a decision was taken to "decontrol" all prices in the economy. The Zambia Industrial and Mining Corporation (ZIMCO) Board is now authorized to get economic prices for all products, subject to post facto review by the Prices and Incomes Commission. It is not yet clear what the full impact of this decision will be, although it appears that the new system should reduce substantially the delays in adjusting prices to reflect full costs.

17/ Such as the Broken Hill (lead and zinc) Industry and the Rokana Copper Smelting Operations.

18/ Even with this subsidy, fuel oil is still more costly than coal. The subsidized fuel oil price is about $160/tonne or US$0.58/gallon. The delivered price of coal at the mines is about $60/tonne. Assuming that 1.6 tonnes of Maamba coal is equivalent (calorific) to 1.0 tonnes of fuel oil, the equivalent cost of coal is about US$0.35/gallon.

formula exists to adjust margins and retail prices to reflect cost increases at intermediate stages, the availability of pejtroleum products at places farm from Lusaka is, at times, tight. In the mission's view, the basis of petroleum product prices need to be examined in detail to correct these anomalies. The mission recommends that the subsidies, government taxes, and dealers margin on all products should be rationalized and wholesale prices ex-NOSCO 19/ should reflect the international supply/demand relationship between the products. Based on the relative import parity costs, the mission estimates that the wholesale price of premium gasoline and fuel oil should be about 95% and 72% that of kerosene, respectively. Currently, the wholesale price of premium gasoline is about 218% that of kerosene.

Coal

30. The production cost of coal is high due in part to the inefficiency and lack of proper management of the colliery. Coupled with the poor transport system, this results in unnecessarily high delivered prices to consumers. For example, the mine-head cost of Zambian coal is about $47/tonne, whereas the delivered cost to the mines is $60/tonne. 20/ Unless these problems are resolved, the production cost will further escalate and this could jeopardize any program for fuel substitution that involves coal.

Power

31. More as a result of political than economic exigencies, power tariffs have intentionally been kept low and do not generate enough finances to maintain and expand the system. ZESCO is currently selling power to the copper mines at about 40% below cost and although ZESCO estimates a surplus of $3 million from total power sales in 1981/82, a deficit is anticipated for 1982/83. In order that ZESCO can be financially viable and operate at a profit, an increase in tariffs to all consumers is required. There is therefore a need for a detailed tariff study to determine the level of increase in tariffs that will allow ZESCO to fulfill its loan commitments to maintain an adequate return on assets, and the mission supports ZESCO's decision to commission such a study based on LRMC for power distribution. 21/ In the interim, the mission recommends a tariff increase (within Zambia) to all non-mining consumers and to CPC to generate funds to cover part of ZESCO's operating costs and allow ZESCO to achieve a reasonable rate of return on its investments.

19/ The National Oil Storage Company (NOSCO) is responsible for wholesale marketing of the refined petroleum products.

20/ This delivered cost is based on haulage by rail. The delivered cost is higher still with road haulage.

21/ ZESCO has awarded the contract to Electricite de France.

The current rate of return of 4.8% achieved by ZESCO in 1980/81 is far below the 8% agreed between ZESCO and the Bank. Preliminary analysis made by the mission shows that based on the consumption level of 1980/81, ZESCO could realize about $26 million by increasing its tariff by 30% to all non-mining consumers and 40% to CPC. The Government has completed a study on export tariffs to Zimbabwe and negotiations have started between the countries on the appropriate increase of these tariffs. 22/ The increase in the export tariff requires careful negotiation since it will affect future joint development of the Zambezi by the two countries. If the tariff is too high, Zimbabwe may stop importing power and develop thermal plants using its vast coal resources. If the tariff is too low, Zambia will find it difficult to meet its financial commitments and maintain its power system.

Charcoal

32. Although the Government controls and sets wholesale prices, it is unable to enforce them. The "controlled" prices do not take into account the charcoal market supply/demand situation. For example, controlled prices have declined in real terms from US$2.45/40 kg bag in 1976 to about US$1.52/40 kg bag in 1982. 23/ The actual wholesale prices, although different from the controlled price, reflects the market situation and high transport costs. The current wholesale prices are about 50% above the controlled price. The mission recommends that the Government review the basis for its controlled wholesale price, with particular reference to transport costs and the objective of developing financially viable wood plantations close to major markets such as lusaka.

33. In the mission's view, the need for a rationalized pricing policy involving all energy resources (coal, power, woodfuel and petroleum products) is urgent. Current pricing policies have caused major distortions and inefficiencies in the energy sector. Although the copper mines seem to be benefiting from these policies (through subsidized fuel oil, coal and electricity), various other energy resource-producing and distributing companies (ZESCO, Maamba Colliery, etc.) are financially weak and are unable to operate efficiently, and risk further deterioration in their ability to satisfy energy demand. The mission recommends that new investments should not be implemented in the energy sector until the pricing policy is revised to ensure that the price of resources reflect their economic costs.

22/ This study was done by the consulting firm of Landell Mills Associates Limited which is based in Lusaka, Zambia.

23/ In current dollars, the controlled price was US$2.45 in 1976 and US$3.00 in 1982/40 kg bag. However, the market price was US$3.50 in 1976 and US$4.80 in 1982/40 kg bag.

Organization and Planning

34. In the mission's view, the Government's objective in creating the National Energy Council (NEC) is sound, and demonstrates its commitment to energy planning. NEC's role is to review and formulate national energy plans of action; identify investment requirements and allocations; and provide directives on policy instruments such as energy prices, tax provisions, and subsidies. The mission recommends that NEC be supported by a small full-time technical secretariat and also that NEC's effectiveness be reviewed on a regular basis, at least once a year, to ensure that it is meeting the needs of the sector.

35. The secretariat to NEC would take over the responsibility for energy planning and development in the country. Its terms of reference should cover preparation of an energy plan of action including:

(a) a five- to ten-year investment program and its tentative sources of financing;

(b) assessment of external financing and technical assistance requirements;

(c) assessment of the energy impact of developments in other sectors such as mining and transport; and

(d) assessment of local manpower development and training needs in the overall energy sector.

36. Financial and manpower assistance for the secretariat could be covered under an external technical assistance program. Other energy related institutions should continue with their responsibilities for implementing programs relevant to their ministries and should be responsible for translating the national energy plan into specific action programs. The NEC should be responsible for monitoring the progress of these other agencies to ensure that the work is consistent with the national energy program.

Investment Implications

37. In the short-term (1982-85), the following investments in the energy sector are critical to upgrade the efficiency and capabilities of existing system. These are estimated at about $110 million and include:

(a) $40 million for ZESCO to purchase spare parts to rehabilitate the power distributing system 24/;

24/ ZESCO has recently applied for a $50 million loan from the Bank for system rehabilitation.

(b) $30 million to rehabilitate and continue maintenance of the Maamba Colliery;

(c) $16 million for woodfuel projects;

(d) $10 million in the railways;

(e) $10 million for technical assistance and manpower development programs; and

(f) $1 million for the refinery modification study.

Although not critical for meeting energy demands, the following other finances ($90 million) will be needed):

(a) about $37 million for ZESCO to pay outstanding bills; also ZESCO estimates that it needs over $50 million for ongoing projects, including the installation of a 330-kV line between Kabwe and Serenje, as part of its rural electrification program; and

(b) $5 million in the copper mines for continuing the conversion of diesel using equipment to use electricity.

ZIMBABWE: ENERGY BALANCE, 1980
(thousand tonnes of oil equivalent)

	Non-Commercial		Commercial Energy						
			Solid Fuels		Liquid Fuels				
	Fuelwood	Bagasse	Coal	Coke	Petroleum Products	Ethanol	Electricity	Total	Total
Primary Supply									
Production	1,645	150	2,075		-	15	1,010	3,100	4,895
Imports			-		693	-	693	1,386	1,386
Exports			(172)	(87)	-	-	(4)	(263)	(263)
Total	1,645	150	1,903	(87)	693	15	1,699	4,223	6,018
Statistical Differences			(83)		-	(6)	-	(89)	(89)
Thermal Power Generation			(219)		-	-	84	(135)	(135)
Coal Cokifaction			(206)	158	-	-	-	(48)	(48)
Sector Own Use/Losses		(150)	n.a.	n.a.			(96)	(96)	(246)
Net Supply/Demand	1,645		1,395	71	693	9	1,687	3,855	5,500
Demand									
Industrial/Commercial	58		781	63	76	-	829	1,749	1,807
Iron & Steel			538	58		-	51	589	589
Ferrochrome			16	5		-	281	355	355
Chemicals			-	-		-	219	224	224
Others	58		227		76	-	278	581	639
Transport			186	1	372	9	-	568	568
Road			-	-	214	9	-	223	223
Railways			186	1	86	-	-	273	273
Aviation			-	-	72	-	-	72	72
Others	1,587		428	7	208	-	858	1,301	3,088
Agriculture	175		216	-	93	-	139	448	623
Government			-	-	90	-	-	90	90
Households	1,412		-	-	9	-	223	242	1,654
Mining			90	3	16	-	309	418	418
Other			122	4	-	-	177	303	303
Non-Energy Use					37		-	37	37

toe = 10 mn kcal
kWh = 2520 kcal

ZIMBABWE 1/

1. Zimbabwe's energy problem is threefold: first, how to reduce the growing burden of energy imports, second, how to develop indigenous energy resources at least-cost as development and restructuring of the economy proceeds, and, third, how to make more efficient use of all energy whether imported or produced locally. To tackle the various elements of this problem requires urgent actions in a number of areas. For liquid and the future of the mothballed refinery at Umtali; for electricity the best way of increase production; and for all energy using and producing subsectors the most appropriate pricing policies and organization.

Liquid Fuels

2. Zimbabwe's petroleum consumption consists of liquefied petroleum gas (LPG), petrol (gasoline, aviation kerosene (turbo fuel A1) and aviation gasoline, illuminating kerosene, and gas oil (automotive diesel oil). 2/ Petroleum products are currently imported through the Republic of South Africa (RSA) by rail. About 40 million liters of ethanol are produced locally from sugarcane juice and blended with imported petrol. To minimize the cost of importing liquid fuels and to lessen reliance on transit through RSA, the Government has been considering the following alternatives:

(a) increasing ethanol production, which currently replaces 15% of the petrol consumed, to further substitute for imported petrol;

(b) producing syn-crude from coal;

(c) rehabilitating the Feruka refinery at Umtali; and

(d) reducing the railway freight of imports by using the Beira/Umtali pipeline, which is currently being rehabilitated.

The Government has not pursued exploration of oil and gas within the country. On the basis of available geological information about the Western and Northwestern region, petroleum potential cannot be totally ruled out.

3. The mission reviewed these alternatives and came to the following conclusions:

1/ Adapted from Report No. 3765-ZIM, June 1982.

2/ Bitumen and lubricants are included in the energy balance under non-energy uses.

Economic Context

At independence, the new Government inherited a generally strong, well-diversified economy with good development potential. The economy continued to grow despite the 15 years of sanctions before independence; after an initial setback in 1966, exports continue to increase and in 1979 were about 20% higher in real terms than before the sanctions were introduced. Infrastructure was developed rapidly, and there was a sharp increase in agricultural and manufacturing output, which made the country more self-sufficient. Between 1965 and 1974, real GDP grew at an average rate of about 7% a year. From 1975 to 1979, because of the intensification of the war and the occurrence of unusual droughts, GDP in constant prices declined by 3% a year, but immediately after independence a sharp economic recovery set in. GDP grew by 10% in 1980 and indications for 1981 are that it has continued to grow rapidly, although at a lower rate than 1980.Because of the relative importance of the industrial sector (25% of GDP in 1979) and commercial agriculture (11%), energy consumption per capita (commercial and non-commercial) is high in Zimbabwe (about 5.28 barrels of oil equivalent (boe) in 1980). Total energy consumption amounts to 5,874 thousand tonnes of oil equivalent (Mtoe) or 38.9 million boe. Indigenous sources (coal, woodfuels, hydropower, and ethanol) satisfy much of the energy demand, so that reliance on imported energy is less than in many other developing countries. Nevertheless, in 1980 23% of energy supplies was imported, of which 11.5% was electricity and 11.5% petroleum products. In 1980 the cost of energy imports was 22.6% of total export earnings; and in 1981 it is again estimated to be about 22%.

(a) Pure ethanol as automotive fuel is not advisable at present for it would require engine redesign as well as high new investment in storage and distribution facilities. It should continue to be used as an extender of petrol and be mixed within a 20:80 ethanol-petrol ratio. 3/

(b) Oil-from-coal as part of the country's liquid fuels policy should be deferred until the technologies of coal liquefaction and gasification are commercially proven and the costs are competitive with petroleum.

3/ The Government is currently carrying out tests to determine whether a ratio of 25:75 is feasible; the mission supports this activity.

(c) Rehabilitation of the Feruka refinery as designed is not an economic option, because the product mix does not match current and projected demand and the refining costs are high.

(d) The rehabilitation of the Beira-Umtali pipeline, when completed, will considerably reduce the cost of imported petrol and gas oil, provided that reasonable pipeline thruput charges can be negotiated with the owners. The mission supports the proposed study to determine the least-cost option for meeting the country's liquid fuel needs. This study should include an evaluation of the following alternatives:

(i) import of petrol, gas oil, and other compatible products whether purchased directly or through an offshore processing arrangement, through the Beira-Umtali pipeline, and non-compatible products (such as LPG, and turbo fuel) by other means (road and rail). Within this option, extending the Beira-Umtali pipeline to Salisbury should also be considered;

(ii) rehabilitation of the Feruka refinery with changes in configuration to match current and prospective changes in market demand the types of crude oil feedstock likely to be available;

(iii) construction of a new refinery with sufficient flexibility to match changes in market demand and to process different qualities of crude oil;

(iv) import of refined products from the Ndola refinery in Zambia with a possible petroleum product pipeline from Ndola to Lusaka and to Salisbury.

Coal

4. Zimbabwe is well endowed with coal and has, traditionally, made good use of it for railways, power generation, steel production, tobacco curing, and other activities. Possible resources in 24 coal fields are estimated at 29 billion tonnes. About 2.2 billion tonnes, or 7% of the total, can currently be classified as proven recoverable reserves. The only colliery, located at Wankie, produced 3.2 million tonnes of raw coal in 1980. Currently coal supplies about 27% of the country's total energy requirements. In the future this resource will dominate the energy mix and supply 46% of the country's energy needs by 2000.

5. The major issues in the coal sub-sector are: first the need to establish clear coal development policies, including the role of the newly proposed Minerals Marketing Board (MMB) in stimulating new investments and exploration, 4/ and what to do about pricing of the 2

4/ To determine which fields should be developed first and for what specific use.

million tonnes of high ash steam coal a year that self-ignites after being discarded at Wankie open pit mines and which will be used for thermal power generation; and second, how to reduce the loss of skilled and professional manpower.

6. The mission makes the following recommendations:

(a) the Government should commission a comprehensive coal utilization study. This study should include the evaluation of coal conversion possibilities as well as the potential for exports of coal products;
(b) the coal which currently self-ignites should be used for thermal power generation as is currently proposed in the development of the Wankie I power project;
(c) the Government should start training programs to replace the lost skilled labor. Since this is a medium to long term solution, measures should be taken to provide immediate manpower needs through technical assistance; and
(d) the Government should consider, once the study under (a) is completed, the role of private investment in the coal sub-sector.

Electric Power

7. Per capita electricity consumption in Zimbabwe is one of the highest in the Eastern Africa region (928 kWh per capita in 1980), largely because of use by the manufacturing and mining sectors which together consume about 69% of the total electricity (1980). Four large manufacturers (Sable-chemical, Zisco-steel, Rhodall and Rhomet-ferrochrome) account for about 63% of electricity consumed by the manufacturing sector. Domestic consumers (almost entirely in the urban areas) account for only 13% of total consumption. Power demand has been met since 1960 largely from: (a) four relatively old coal fired thermal power stations; (b) the Kariba South power station; 5/ and (c) imports from Zambia, which meet 37.8% of total requirements. The only plant under construction is Wankie Stage I (4 x 120 MW), which is expected to use 1.6 million tonnes of low quality steam coal.

8. Power Development. The timing for new generating plants following Wankie I depends to a large extent on how much 'surplus' power is available from Zambia. However, even with a conservative estimate of future demand in Zambia. However, even with a conservation estimate of future demand in Zambia, a new power plant needs to be commissioned in Zimbabwe by April 1985. The consultant's evaluation indicates that only Wankie Stage II Phase I (2 units of 200 MW each) could be commissioned by

---

5/ A small area of the country in the vicinity of Beitbridge is supplied with electricity imported from RSA, but the amount is less than 0.2% of the country's total requirements.

that date. The extensions at Kariba would follow this development. The new schemes on the Zambesi River (which are the Mupata Gorge, Batoka Gorge, Devil's Gorge, and Victoria Falls hydro projects) are longer terms prospects; only Mupata Gorge could be built by the end of the 1980s; the others could only be built during the 1990s. The Government is also anxious to lower its dependence on imported power from around 38% to 15%-20% for security reasons. The mission considers that the costs of reducing this dependence would be excessive, since it would mean fast construction of new power plants in the country.

9. Another factor which affects the power development program is the efficiency with which electricity is used by the major industrial consumers. A preliminary energy audit of seven large electricity users shows a gross potential savings of about 159 MW although not all of these savings are economically recoverable. The mission recommends that an energy efficiency program be introduced in those plants where the payout is quick. Energy audits for all other major energy users should also be conducted.

10. Among the seven large electricity users, Sable's consumption is the largest. The mission recommends that a study to analyze the long-term prospects that a study to analyze the long-term prospects for using coal to produce ammonia and replace the electrolytic hydrogen production should be commissioned.

11. Electricity Connections. Zimbabwe's power supply is mainly geared to industry and commerce, and serves only a small proportion of the urban population. The mission recommends that urban low income households be connected to the grid as soon as possible to lessen the pressure on fuelwood demand. However, because the rural population is widely scattered, rural electrification will remain a medium to long term objective and in the short term only the rural 'growth points' should be connected to the grid. The program for electrification of both the growth points and other rural areas requires further study, and this should be done in the near future.

12. Manpower. The electric power sector faces an increasing shortage of qualified manpower. Training is insufficient, and measures are necessary to reduce the outflow and to represent the lost manpower. The mission recommends that extensive training be carried out to solve the long term manpower shortage. In the short term, the manpower shortages should be met through technical assistance. Funds to cover foreign exchange for training and technical assistance could be provided as a component of the proposed Bank power project loan which is being processed or through other aid funds.

Fuelwood

13. While wood is the most important source of energy for both rural and urban households, Zimbabwe's indigenous woodlands present a

fragile energy base. In several of the old and densely populated 6/ eastern midveld rural settlements, would resources have been depleted to a critical level. In the rural areas, wood is expected to remain the principal energy source for at least the next 20 years, with some possible shifts to alternative sources of energy. However, while the mission supports rural afforestation activities based on communal woodlots, especially within the wood deficit areas, as proposed by the Government, clearer delineation of the respective roles of the government departments and local authorities is necessary; in particular there should be recognition of the leading role of the Ministry of Industry and Energy Development (MIED) in the planning and use of fuelwood supplies. In and around the low income urban areas, where wood is the primary fuel for cooking and heating, and consumption is estimated at 1 million m^3, or about 17% of total household energy consumption, the depletion of woodlands is of grave concern. The mission recommends that commercial farming estates be encouraged to supply urban fuelwood markets. Licenses to fuelwood merchants should be issued only if they obtain supplies from nearby commercial fuelwood plantations which are currently underutilized. In the medium term, fuelwood supplies should be increased by encouraging the development of new commercial fuelwood plantations. Fuelwood demand by commercial agriculture (for tobacco curing and crop drying) has declined recently because of the wider use of coal. However, as long as shortages of railway wagons and bottlenecks persist, further substitution by coal on a large scale is unlikely on scattered commercial farms. Since an estimated 750,000 m^3 of wood residues is discarded annually by commercial forests, commercial production of charcoal from the residue should be encouraged near these plantation districts. This could be used to meet commercial agriculture's demand and part of urban fuelwood needs. Distribution of charcoal is urban markets may be left to small private entrepreneurs as is done in most African countries. The use of charcoal stoves and efficient wood burning stoves should be promoted.

Alternative Energy Sources

14. Metrological records indicate a good wind potential for the highveld, particularly during the dry season of late July to October, when mean windspeeds are high. The viability of using windpumps for supplying drinking water from boreholes in communal areas (former Trustlands with the highveld) should therefore be determined. Solar insolation in Zimbabwe is excellent in most regions; the annual average is between 3,000-3,600 sunshine hours, and the mean daily solar radiation is 490 cal/cm^2. The mission there recommends that the Government increase support through research and tax incentives for solar crop dyers and solar water heaters. With livestock population at about 7.4 million,

---

6/ With population densities sometimes exceeding 40 persons/sq. km., the demand on wood resources may already have exceeded the sustainable level of supply.

the potential for using animal wastes for biogas is also promising, but its development on a widespread basis awaits the rehabilitation of livestock production in the country. Ongoing research on biogas (which is currently fragmented) should therefore be consolidated. Finally, since there is currently no known exploitable geothermal potential, and since the use of vegetable oil as a substitute for gas oil does not appear to be viable, further research is needed before any investments are considered in these fields.

Energy Organization

15. The organization of the energy sector has recently become more coordinated with the establishment and strengthening of the MIED, whose responsibilities are to implement, coordinate, and monitor appropriate energy and pricing policies. The power sector organization is still fragmented, but the individual organizations supply electricity efficiently and operate reasonably well. However, the overall power sector planning is lacking and a central planning unit needs to be established. The administration of other energy sector requires an acceleration of the coordination process, and the manpower aspects of the MIED should be strengthened, where necessary, through external assistance. The collection of energy data base should be developed to provide the groundwork for developing a national energy plan.

Energy Pricing

Petroleum

16. Although the Government's pricing policy is to fully reflect import costs, the price structure at the time of the mission did not do this. Current transport costs through RSA are high and vary from US$114 per tonne for gas oil to US$167 per tonne for kerosene. To maintain stability in petroleum prices, 7/ the Government set up a Price Equalization Fund, which is administered by ZOPC. 8/ At the time of mission, the reserve was being depleted at Z$1.5 million (US$2.4 m) per quarter to cushion cost increase and ZOPC's landed cost ex-Salisbury was higher than the price at which the products were sold to the marketing companies, with the difference being met by the Reserve. For example, in June 1981 the landed cost of petrol blend was Zc35.48/litre (US$2.14/US

7/ The cost of supplies through RSA suffers from uncertainty due to spot purchases at times.

8/ The Zimbabwe Oil Procurement Consotium consists of Shell, B.P., Caltex, Total and Mobil. The Consortium operates on a break even basis.

gallon), whereas the price to marketers was Z¢27.03/litre (US$1.63/US gallon). The mission recommends that no cross subsidies be given to petroleum products and that the whole question of petroleum prices be considered in the recommended energy pricing study. In any event, the opening of the Beira pipeline will help to reduce the cost of transport and bring stability to product prices. To avoid distortions in petroleum product demand, the Government should also endeavor to reduce the gap between the prices of petrol and gas oil.

Electricity

17. In Zimbabwe, power tariffs are low because they are mainly based on the low historical assets and debt servicing costs of Kariba which was constructed in the late 1950s and early 1960s. The Electricity Supply Commission's average selling price per kWh for 1980 was Z¢1.24 (US¢2.07); tariff levels in the cities are even lower. An increase of 20% was imposed on January 1, 1981, to help fund the local costs of the Wankie I project. Tariff levels should be raised to approach the economic cost of power supply and generate funds to finance the large sector development program that is required. The structure of the tariffs encourages power-intensive industries, such as the production of ammonia through electrolysis of water. The mission recommends that a study on the rationalization of the tariff structure be commissioned as soon as the Government has decided on the implementation of the least-cost power program.

Coal

18. Coal and coke prices are regulated under the Coal Price Agreement (CPA) signed by the Government and Wankie Colliery Company Ltd. (WCC) on August 31, 1976. The CPA was amended in November 1981 and will expire on August 31, 1995. Prices are set to permit the Company a 12.5% return on historical capital employed 9/ and an additional 5% on export sales. This agreement does not provide incentives for major new investments. The mission recommends, therefore, that the Government reconsider its coal pricing policies to ensure that they attract new investment in this sector.

19. The mission concludes that the energy prices in the country do not reflect their true cost. In order to finance large future investments in the energy sector, these prices need to be increased and rationalized. The mission recommends that a general energy pricing study be commissioned to determine a rational energy products (coal, power, and petroleum products) pricing policy. The study could be financed as part of the Bank's power project loan or through other external assistance. In the meantime, the level of power tariffs should be increased

---

9/ Capital employed is defined as net book value of fixed assets and stocks.

immediately. The realistic prices of energy resources are expected to also encourage an efficient use of various energy resources in the country.

Demand Projections

20. It is likely that Zimbabwe's GDP will grow at 4-5% a year for the rest of the decade. However, because the future is so uncertain, likely energy demand and investments in the energy sector are projected on the basis of three scenarios: 3%, 5%, and 7% 10/ sustained annual growth rates of GDP. An annual growth of 3% (low growth) would be somewhat disappointing given the country's potential, while 5% growth (medium growth) should be attainable with moderately successful policies and favorable external circumstances.

21. Total energy demand is expected to increase in line with the GDP growth rate. Under the high growth scenario (7%), total energy demand in 2000 is projected to be 25.6 million toe (a growth rate of 7.6% p.a.) with 29% of it coming from imports, of which electricity would account for 17% and petroleum 12%. Under the 5% GDP growth scenario, which the mission considers the most likely, total energy demand would increase to 16.9 million toe (a growth rate of 5.4% p.a.) with imports at 16% (electricity 10% and petroleum 6%).

Investment Implications

22. Under the medium growth scenario (a 5% sustained growth), the necessary investment in the energy sector to 2000 is estimated at US$7.1 billion (1980 dollars). About 74% of this will be in the power sector and 25% in coal. 11/ Within the power sector, 69% of investment will be in generation and the main transmission lines which would include Wankie II Phase 1 and 2 coal-fired, and Kariba North and South hydro extensions,

---

10/ The Government has emphasized that during the next three years the GDP growth will be 8%. Thereafter the growth rate will slow down. The plan figures for long-term growth are not yet available. However, the Government hopes to achieve a 7% average growth during the next 10 years.

11/ Assuming that the export potentials can be developed and transport constraints are resolved. The power sector cost estimate are based on a least-cost program and should be financed by increasing the power tariffs to an adequate level. Coal development for export may be financed by the private companies to supply their overseas affiliates.

and the Batoka and Mupata hydro projects. Investment costs for substations and distribution facilities are estimated at 31% (US$1.6 billion) of total power investments. In the fuelwood sector, investment of about US$30 million in the next 10 years is to provide for maintenance of an afforestation extension program and for manpower training.

23. Such a large and diversified energy investment program requires careful planning. The mission recommends that the MIED embark on a comprehensive energy development program based on the medium growth scenario. Assistance should be sought to strengthen the institutional capability of the Ministry to perform this task.