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Report No. 3903-MAI

Malawi: Issues and Options in the Energy Sector

August 1982

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

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MALAWI

ISSUES AND OPTIONS IN THE ENERGY SECTOR

August 1982

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CURRENCY EQUIVALENTS

Currency Unit	Kwacha (K)
100 tambala (t)	K1
K1	US$ 1.07
US$1	K0.93

ABBREVIATIONS AND ACRONYMS

CUC	Coal Users Committee
DSB	Department of Statutory Bodies
EPD	Economic Planning Division
ESCOM	Electricity Supply Commission of Malawi
GWh	Gigawatt hour = One Million kilowatt hours
IFC	International Finance Corporation
kcal	kilocalorie
kg	kilogram
kW	kilowatt = 1,000 watts
kWh	kilowatt hour
MJ	Megajoule = 239 kilocalories
MW	Megawatt = 1,000 kilowatts
NSO	National Statistical Office
OILCOM	Oil Company of Malawi
OPC	Office of the President and Cabinet, Government of Malawi
SUCOMA	Sugar Company of Malawi
toe	tonne of oil equivalent = 41 million Btu = 10.3 million kcal
TRA	Tobacco Research Authority
UNDP	United Nations Development Program
USAID	United States Agency for International Development

This report is based on the findings of an Energy Assessment Mission which visited Malawi in September 1981. The composition of the mission was: Masood Ahmed (Mission Chief), P. Hall (Investment Program and Institutions), G. Collins (Energy Planner), A. E. Bailey (Electric Power Consultant), M. Alexander (Coal Consultant), and T. Graham (Renewables Consultant, USAID).

The mission obtained significant input and assistance from a staff group of the Economic Planning Division in Malawi which had been gathering and analyzing data on historical energy supply and consumption.

A follow-up mission consisting of Masood Ahmed, P. Hall and G. Collins visited Malawi from June 28 to July 2, 1982 to discuss the report with the Government and interested agencies and to obtain their comments, which have been incorporated in the final report. Secretarial assistance for this report was provided by Ms. Linda Walker-Adigwe.

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INTRODUCTION AND RECOMMENDATIONS

1. Malawi faces two major energy problems. First, the consumption of fuelwood, which accounts for ninety percent of the primary energy supply for the country, exceeds the sustainable yield of this resource 1/. 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 sustainable 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 substantial fuelwood savings in a relatively short period and consequently it deserves a much higher level of public funding and support than has been the case 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. A number of other issues, while less important than the two problems raised above, also need to be addressed in the near future to ensure the efficient development and management of the energy sector. While most of these relate to specific fuels and are accordingly grouped in that way in the body of the report, the general theme of institutional strengthening and improved coordination is present in each. This issue is dealt with at length in the final chapter of the report and the report makes specific recommendations for strengthening the institutional framework for energy policy and management. It also presents an outline of the technical assistance that would be required to develop an effective national energy planning capability.

4. These and the other main recommendations in the report are listed in the following section for ease of reference. However, it is

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1/ Per capita consumption of primary energy in 1980 amounted to 0.56 tonnes of oil equivalent; however, the per capita consumption of commercial energy sources was only 0.046 toe.

important to put these recommendations and indeed the whole discussion in the report, in their proper perspective. Malawi's energy problems are far less severe than 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 this report are therefore, designed to assist the Government in maintaining its good record in energy policy and management.

5. Summary of Recommendations

A. Fuelwood

(i) The work being done by the TRA 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. (Paras. 1.14, 2.12).

(ii) The reforestation program needs to be reoriented (a) to target the seedling sales to areas where there is already an apparent and recognized fuelwood shortage, (b) to sell species suitable for building poles rather than fuelwood, (c) where seedlings are sold for fuelwood production, to introduce species which can be grown on marginal land to reduce competition with agricultural crops, (d) 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 (Para. 2.06).

(iii) 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 (Paras. 2.13-2.15).

B. Petroleum

Supply

(iv) 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 (para. 3.11) but the recommendation regarding strategic storage requires further clarification (para. 3.12-13). 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.

(v) A detailed allocation program should be drawn up for distributing petroleum products to priority users in the event of a shortage. It should be up-dated periodically and should account for seasonal changes in demand (Para. 3.07).

Pricing 1/

(vi) The Government should re-examine with the oil companies the financial disincentives embedded in the current procedure for holding inland stocks (Paras. 3.15-18).

(vii) 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 (paras. 3.15-18).

(viii) 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 anomalies in these costs are addressed without undue delay (Paras. 3.16-3.18).

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

C. Electricity

Supply

(ix) 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 consideration should be given to diversifying away from the Middle Shire river (Paras. 4.17-4.19).

(x) Government and ESCOM should begin a survey and identification of the country's small hydro potential for replacing isolated diesel generation (Paras 6.05-6.06).

Pricing

(xi) The next round of tariff revisions should be based on the results of an updated 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. (Paras. 4.11-4.16).

D. Coal

(xii) The Coal Users Committee should continue its operations as long as all the users are satisfied with this arrangement (Para. 5.02).

(xiii) 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 (Paras. 5.10-5.11).

(xiv) 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 (Para. 5.12).

E. Non-Conventional Energy Sources

(xv) 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 (Para. 6.13).

(xvi) The institutional framework for this work also needs to be clarified, in particular the role of the National Science Council (Para. 7.15).

(xvii) The feasibility of expanding ethanol production by using cassava as a feedstock needs to be carefully examined before investment decisions are made (Para. 6.04).

(xviii) 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 (Para. 6.07-08).

(xix) The costs of generating power from using bagasse more efficiently at SUCOMA 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 (Para. 6.09).

(xx) The potential for expanded use of cotton seed husks as boiler fuel in the Blantyre area should be examined (Para. 6.09).

F. Conservation

(xxi) The pattern of energy consumption and the potential for increased efficiency of energy use in the industrial sector need to be examined further (Para. 1.13).

G. Institutions

(xxii) The terms of reference of the Contingency Planning Unit 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 (Para. 7.18).

(xxiii) The Contingency Planning Unit in OPC should represent the Government on the tripartite petroleum supply committee proposed above (Para. 7.18).

(xxiv) 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 EPD (Para. 7.19).

(xxv) EPD will require technical assistance in the initial 18-24 month period to be able to effectively discharge these responsibilities (Para. 7.20).

Developments Since the Assessment Mission

6. Since the mission's visit to Malawi in September 1981, the Government has continued to take action on issues in the energy sector. The following items were included as recommendations in the draft report to the Government but the follow-up mission learned that appropriate steps had already been taken:

(i) The Energy Studies Unit has been moved from the Ministry of Agriculture to the Ministry of Forestry and Natural Resources where its work can be better coordinated with the Wood Energy Division.

(ii) The post of Executive Chairman of ESCOM has been eliminated with the resulting clarification in senior management responsibilities. ESCOM is also actively seeking a qualified Chief Engineer and has promoted two Malawians to the position of Deputy Chief Engineer.

(iii) The Government is examining the duty structure for automobile imports to ensure that it provides appropriate incentives for energy conservation in the transport sector.

7. 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.

CHAPTER I

ENERGY IN THE ECONOMY OF MALAWI

Country Background

1.01 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.

1.02 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.

1.03 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.

1.04 The adverse effect of these external forces has also 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.

1.05 Developments in the energy sector will have an important bearing on the success of these efforts just as they have been a major factor in contributing to Malawi's current economic difficulties. Between 1975 and 1980, despite virtually no increase in the consumption of imported energy (primarily oil and some coal), the energy import bill almost trebled to K56 million ($60 million) and the proportion of export earnings devoted to importing energy increased from 17.8% in 1975 to 23.4% in 1980. At the same time, rising energy prices have fueled inflation and interruptions in the supply of energy imports have repeatedly caused disruption and expense to the economy.

TABLE 1.1

Cost of Energy Imports
(Millions of current Kwachas)

Year	Oil	Coal	Total Energy	Export Earnings
1975	17.5	1.4	18.9	106.3
1980	52.1	3.9	56.0	238.9

Source: NSO.

Energy Consumption Overview

1.06 The rising cost of commercial energy and disruptions in its supply have been the most visible of Malawi's energy problems, but these modern fuels supply only about 10% of the country's primary energy requirements.1/ The predominant source of energy for Malawi is fuelwood, which, along with agricultural residues and other similar traditional fuels, accounts for 90% of primary energy supply. To some extent this is a reflection of the relatively lower efficiency with which these traditional fuels are burned which results in their share in primary energy supply being much higher than in "useful" or final energy consumption. However, even when allowance is made for different end-use efficiencies, these traditional fuels still provide three-quarters of Malawi's energy needs. (Table 1.2) The energy supply by source to each sector is shown graphically in Figure 1.1 which is based on the energy balance in Annex 4.

1/ Throughout the report the term "commercial energy" refers to petroleum products, coal, and electricity although much of the fuelwood consumed is purchased. Non-commercial energy includes fuelwood, bagasse, cotton seed husks and other agricultural residues.

1.07 Historical data on energy consumption are available only for the commercial fuels and because of discrepancies between different sources these data should be used cautiously. The estimates compiled by the mission from a variety of sources indicate that aggregate commercial energy consumption grew from 169 thousand toe in 1970 to 276 thousand toe in 1980, an average annual growth rate of 5.0%. However, energy demand growth in the second half of the decade (1.9% per annum) was well below that experienced from 1970 to 1975 (8.3% per annum).

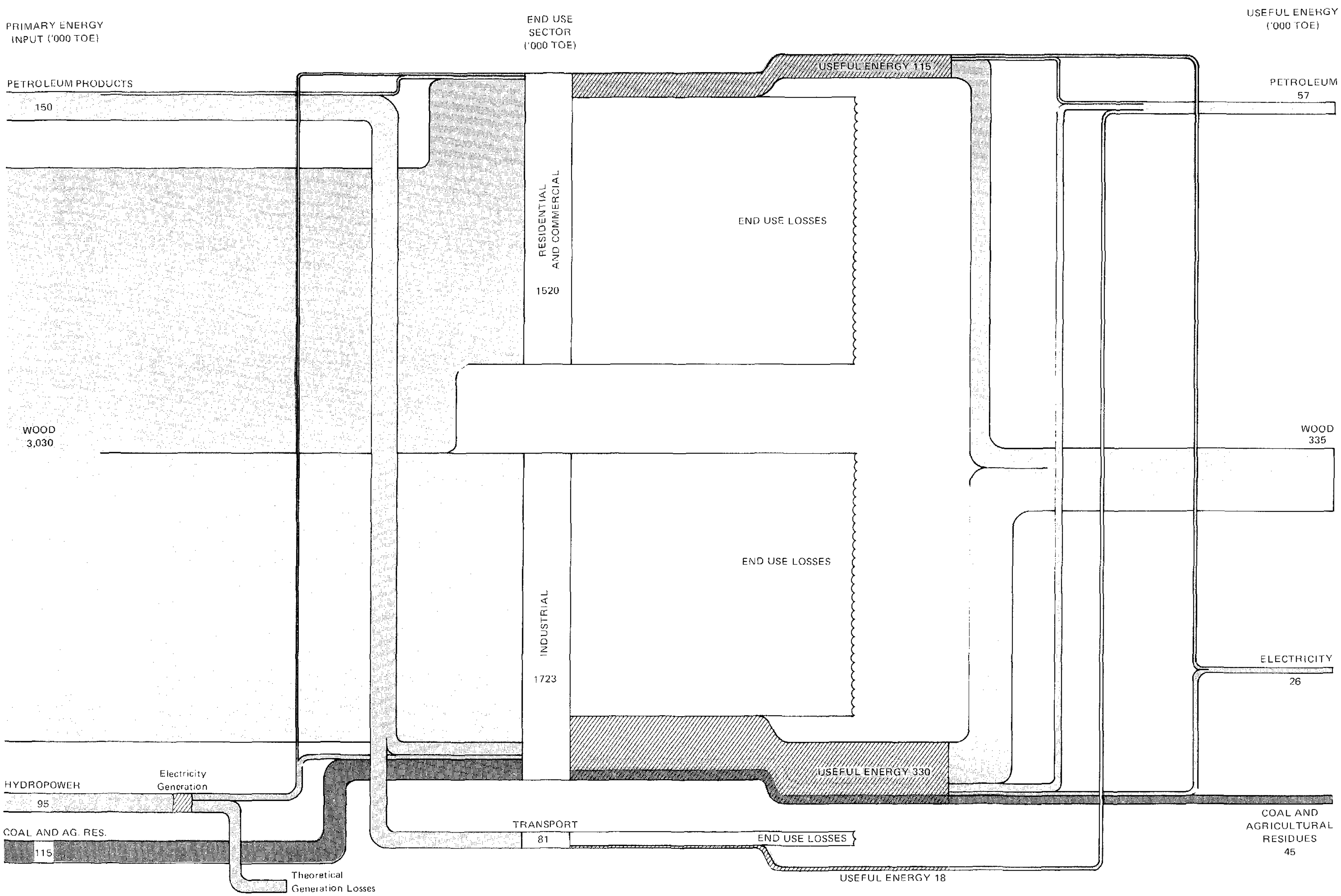
TABLE 1.2

Energy Supply By Source, 1980
(Percent)

Source	Primary Energy	"Useful Energy" a/
Fuelwood	89.3	71
Other Biomass	2.5	6
Petroleum Products	4.5	13
Hydroelectricity	2.8	6
Coal	0.9	4
Total	100.0	100.0

a/ Weighted by sector-fuel-specific end-use efficiencies; see Annex 4 for details.

FIGURE 1.1: MALAWI ENERGY CONSUMPTION, 1980



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Source: Energy Balance Tables, Annex 4

TABLE 1.3

Commercial Energy Consumption Trends 1970-80
(Thousand toe)

Fuel	1970	1975	1980	Average Annual Growth Rate 1970-75	1975-80
Electricity a/	33.1	66.1	97.4	14.8	8.1
Petroleum Products c/	106.5	137.5	147.4	5.2	1.4
Coal	29.5	47.8	31.2 b/	10.1	- 8.2 b/
Commercial Energy	169.1	251.4	276.0	8.3	1.9
GDP	-	-	-	7.7	5.4

a/ Sales by ESCOM which are almost exclusively hydro based. This does not include petroleum based electricity generation from captive plants for which no reliable data are available.

b/ The low figure for coal consumption in 1980 should be viewed with caution because there is a particularly large discrepancy between consumption and import figures for that year.

c/ The small amounts of diesel oil used for electricity generation by ESCOM are included as electricity not petroleum products.

1.08 It is important to note, however, that the growth rate for commercial energy consumption depends on the source of the data and the period selected. Table 1.4 illustrates this problem clearly for petroleum products and coal. The growth rates fluctuate widely because of data discrepancies and because changes in stock levels, while not large in absolute terms, can have a significant effect on a low level of consumption.

TABLE 1.4

Average Annual Growth Rates for Petroleum Product and Coal Consumption
(Percent)

Period	Petroleum Products: NSO Data	Petroleum Products: Oilcom Data	Coal: NSO Data	Coal: CUC Data a/	GDP
1973-80	1.5	-	7.9	-	5.3
1974-80	2.7	-	5.8	-	5.2
1975-80	1.3	-	0.7	-	5.4
1976-80	1.0	2.0	4.3	-	5.3
1977-80	4.1	1.2	9.4	-	4.1
1978-80	0.9	- 3.1	15.7	- 7.4	2.6
1979-80	- 2.8	- 4.6	116.7	-19.1	0.0

a/ Coal Users Committee plus consumption by Portland Cement Company.

1.09 Because of these fluctuations in the growth rate for commercial energy consumption, standard indicators such as the energy elasticity of GDP growth are not very meaningful for analyzing Malawi's energy sector. Nevertheless, it is clear that there has been a marked decline in the rate of growth of commercial energy consumption since about the mid-1970's both in relation to the previous five years and to the rate of growth of the economy as a whole. There are a number of reasons for this. First, the Government has passed on increases in the cost of commercial energy promptly to final consumers and there are no subsidies on any of the commercial fuels. Second, in response to higher prices and recurrent supply problems many of the large commercial energy users have become increasingly conscious of energy wastage and taken steps to improve the efficiency of energy utilization. Third, much of the growth in the economy has come from agriculture and related processing industries which do not rely heavily on commercial energy. And finally, some tea estates have shifted from using coal to fuelwood grown on their own plantations but the magnitudes involved here are small and likely to remain so for the near future.

1.10 It is not possible to show how the sectoral energy consumption pattern has evolved over time because of the absence of sufficiently disaggregated historical data for the commercial fuels and of even aggregate consumption estimates for the non-commercial sources of energy. However, it is possible to develop a rough estimate of the current pattern of energy consumption in the various sectors. This is shown in Table 1.5 below which has been prepared by the mission on the basis of information - of varying reliability - supplied by a number of sources.

1.11 While these estimates are subject to a margin of error and should be viewed as indicative only, they serve to illustrate the pattern of energy consumption in the different economic sectors. They show, for example, the almost complete dependence of the household sector on fuelwood and other non-commercial fuels. Direct household demand for the commercial fuels does account for about 8% of total commercial energy consumption, but, although only limited data are available, it is reasonable to postulate that this is attributable to only a very small segment of society. Only 2% of the population and virtually none of the rural households have access to electricity. Kerosene is more widely available but few households can afford to use it even for lighting. Moreover, the recorded consumption of kerosene has declined by 60% since 1973 and is now quite small - about 6,000 toe or approximately 1 kg per capita per year. Thus, for the vast majority of Malawi's population, traditional fuels are the only source of energy to meet their modest cooking and heating requirements. Even in the urban centers where commercial fuel use is more common, these fuels are used for quite different purposes. Fuelwood remains the primary cooking fuel with electricity use being mainly confined to lighting, water heating and the running of other household appliances. The one important difference between urban and rural fuelwood use is that fuelwood is generally marketed in the towns, whereas most rural households gather their own requirements.

1.12 Fuelwood is also an important source of energy for the industrial sector, which in turn accounts for over half of the estimated total consumption of this resource. However, it is important to emphasize that industrial fuelwood use is restricted to a few specific industries and its importance as an industrial fuel stems from the dominance of these industries rather than from its generalized use as an industrial fuel. The most important of these industries is tobacco processing which alone accounts for over 90% of industrial fuelwood consumption. Other important users are the tea processing and brickmaking industries. Other than fuelwood, non-commercial energy use in the industrial sector includes about 350,000 tons of bagasse on two sugar estates and a small amount (5,200 tons) of cotton seed husks in a seed processing plant and a brewery. The rest of industry relies essentially on commercial fuels and is in turn a major consumer of these fuels. Forty percent of petroleum consumption, nearly three-quarters of electricity sales and virtually all of the coal demand is in the industrial sector.

TABLE 1.5

Sectoral Energy Consumption Pattern, 1980
(Thousand toe)

Source	Sector: Industry	Transport	Commerce	Households	Total
Petroleum Products	60.4	80.6	0.1	6.3	147.4
Electricity	71.5	-	10.6	15.6	97.7
Coal	29.6	-	1.6	-	31.2
Subtotal: Commercial Energy	161.5	80.6	12.3	21.9	276.3
(Percent)	(58.5)	(29.2)	(4.4)	(7.9)	(100.0)
Fuelwood	1527.0	-	9.0	1493.0	3029.0
Other Biomass	83.4	-	-	-	83.4
Total Energy	1771.9	80.6	21.3	1514.9	3388.7
(Percent)	(52.3)	(2.4)	(0.6)	(44.7)	(100.0)

Notes

(i) Electricity figures include a small amount (1,600 toe) of diesel used by the ESCOM but 98% of ESCOM's electricity supply is from hydropower. However, these figures do not include the petroleum used to generate electricity in captive plants for which accurate data are not available.

(ii) Hydroelectricity converted at thermal generation equivalent.

(iii) These figures refer to primary energy consumption and do not take end-use efficiencies into consideration. Transmission and distribution losses are allocated to the end-use sectors on a pro-rata basis.

Source: Mission estimates based on data supplied by ESCOM, OILCOM, GOM and other agencies. See Annex 4 for details and conversion factors.

1.13 With one or two exceptions, the larger industrial energy consumers are reasonably efficient in their use of the commercial fuels. One of the main reasons for this is that many of these companies are connnected with large international corporations and have been able to make use of their technical expertise. However, it is likely that improvements could be made in the efficiency of energy use in the numerous small and medium scale industrial and commercial enterprises which do not have the same kind of technical links with international corporations and are probably less aware of recent developments in the field of energy conservation techniques and equipment. The first step in evaluating the potential for energy savings in these firms as well as to confirm the preliminary findings for the larger firms, is to collect better data on the existing pattern of energy consumption in the industrial sector on which little information is currently available.

1.14 In sharp contrast to the commercial fuels, the potential for increasing the efficiency of fuelwood use in (the tobacco) industry is both large and achievable in a relatively short period. The tobacco industry is both a major wood user and by all accounts a relatively inefficient one. The amount of wood used to process a unit of tobacco is reported to vary enormously from estate to estate -- the Tobacco Research Authority (TRA), quotes a figure of 7:1. Consequently, the potential savings that would accrue from bringing up the less efficient operators to the level of the better run estates are large. Quite apart from this, the TRA is doing some interesting work on modifying flue and barn designs which could lead to savings of up to 50% in wood consumption by even the better run estates and at relatively low costs. The main constraint to the widespread application of this work, and the realization of the savings accruing from it, is an institutional one. The TRA is an advisory, grower-supported body with no enforcement powers and no effective mechanism for getting the results of its work through to the smallholder sector which is where the greater savings potential lies. The Government provides little support to the TRA and its own Energy Studies Unit in the Ministry of Forestry and Natural Resources has so far restricted its focus almost entirely to the use of wood by households where the widespread diffusion of more efficient stoves and appliances is generally more difficult and takes a long time. Given these factors, the mission strongly recommends that the Government attach a much higher priority to strengthening and disseminating the ongoing work on improving the efficiency of fuelwood use in the tobacco industry.

1.15 Transport is the other main user of commercial energy being based entirely on petroleum and in turn accounting for over half of the country's petroleum consumption. In fact, the share of petroleum consumption in the transport sector may be somewhat higher than indicated by the figures in Table 1.5 because some (unquantified) proportion of the diesel sales to industry is for running company vehicles. Given the high share of the transport sector in petroleum consumption, it is important that any measures to conserve energy in this area be given high priority. In Malawi the main potential for such savings appears to lie in encouraging a modification of the existing vehicle fleet. While disaggregated data are not available, the private car fleet in Malawi appears to have a much higher proportion of larger engined vehicles than is the case in most developing countries. This in turn stems from the fact that for all practical purposes there is a uniform and relatively low rate of import duty on cars regardless of value or engine size. This duty structure is now being examined by the government to ensure that it provides appropriate incentives for energy conservation in transport. The Government is also reviewing its own vehicle procurement and operation policies so as to limit the use of heavy fuel using, four-wheel-drive vehicles to those areas where they are needed and to reduce their use for intra-urban operation.

1.16 This discussion of sectoral energy consumption in Malawi has an important bearing on the preferred approach for analyzing the country's energy problems because it highlights the generally strong associations between specific sources of energy and specific categories of energy demand in the Malawian economy. The bulk of the population uses firewood and agricultural residues for their cooking and other household energy needs and these requirements in turn account for half of the country's fuelwood consumption. The tobacco industry forms a similar enclave relying almost exclusively on fuelwood and accounting for almost all of the remaining half of fuelwood demand. Oil imports are equally associated with the transport sector, construction and the operation of industrial pumps and engines. Coal is used mainly for industrial process heating and steam raising. Electricity, generated almost entirely from domestic hydro resources, is used in urban areas for lighting and operating electrical machinery and appliances.

1.17 This compartmentalization is by no means complete; some users can and do shift across fuels, one recent example being the few tea estates in the south which have switched from burning coal to using fuelwood grown on their own plantations. Nevertheless, this division reflects the situation sufficiently well to warrant treating energy in the Malawian context more as a series of parallel subsectors than as an integrated whole at the present time. This approach is reinforced by the nature of the available data and of the important issues facing energy policy makers in Malawi today, both of which are more easily classified by fuel and less amenable to a standard energy supply/demand approach.

1.18 For these reasons, the discussion of the energy sector in the following chapters of this report is structured by the specific fuels that are used in Malawi's economy. The labelling of energy sub-sectors by the type of fuel involved or the source of supply does not detract from the importance that should be attached to the management of energy demand. In the fuelwood sub-sector in particular, efforts to improve the efficiency with which fuelwood is currently used in the tobacco industry are likely to yield a much greater and faster return than efforts to increase supply although both facets of the program are necessary. Nor is it meant to imply that there are no interfuel substitution possibilities in Malawi. Some expansion of coal use at the expense of petroleum products is both possible and desirable in the short term and, in the longer term, the development of nonconventional, renewable energy sources could help to moderate the demand for commercial energy. Similarly, institutional strengthening for energy policy and management is a concern which relates to all forms of energy supply. These threads are brought together in the final chapter of the report, which provides an overview of the likely energy supply and demand balance in 1985 and 1990, and discusses the implications of this scenario for both energy policy and the macroeconomic framework.

CHAPTER II

FUELWOOD

Supply and Consumption

2.01 Fuelwood is Malawi's main source of energy. The country's total fuelwood requirements are estimated at around 10 million m^3 per year. Wood is not only the main household fuel for 90 percent of the population but also the primary fuel for tobacco processing, tea curing and brick-making. 1/ The tobacco industry alone accounts for 40% of all wood used. This demand for wood is met from a variety of sources by far the largest of which is indigenous forests on customary land from which wood is generally removed free or at nominal charge and without restriction by the rural population for domestic and agricultural use. Other sources of fuelwood, such as managed forest reserves on Government and private plantations, supplement the supplies from customary land but aggregate consumption still exceeds the level of sustainable yield on a national basis by about 30 percent.2/ The difference is met from the continuing diminution of Malawi's natural forest cover which is currently disappearing in terms of gross area at 3.5 percent per annum.

2.02 However, these national figures subsume important regional variations in the pattern of fuelwood supply and demand. In the relatively sparsely populated and less developed Northern Region of the country, the sustainable supply of fuelwood is well in excess of current demand and adequate fuelwood availability is not an important problem. The principal use of fuelwood in this region is as a domestic fuel with tobacco curing and other industrial uses accounting for only 20 percent of total consumption. This pattern is very different in the more developed and heavily populated Central and Southern Regions which account for 90% of the country's fuelwood consumption and where industrial users are as important as the household sector. These are also the regions where the sustainable supply of fuelwood falls far short of the level of consumption and where localized fuelwood shortages have already begun to emerge. In these regions the continued availability of adequate fuelwood is a potentially serious problem but it is important to emphasize that even here the availability of fuelwood is currently not a source of acute concern to the general public, at least in rural areas.

1/ As such fuelwood is both a commercial and non-commercial fuel but the proportion of wood purchased is not known. (See para. 2.13-15).

2/ In calculating this deficit, the demand for building poles (about 1.8 million cubic meters per annum) is added to the demand for fuelwood because they are both met from the same sources of supply. See Annex 3 for a detailed breakdown of these sources.

TABLE 2.1

Fuelwood and Poles Demand and Supply
Balance by Sector and Region 1980
(thousand cubic meters, solid)

Region	Sector					Building Poles	Total Demand	Sustained a/ Supply	Balance
	Domes.	Tobacco	Institu.	Other Industry	Total Demand				
Southern	2479.3	1212.6	8.3	291.8	3992.0	795.1	2787.1	1380.8	(3406.3)
Central	1891.2	3246.3	10.2	6.6	5154.3	602.4	5756.7	2960.0	(2796.7)
Northern	569.2	44.1	13.6	86.9	713.8	454.1	1167.9	4606.4	3438.5
Total	4939.7	4503.0	32.1	385.3	9860.1	1851.6	11711.7	8947.2	(2764.5)

a/ Some of the supply is inaccessible or unavailable for conservation reasons.

Source: Fuelwood and Poles Project, Ministry of Agriculture and Natural Resources, 1978.

2.03 A useful insight into the pattern of household energy use and the degree to which rural households are concerned about adequate energy availability is provided by a recently completed rural energy survey carried out by the Energy Studies Unit with the help of the National Statistical Office. The survey covered about 2400 rural households and was administered nationally in two rounds to take account of seasonal fluctuations in energy use. Results of the first round are now available 1/ and they confirm that, despite a general feeling that fuelwood is increasingly scarce, the fuelwood problem is not felt to be an acute one in most rural areas. More than 90% of rural households collect all their own wood and more than half of them can find it within one mile of their home. While two-thirds of the households interviewed felt that fuelwood collection was "difficult" and an equal number felt that it had become "more difficult" over the past five years, there was no evidence to suggest that people had responded by performing fuel consuming tasks less often. For example, wood scarcity (either defined in terms of difficulty of collection by the respondent or in terms of distance walked for collection) does not appear to have any effect on the number of meals cooked daily or on the frequency of undertaking other tasks such as brewing beer or heating water for bathing. Equally there was no

1/ Rural Energy Survey; Report of the Energy Unit, Ministry of Agriculture, December 1981.

significant relationship between wood scarcity and the likelihood of planting trees, although this is explained to a large extent by the fact that most of the households which had planted trees during the previous year had done so primarily for building poles and fruit and not for fuelwood. Nevertheless, there do appear to be some discernable effects of the level of fuelwood scarcity. For example, people in wood scarce areas were more likely to purchase fuelwood or cook with crop residues, bark, roots or other less preferred fuels. However, only a small number of rural households had begun to respond to wood scarcity in these ways: less than 10% purchase wood and only a quarter use a secondary cooking fuel.

2.04 These results are not only interesting in their own right but they also have important implications for public policy in fuelwood management and pricing. On the one hand objective criteria indicate that a high priority should be attached to measures which could reduce the gap between fuelwood consumption and sustainable supply because a continuation of current trends could result in an energy crisis of serious proportions. The Government has rightly recognized the potential seriousness of this problem and embarked upon a three pronged strategy to increase fuelwood supply. One aims at building up the long-term supply by providing fuelwood seedlings for sale nationally to the public accompanied by a complementary program of extension services to enable them to grow their own supplies of wood. The second strategy involves an intensive afforestation program in areas of localized wood shortages and high population density. The third strategy is to improve the management of customary land by District Councils. Much of this work is being done within the context of the IDA assisted Wood Energy Project which constitutes the main thrust of the Government's program in this area.

2.05 This strategy is basically sound, but its success, particularly insofar as the self help woodlots are concerned, clearly depends on the degree to which potential buyers perceive the fuelwood problem as being a critical one and, consequently, on the value they place on the seedlings offered to them. It is in this context that the results of the recent survey have an important bearing on the direction of future reforestation efforts. If, as the survey suggests, fuelwood availability is not nationally perceived as an acute problem, then efforts to encourage farmers to purchase, plant and maintain trees for fuelwood are likely to meet with only limited success.

2.06 These factors suggest that to be effective the Government's reforestation strategy should be reoriented to place more emphasis on (i) managed plantations rather than the sales of seedlings to individuals where the ultimate success depends more on people's perceptions of the fuelwood crisis; (ii) selling species suitable for building pole production rather than fuelwood because the former are the most immediate concern of farmers; this would also increase wood availability for fuel indirectly; (iii) where seedlings are sold for fuelwood production, species which can be grown on marginal land should be emphasized to reduce competition with agricultural products; (iv) improving the extension service to provide follow-up on the care of seedlings; and (v) targetting the seedling sales program more closely to areas where there is already an apparent fuelwood shortage manifested in a higher proportion of people having to purchase fuelwood or to rely on other less preferred fuels for cooking. The results of the survey suggest that target districts for such an effort would include Zomba, Chiradzulu, Blantyre, Thyolo and Nsanje in the Southern Region where the fuelwood shortage is most widespread, and the more urbanized districts of Lilongwe, Dedza and Karonga in the rest of the country. These efforts should also explore ways of involving women more directly in tree planting since it is the women who generally gather the firewood.1/

Viphya Forest Resources

2.07 This plantation consists of about 54,000 ha of mainly pine trees and was established with assistance from the British Overseas Development Administration to support a pulp and paper mill and saw mills based on export markets. The viability of these large projects is doubtful and alternative uses of the resource are being examined. The originally proposed mill would have to use practically all the available wood, to produce 180,000 tonnes of bleached sulphate pulp per year but an appraisal of this project in 1978 found the rate of return to be unacceptably low.2/ Alternative proposals include a gasification plant to provide feedstock for methanol, gasoline, and fertilizer production, chemical manufacture, charcoal, sawmilling and wood-panel production, pulp and paper production on a small scale, and densified wood. At present most of these alternatives are unproven commercially and require further investigation.

2.08 Because of its distance from the demand centers and high transport costs, full, large-scale utilization of the Viphya forest resources to meet fuelwood, pulp and paper or charcoal demand is difficult under existing conditions.3/ However, there are a number of smaller scale investment which appear to be economically viable. The Government has recently submitted for consideration to the World Bank and Kreditanstalt fur Wiederaufbau a combined sawmill, plywood and blockboard project which would utilize about 15% of available Viphya wood resources. The project is scheduled for appraisal in late 1982 and will include feasibility studies on alternative uses of Malawi's wood resources, including the small scale paper mill, etc. In preparing the project for appraisal, the Government will be deciding on the corporate structure, organizational arrangements and operating strategy for the management of the proposed project, in particular, and the forest

1/ Similar efforts to involve women in the improvement of rural water supply have been effective.

2/ The World Bank: Viphya Pulp Project, Preliminary Appraisal, 1978.

3/ The Viphya forest resources have therefore not been included in the supply shown in Annex 3.

industries sector, in general. At present, the Viphya Pulp and Paper Corporation, which was established in 1973 as a private company, coordinates preparatory activities on the project and may operate the mills on a commercial basis. The Ministry of Forestry and Natural Resources plants and maintains the Viphya forests and also sells the forest products from other Government plantations. These arrangements need to be clarified to ensure the most effective and efficient utilization of Malawi's wood resources.

Demand Management

2.09 The main thrust of the Government's strategy to tackle the fuelwood problem has so far comprised measures to increase the supply of this resource, with little being done to improve the management of fuelwood demand. Tackling the demand side is more difficult because, for most users, wood is not a commercial fuel. However, one aspect of demand management which holds considerable potential and which has been comparatively neglected to date is a program to increase the low efficiency with which the tobacco industry currently uses fuelwood.

2.10 Some interesting work being done on this area by the Tobacco Research Authority (TRA), a grower-supported advisory body, suggests that substantial reductions could be obtained in the fuelwood consumption of the tobacco industry. These reductions would accrue from two sources. First, there is now a wide variation across tobacco estates in the amount of fuel used to process a unit of tobacco. The TRA estimates that the amount of wood consumed 1/ per kilogram of flue cured tobacco ranges between 0.02 m^3 in the most efficient estates to 0.13 m^3 in the least efficient ones - a range of almost 7 to 1. Thus, by improving the efficiency of the furnaces and barns and instituting good housekeeping practices in the less efficient estates, the TRA estimates that the aggregate fuelwood requirements for flue cured tobacco could be reduced by 50%. Earlier tests done by the Tropical Products Institute for the Kasungu Flue-Cured Tobacco Association in 1977-78, confirmed that wood consumption could be reduced to 0.02 - 0.03 m3 per kilogram of cured tobacco by using improved barn designs but their assessment of overall industry savings was somewhat lower at 30%.2/ Whichever figure turns out to be more accurate it is clear that the potential for conserving fuelwood in this use is substantial.

2.11 In addition to the savings accruing from improved furnace and barn designs at the less efficient estates, the TRA is also working on developing new designs for the flues themselves to achieve better heat transfer and thus lower the fuel requirements for even the better run

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1/ On a solid and dry basis.

2/ "A Technical and Economic Evaluation of Suggested Improvements in the Design of Barns Used for the Flue-Curing of Tobacco in Malawi", Tropical Products Institute, 1978.

estates. It is also planning to do some work during the coming curing season on identifying potential savings for fire-cured tobacco processing. This work appears to be promising but it is still at an early stage and is likely to bear fruit only in the second half of the decade.

2.12 The mission strongly supports these efforts and recommends that a much higher priority be attached to them than has been the case in the past. Specifically this will entail the allocation of public funds to supplement TRA's own finances for carrying out this work and the use of the Government's agricultural and forestry extension network to help diffuse the results of TRA's work, particularly in the smallholder sector. This recommendation is based not just on the considerable potential of this work but also on the fact that other options to improve the efficiency of fuelwood use are limited. In the household sector, efforts to popularize more efficient stoves in urban areas may prove fruitful but in the rural sector, which accounts for the bulk of non-industrial firewood consumption, these efforts are likely to meet consumer resistance for the same reasons which have hampered the success of the seedling sales program, i.e., the perception of most rural households that fuelwood availability is not an acute problem at this time. Furthermore, to achieve the same level of savings in the household sector would require a far more expensive and extensive program because it would have to reach thousands of small users. By contrast, the diffusion problems for the tobacco industry, while by no means negligible particularly in the smallholder subsector, would be more manageable and able to take advantage of a pre-existing agricultural extension network.

Pricing

2.13 Currently, most fuelwood is a non-traded commodity, collected free of charge from customary land by family members. For resale, a license must be obtained and fixed stumpage rates paid for cutting wood. The average stumpage price of fuelwood from customary land is US$1.28 per m^3, from plantations the price ranges from US$1.70 to US$4.0 per m^3. To promote more efficient use of wood resources and to stimulate further forestry development, the Government has accepted in principle the gradual increase of wood prices. Under such a policy, by the time the wood produced under the Bank-assisted project is marketed in the mid-1980's, the prices would be sufficient to recover in real terms the cost of wood production. Based on the project targets and a 10% discount rate, the average stumpage prices of fuelwood and poles in constant terms would have to be US$8.7 per m^3 on District and Town plantations by the time the project output is marketed.

2.14 This is a laudable objective, but it is not clear that it can be realized. Quite apart from the social and political considerations which affect the Government's wood pricing policy 1/, the main concern is that

1/ The Government does not actually set market prices for wood but charges a royalty for wood from forest reserves, customary lands, and Government plantations. The royalty depends on the species and intended use.

any attempts to substantially increase the official selling price of wood would simply result in the increased use of wood from indigenous forests over which little control can be exercised. In other words, in a situation where 90% of rural households and a substantial proportion of urban families collect their own wood free of charge, the Government has only limited freedom to set wood prices independently. However, the Government may be in a position to increase the price of wood to the tobacco and tea industries, which purchase a substantial proportion of their fuelwood requirements. The appraisal report for the Bank's Wood Energy Project 1/ considered this possibility of increased prices and modelled the effect of higher fuelwood prices on revenues for a number of representative estates. The analysis showed they would still be profitable at the higher wood prices required for cost recovery. Higher prices would also provide an additional incentive to the tobacco estates to create their own fuelwood plantations as they are required to do by law but not all have actually done.

2.15 The main implication of these discussions is that in a highly segmented fuelwood market in which the Government is only a minor supplier it may be unrealistic to attempt to develop a national fuelwood pricing policy. Rather a careful analysis is required to identify those segments of the market where commercial fuelwood supply is an important component and where the Government has sufficient flexibility of action in influencing the level of prices. The preliminary analysis in this report suggests that these segments could comprise the commercial users and urban households. For the other rural users, the Government should monitor the supply/demand balance but any price increases should be preceeded by an analysis of their effect on the substitution of Government supplied wood by additional withdrawals from forest on customary land.

Institutions

2.16 The newly established Ministry of Forestry and Natural Resources is largely responsible for wood and charcoal energy planning in Malawi. The Forestry Department has overall responsibility for forestry development, protection and conservation of forests as well as for fuelwood pricing policy. All plantations, except for small private ones, are owned by the state through the Department of Forestry which oversees five operating divisions including the recently established (1979) Wood Energy Division. This Division distributes seedlings to farmers to achieve nationwide afforestation, provides extension and information services and is responsible for present and future fuelwood plantations. The Wood Energy Division was originally to have been serviced by an Energy Studies Unit responsible for carrying out surveys and studies aimed at improving the efficiency of fuelwood use and investigating alternative sources of energy to replace wood. The Unit,

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1/ World Bank Staff Appraisal Report No. 2625-MAI, 1980.

which is financed as part of the Bank assisted wood energy project, was originally attached to the Planning Unit in the then Ministry of Agriculture and Natural Resources. In 1981 the Ministry was split into two and the Ministry of Agriculture retained the Energy Studies Unit, an arrangement which posed potential coordination problems. However, this issue was resolved in May 1982 when the unit was moved to the Forestry Department which also houses the Wood Energy Division.

2.17 The more important issue, however, is not of coordinating the work but of omission. The Energy Studies Unit has thus far concentrated its investigations primarily on the use of wood as a household fuel and neither it nor the Wood Energy Division has examined the possibilities of increasing the efficiency of wood use in the tobacco industry. This limited focus needs to be urgently broadened and much closer coordination is required with the work being done by the TRA which has demonstrated fuelwood savings in flue-cured tobacco. The next task is dissemination of this information to barn owners and managers.

2.18 A related issue concerns wood energy planning and pricing. At present, the Forestry Department in the Ministry of Forestry and Natural Resources prepares all the projections on the supply and demand for wood resources and recommends price increases for fuelwood, unprocessed and processed wood. The need for a close review of wood energy pricing in the near future may require a strengthening of the economic expertise either in the Forestry Department or in the proposed planning division in the Ministry headquarters.

Future Consumption

2.19 The future demand for fuelwood will depend critically on the speed with which the potential savings in wood use in the tobacco industry can be realized. The most comprehensive projections of fuelwood demand were made in 1978 in the project feasibility study for the Bank assisted Wood Energy Project. These projections assumed no improvement in the efficiency of wood use in the tobacco industry and on this basis estimated 1985 and 1990 fuelwood consumption levels of 11.5 million m3 and 12.1 million m^3 respectively. However, in view of the preceeding discussion, the mission has prepared an alternative scenario under which efficiency improvements in the flue-curing of tobacco would lead to a reduction in the level of wood consumption for this purpose of 25% and 50% in 1985 and 1990 respectively from the levels projected in the Wood Energy Project Report. This results in a total fuelwood consumption level of 10.5 million m^3 in 1985 and 9.9 million m^3 in 1990 as shown in Table 2.2 below.

2.20 Even the lower projections of fuelwood demand in the alternative scenario will imply a continued gap between sustainable yield and total consumption. The latest estimates of incremental wood production prepared by the Ministry of Forestry and Natural Resources in 1981 show an annual supply level of around 8-9 million m3.1/ To this must be added

1/ See Annex 3.

the estimated 0.5 million m^3 that will be produced annually by 1990 from the plantations under the Wood Energy Project and the more difficult to quantify additional wood supply resulting from the seedlings distribution program. Nevertheless, the main implication of these figures is that efforts to increase fuelwood supply and to reduce its demand through conservation should continue to receive high priority in the energy sector.

TABLE 2.2

Fuelwood Consumption Projections
(Million Cubic Meters, Solid)

Sector	Year 1980	1985	1990
Households a/	5.1	5.8	6.0
Other Industry b/	0.4	0.5	0.5
Tobacco - no efficiency improvement c/	4.8	5.2	5.6
Total - Scenario I	10.3	11.5	12.1
Tobacco - Improved Efficiency in flue-cured d/	4.8	4.2	3.4
Total Scenario II	10.3	10.5	9.9

Notes:

a/ Based on assumptions that (a) households dependent on fuelwood decline from 95% in 1977 to 85% in 2010, (b) initial per capita consumption of fuelwood of 0.85 m3 declines to 0.65 m^3 by year 2000.

b/ Based on annual average growth rates of 2.5% and 4% for tea manufacture and brickburning respectively.

c/ Based on (a) constant flue-cured tobacco growth rate of 2.2% p.a., (b) 0.5% for fire-cured tobacco up to 1985 and no growth thereafter, and (c) dry tobacco leaf/wood ratios of 1 kg:0.093 m^3. and 1 kg:0.136 m^3 for fire-cured and flue-cured respectively.

d/ As for (c) but assuming 25% reduction in wood use for flue-cured tobacco in 1985 and 50% reduction in 1990.

Source: Wood Energy Project SAR 1980; Staff estimates.

CHAPTER III

PETROLEUM

Overview

3.01 Malawi's petroleum requirements are currently met through the direct import of refined petroleum products. Although these imports are small in absolute terms - about 150,000 toe in 1980 - they are a source of concern to the country partly because of their rising cost but also because interruptions in their supply through neighbouring Mozambique have repeatedly caused disruption to the economy. Although there has been virtually no growth in petroleum consumption in recent years, the oil import bill has more than doubled since 1977 to an estimated $56 million in 1980 and accounts for 22% of the country's export earnings. To this must be added the economic costs of periodic supply interruptions which are more difficult to quantify but likely to be substantial. For example, a recent analysis of the 1979 supply disruption estimates the cost to the economy, in terms of delays in the implementation of important development projects and associated claims by Contractors, was of the order of K6.5 million, about 2.5 times the direct costs incurred by the Government in organizing an airlift of essential products to restore full supply. The more recent (September 1981) gasoline shortage brought the country's private transport fleet to a virtual standstill and resulted in a diversion of considerable productive time and effort to obtaining scarce fuel.

3.02 Given these factors, the overriding concern in the petroleum sector is to develop a more reliable system of supply. The options for achieving this are still under study but they are likely to include: holding a small amount of strategic reserve, diversifying sources of supply, streamlining the existing supply operation and developing a contingency allocation plan for use in the event of a shortage. A strengthened institutional framework and improved coordination among the various agencies involved in petroleum supply are essential prerequisites for effectively addressing this issue.

Supply and Consumption

3.03 The consumption of petroleum products has grown very slowly over the past five years (about 1.4% per year on average) as consumers responded to rising prices and supply uncertainties by shifting to alternative fuels where these were available. The most dramatic shift has taken place in the household sector which is the main user of kerosene, a product whose recorded consumption has fallen from 13,500 toe in 1975 to 6,200 toe in 1980. Although this may overstate the decline to some extent because of a small amount of unrecorded consumption near the borders with Tanzania and Zambia (where kerosene is less expensive than in Malawi) it still demonstrates the clear response of users to a five fold increase in retail prices. Jet fuel consumption also dropped sharply in 1979-80 as a result of a scaling down of Air Malawi's international operations whose profitability had been adversely affected by rising fuel costs and other factors. The two products which showed positive rates of growth over the 1975-80 period were diesel and gasoline and together they now account for 85% of the total sales volume. This growth is attributable both to the strong performance of the sectors in which these products are used - construction, industry, transport - as well as the absence of suitable substitute fuels for these activities.

TABLE 3.1

Petroleum Product Consumption

Product	Consumption Thousand toe 1975	1980	Average Annual Growth Rate (Percentage)
Gasoline	39.1	43.0	1.9
Diesel	62.8	82.7	5.7
Kerosene	13.5	6.2	- 14.4
Jet Fuel	19.6	12.8	- 8.2
Others	4.6	4.0	- 2.8
Total	139.6	148.7	1.3

Source: National Statistical Office, GOM.

3.04 Petroleum product supply is organized through four oil companies with little direct Government involvement. The largest of these is the Oil Company of Malawi Ltd. (OILCOM) which is 80% owned by Press Holdings of Malawi and has the minority participation of BP and Shell. OILCOM has a 61.5% share of the market and acts as an informal industry spokesman for the three other marketing companies, Mobil (market share 18.8 %), Caltex (11.6 %) and Total/Lonrho (8.1 %). These companies import refined products through their affiliated international network. The products are generally brought in via the Ports of Beira and Nacala in Mozambique from where they are shipped by rail to Blantyre and the other consumption centers.

3.05 The system does not always work smoothly. Over the past three years derailments and collisions (in Malawi as well as Mozambique) have caused numerous delays lasting from one to seven days while insurgent activities in Mozambique in 1979 closed the Beira rail line for about three weeks on two occasions. More recently, the mission's arrival in Malawi coincided with a serious nationwide gasoline shortage which persisted for over a week and was only alleviated through the purchase of emergency supplies from Zambia at a landed cost (at Blantyre) of US$2.60

per gallon, which is nearly twice the price paid under normal circumstances for gasoline imports through Mozambique. In this particular instance the shortage had been caused by a combination of procurement delays on the part of one oil company and the borrowing of another company's stocks at Beira by the Mozambique National Petroleum Company. But, as noted above, periodic petroleum supply interruptions are not a new phenomenon for Malawi and their more usual cause has been transport bottlenecks in Mozambique. These in turn have stemmed from both operational problems at the ports and on the railways and from the poor physical condition of the railway lines from Beira and Nacala to Malawi. Recent developments suggest that there has been some improvement in regard to the first of these problems but the second more intractable issue - the poor condition of the physical infrastructure - is likely to remain a major constraint to the smooth inflow of petroleum and other imports into Malawi.

3.06 These external difficulties have been compounded by institutional weaknesses within the country which have added to the inefficiency of the existing supply mechanism. There are two principal issues which need to be resolved. First, the relationship between the oil companies and Malawi Railways is unsatisfactory and the level of their day-to-day coordination is poor. This situation needs to be changed urgently. Second, and this is to a large extent the root of the problem, there is no one in Malawi who is charged with the responsibility of ensuring an uninterrupted flow of petroleum supplies into the country. The oil companies periodically send statistics on the level of inland stocks to the Contingency Planning Unit in OPC, but there is no evidence that these figures are used for planning purposes. Nor is there any mechanism in place which would alert the three main actors -- the oil companies, the Railways and the Government - to a potential crisis in the event that product stocks fall to a dangerously low level. Finally, there are no predetermined or widely agreed criteria which would govern the distribution of scarce fuels in the event of a shortage.

3.07 To improve this situation, the mission recommends that the following measures be undertaken as a matter of priority:

(a) A formal "alert" mechanism needs to be formulated which would be triggered whenever the combined stocks of any product at the port or in the country fell below a certain pre-specified level. OILCOM, the national oil company, which controls 60% of the market, and already acts as an informal industry spokesman, could be charged with the responsibility of administering this mechanism and informing the other members of the standing committee (see below) as soon as the mechanism is triggered.

(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.

(c) A detailed contingency allocation plan should be drawn up to distribute available stocks of petroleum products in the event of a shortage. This plan should define the needs and priorities of various petroleum users and develop alternative allocation criteria for various lengths and severities of disruptions and should be updated periodically.

3.08 The above measures should lead to a substantial improvement and streamlining of the existing supply operation but they are unlikely to shield Malawi completely from the effects of frequent or prolonged interruptions in petroleum supply. To examine the various options for tackling this broader problem the Government commissioned, with European Economic Community assistance, a comprehensive consultant study of the subject.1/ This study provides a detailed analysis of the existing supply mechanism and evaluates the cost effectiveness of a variety of solutions in meeting supply shortfalls of varying frequency and duration. Its general approach to analyzing the problem is a sensible one and it makes a valuable contribution to the study of this important subject. However, there are a number of questions and uncertainties which the report does not adequately address and which need to be resolved before operational investment decisions can be undertaken.

3.09 The alternative solutions considered by the study fall into three broad groups:

(i) nine land transport solutions using the ports of Dar-es-Salaam and Lindi in Tanzania and the refineries at Ndola (Zambia) and Umtali (Zimbabwe) as alternative supply sources to the existing routes from Beira and Nacala. Pre and post 1985 time frames are considered separately since only two of the solutions, land transport from Ndola and land transport from Dar, are available before 1985.

(ii) three levels of strategic storage reserves (30, 60 and 90 days) within the country; and,

(iii) an airlift of essential products in the event of a shortage.

3.10 The consultants rightly point out that the optimal solution or combination of solutions will meet two criteria. First it will reduce the risk of a fuel shortage more than any other solution for a given cost - i.e., it will be cost-effective. And second, the marginal cost of the solution will be equal to the marginal value of the reduction in risk - i.e., it will result in an optimal amount of (rather than zero) risk.

1/ Kocks Consult Gmbh, "Feasibility Study of Fuel Storage" Final Report, February 1982.

They also show that the effectiveness of the various solutions depends on the type and frequency of interruption expected. In other words, if the probability of an interruption occurring is very low then the costs of holding permanent stockpiles to meet that event are going to be proportionately higher and it might be cheaper to resort to more expensive alternative sources of supply, including an airlift, to meet a shortage when it occurs. Conversely, frequent interruptions in supply might be best met by building up and drawing down strategic reserves rather than by resorting to more expensive alternative sources each time the interruption occurred. Thus, it is important to be clear at the outset on what type of supply interruption these measures are intended to counteract.

3.11 The consultants have examined various types of supply disruptions - ranging from a severe global oil shortage to derailments on the railway lines in Mozambique and attached some probabilities to the likelihood of their occurrence. While these probabilities are obviously subjective to some extent, the consultants' analysis does show that for the type of disruptions that have been the most frequent cause of concern to Malawi in the recent past, i.e., those relating to operational, technical and political factors affecting the transit of goods through Mozambique, the alternative source of supply solutions are generally much cheaper than the solutions involving the building up of strategic reserves. In the short run, the only viable alternative source of supply is from the Ndola refinery although even this results in a much higher delivered cost than using the existing routes through Mozambique as long as they are operational. Nevertheless it is a valid point - and one reinforced by recent experience - that it is much easier to expand the supply from an alternative source with which one has a permanent, although small supply relationship than to try to develop such a relationship when there is a crisis. Thus, the mission supports the consultants' recommendation that the Government enter into a small supply contract with the Ndola refinery and acquire a small reserve fleet of road tankers to be used in an emergency to bring in additional supplies of fuel from Ndola. In the longer run (i.e., beyond 1986) the consultants recommend the use of a new highway route from the Tanzanian port of Lindi to Mbamba Bay on Lake Malawi as a first alternative to be supplemented by Ndola and Umtali if the latter refinery is reactivated. Again this appears to be a reasonable solution but it is of less immediate operational relevance because it depends, inter alia, on considerable investment in the development of the Lindi port and route by the Government of Tanzania 1/, the decision on the reactivation of the Umtali refinery by the Government of Zimbabwe and on developments in Mozambique over the next five years.

3.12 While the basis for the consultants' recommendation on diversifying supply sources is clearly spelt out in the study, the rationale

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1/ Investment costs for the port and highway with storage and transfer facilities at Mbamba Bay are estimated at K 166 million (1981 prices).

for their other main recommendation, to build a six-week strategic storage reserve at the same time, is more difficult to follow. As they point out, some element of judgement will be required to decide on the precise level of strategic reserves that is justified. Nevertheless, from the analysis in the report it is difficult to see why a six weeks supply is considered optimal and whether this figure is justified if alternative supply routes are developed and efforts made to streamline the existing supply operation (as recommended in para. 3.07) and to ensure that the existing commercial storage capacity in the country, about 26 days supply, is kept filled on a more regular basis than in the past. Developing such a reserve would entail, heavy investment and operating costs. The investment cost of the new facilities would be about K10 million, including filling costs, while annual operating costs are estimated to be K310,180.1/ In addition there is the practical problem of filling the tanks via the existing supply routes through Mozambique which can barely carry enough petroleum to meet the existing level of consumption. Utilizing more expensive alternative supply routes to fill these reserves would, of course, entail a higher cost.

3.13 Before taking a decision or developing a national strategic reserve, the Government should ensure that the substantial investment is justified. It is possible that the measures to improve the existing supply system (para. 3.07) would be sufficient to resolve the supply problems with a minimum of investment by the Government.

Pricing and Costs

3.14 Petroleum pricing is not an issue in Malawi because the Government has traditionally followed a realistic and sensible policy with regard to the pricing of these products. The retail prices for all petroleum products are in excess of their CIF cost and increases in this cost have generally been passed on fairly promptly to final consumers. Interproduct price relationships do not appear to be distorted, with gasoil prices being much closer (90%) to gasoline prices than is the case in many other developing countries.

1/ Operating costs include manpower, management, administration, maintenance, spare parts, consumables, energy, and communications.

TABLE 3.2

Retail Prices of Petroleum Products, September 1981

Product	Retail Price US$/US Gal	% Increase Since June 1973 a/	Comparative Prices Zambia (Nov. 1981)	Sri Lanka (June 1981)	Kenya (Feb. 1981)
Premium Petrol	3.17	598	4.31	1.97	2.87
Diesel Oil	2.90	769	2.23	1.25	1.84
Kerosene	2.19	630	1.54	0.82	1.30
Furnace Fuel b/	2.63	n.a.	-	-	1.09 c/

a/ Increase in bulk prices at Blantyre (local currency)

b/ A light product containing as much as 97% gasoil.

c/ Industrial diesel.

Source: GOM, OILCOM, staff estimates.

3.15 While the level and structure of retail prices appears satisfactory, a number of improvements can be made at the intermediate stage. First, the current pricing mechanism acts as a disincentive for the oil companies to build up their stock levels. This is because the price they are allowed to charge is revised only when a new shipment comes in and existing stocks are not revalued. Furthermore, their own margin is fixed as a percentage of this landed cost and there is no explicit allowance for any finance charges that they incur in holding stocks for any length of time. The second anomaly that needs to be rectified is the so-called "kerosene subsidy" which is an administrative legacy from the past and serves no purpose. The Government currently imposes a tax of 17.7 Tambala on each litre of kerosene but it also provides, separately, a subsidy of 5.2 T per litre on kerosene sales which is in turn offset by an additional tax of 0.2 T per litre on gasoline and diesel. The same result could be achieved much more simply and at lower administrative cost by reducing the tax on kerosene to 12.5 T per litre and raising the tax on the other products by 0.2 T per litre.

TABLE 3.3

Structure of Petroleum Product Prices, 1981
(USç/litre)

Product	Landed Cost Blantyre	Import Duty and Surtax	Marketing and Distribution Cost	Retail Price
Premium Petrol	37.2	37.4	9.1	83.7
Diesel Oil	35.3	32.9	8.3	76.5
Kerosene	36.8	18.9	2.2	57.9
Furnace Fuel a/	34.6	29.2	5.8	69.6

a/ This is a light product containing as much as 97% gasoil.

Source: GOM, Oilcom

3.16 Finally, there has been some concern in the past regarding the high CIF price of petroleum products in Malawi. There is indeed some evidence to suggest that between 1979 and 1981, Malawi was paying too much for its oil because OILCOM continued to get its supply -- which is 60% of the market -- from BP and Shell at an average price which was around 15% higher than the cost of supplies for the other oil companies trading in the country. However, this problem has recently been resolved after negotiations between OILCOM and BP/Shell and its product costs are now in line with the others. Malawi will still have to pay a price for its inland location but contrary to previous impressions , this price does not seem to be excessive. In September 1981, the average landed cost of the reconstituted barrel 1/ at Blantyre was $57.42 of which $8.0 was attributable to transport, handling and other miscellaneous charges incurred at the port and for inland transportation.

3.17 In view of the above discussion, the mission recommends the following measures:

(a) The Government should reexamine with the oil companies the financial disincentives embedded in the current procedure for the treatment of their inland stock. This could be done through the introduction of an explicit clause reimbursing their stock finance charges or through allowing more frequent revaluations of stocks held in the country.

1/ It is important to bear in mind the fact that the consumption pattern in Malawi is heavily biased towards lights products as shown in Table 3.1 above.

(b) The "kerosene subsidy" scheme should be abolished and the regular taxes on kerosene and the other products adjusted to provide the same net effect at a lower administrative cost.

(c) The Government should begin to actively monitor the CIF costs reported by the various oil companies to ensure that in future, anomalies -- like the one affecting OILCOM's cost of supply for two years -- are addressed without undue delay. A corollary of this is that the Government should now begin to obtain some independent information on international product price trends so it can evaluate more knowledgeably the submissions made by the oil companies.

3.18 The follow-up mission learned that the Ministry of Trade and Industry is introducing legislation requiring the companies to hold certain minimum levels of stock in Malawi and, in the process, it is evaluating different financial incentives. The administrative mechanism for taxing kerosene is also being revised.

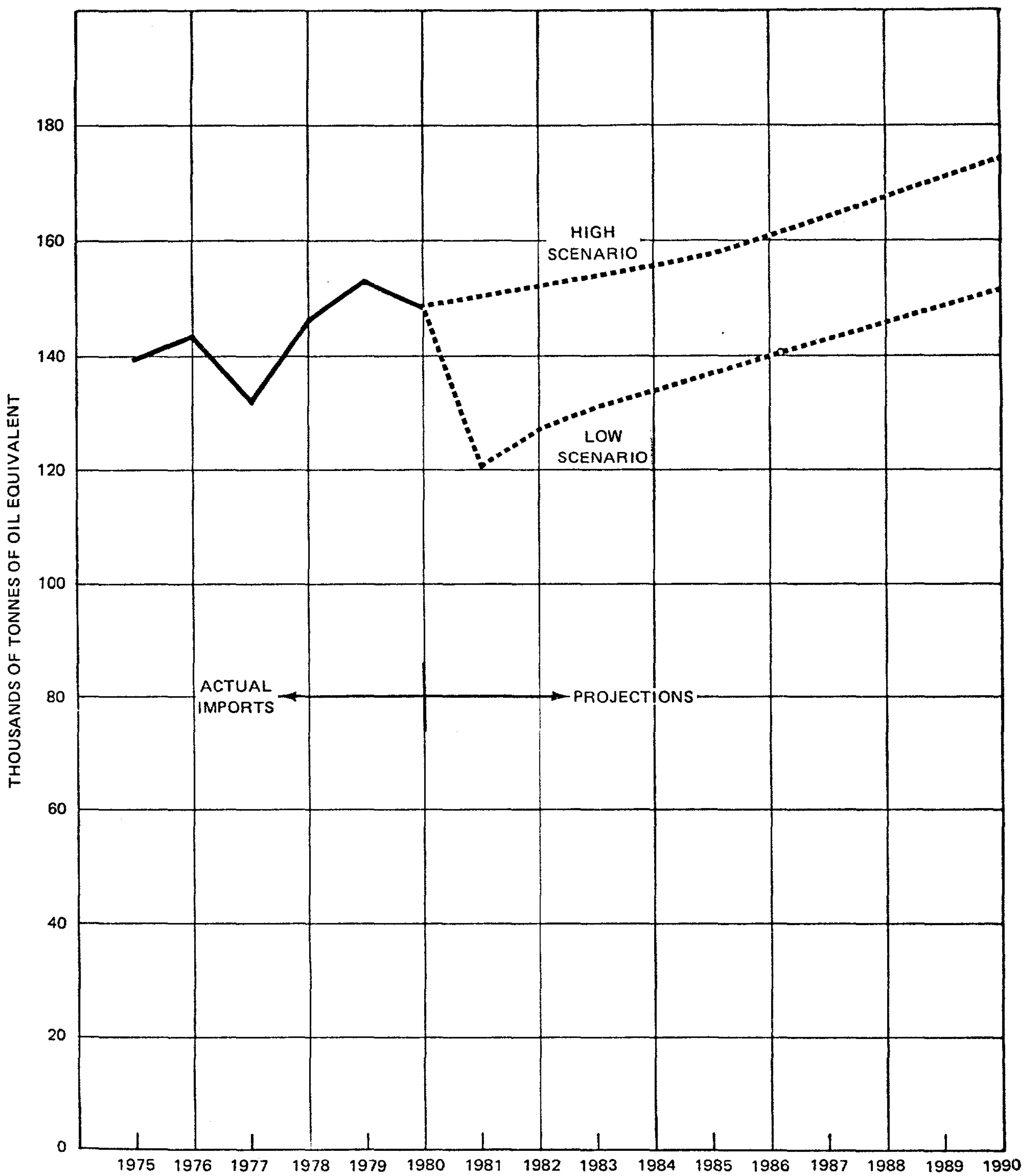
Future Demand

3.19 Precise projections of petroleum demand are difficult to make for the same reasons that make it difficult to establish clear historical trends, i.e., the historical data base and the sectoral consumption pattern are not well established, the total volumes involved are small and vary significantly from year to year as a result of the changing requirements of a few users, and the future prospects for economic growth and international energy prices and their impact on consumption are uncertain. Nevertheless, despite these uncertainties, it is reasonable to postulate that the consumption of petroleum is unlikely to grow rapidly during the coming decade. Indeed OILCOM, the major supplier, estimates that total product offtakes in 1985 will be slightly lower than in 1980. It expects an overall 16% decrease in sales from 1980 to 1981 with a 7% recovery in 1982 and then 3% annual growth until 1985. The sharp drop in 1981 sales is attributed to the impact of higher retail prices and the completion of several construction projects which were large consumers of diesel. These expectations are broadly consistent with the views of the other oil companies and take into acccount the effects of ethanol production (at the rate of 4.8 million litres per year from 1982) on gasoline sales.1/ If further account is taken of the possible substitution of coal for gasoil in a few small and medium sized industrial users, the demand for that product could drop by another one million litres (890 toe) each year between 1982 and 1985.2/ The total

1/ The ethanol project has been recently redesigned and production of ethanol will be 7.5 million litres for the first four years and 6.0 million litres thereafter. See paras. 6.03-04.

2/ See para. 5.08 for a discussion of this question.

FIGURE 3.1: DEMAND FOR PETROLEUM PRODUCTS IN MALAWI



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demand for petroleum products in 1985 would then be 137,000 toe. Annual growth of 2% from 1985 to 1990 would give a total demand of 152,000 toe in 1990.

3.20 This projection may prove somewhat conservative if international energy prices do not rise as rapidly in the next five years as they have done in the preceding quinquennial, or if the Government's economic recovery program results in an early return to vigorous economic growth. The mission has therefore also prepared an alternative forecast, referred to as the "high case", which assumes that petroleum demand will grow at an average rate of 1.2% per year between 1980 and 1985 and 2% a year for 1985-90. This forecast also assumes that there will be no additional substitution of coal for gasoil in the industrial sector. Under this scenario, total petroleum consumption would be 158,000 toe in 1985 and 174,000 toe in 1990. The important issue here is not so much whether the high or the low scenario more accurately predicts the actual consumption of petroleum in the future, but rather to use these projections in determining the plausible range of the future oil import bill and its sensitivity to alternative assumptions about consumption growth. As illustrated in Figure 3.1, the two scenarios are in fact quite close together and the projected oil import bill does not change substantially under either scenario. This is discussed further in Chapter VII.

Prospects for Indigenous Supply

3.21 Malawi's oil and natural gas potential has traditionally been considered to be poor. However, two recent developments suggest that there may be some grounds for optimism, although it is still too early to judge. First, in 1981 a team from Duke University in the United States carried out a seaborne seismic survey of parts of Lake Malawi which indicated that the sediments under the lake were at least 2 kilometres thick and contained structures which could possibly contain natural gas or oil deposits. The results of this work are not yet available and its main objective was not hydrocarbon exploration, so the importance and reliability of this information should not be exaggerated at this time. The second development is the interest shown by Shell Oil in doing geophysical work in the lower Shire Valley and on parts of the lake. Shell performed some work in late 1981 and intends to continue in 1982 but little information is available at this stage.

3.22 These are encouraging signs but at this early stage they warrant cautious treatment. Even if limited hydrocarbon deposits are proven, their commercial development would entail substantial practical difficulties and high costs because of the landlocked nature of the country and the depth of Lake Malawi. And in any event they would not directly affect the energy supply situation during this decade.

3.23 The mission fully endorses the sensible wait-and-see attitude of the Government. The situation should be re-evaluated when the results of both the Duke University survey and the proposed Shell exercise are available. If these are positive, the Government may require assistance in developing an appropriate hydrocarbon exploration strategy which the Bank or other donors could help to provide.

CHAPTER IV

ELECTRICITY

Introduction

4.01 Hydropower is Malawi's most important commercial energy resource. The potential of the Middle Shire River, on which all of the existing hydro capacity is located and which is the only river to have been evaluated for hydro potential in any detail, is estimated at 500 MW with an annual energy production capability of 3500 GWh. This compares with current installed hydro capacity and energy generation of 124 MW and 412 GWh respectively. In addition to the Middle Shire, a number of other rivers in the country also have substantial hydro potential but these have not been investigated in any detail. Carrying out a comprehensive hydro site identification and ranking study is a priority task in the electricity sector.

Institutions

4.02 The Electricity Supply Commission of Malawi (ESCOM), created under the Electricity Act (1963), is the sole distribution company for electricity in Malawi. Until 1980 ESCOM's board reported directly to the Ministry of Trade, Industry and Tourism, but now, like all statutory organizations, it reports to the newly established Department of Statutory Bodies (DSB) in the Office of the President and Cabinet. DSB's main function to date has been monitoring and financial control of parastatal finances. DSB also approves all senior level appointments and in time hopes to provide policy guidance and support.

4.03 ESCOM has enjoyed the reputation of being a well managed utility and this reputation is generally well deserved. Improvements continue to be made in management. Measures have recently been taken to clarify senior management responsibilities and a determined effort is now being made to fill the post of Chief Engineer. In this context, the company has recently promoted two Malawian engineers to Deputy Chief Engineer positions. To complement these efforts ESCOM should check the rapid increase in the overall staff of the utility which has risen by 50% in the last five years, while total generation has grown by less than 40%.

Existing Facilities

4.04 The bulk of the country's electricity is supplied via an interconnected system based on 125 MW of hydrocapacity, a 15 MW gas turbine and 6 MW of diesel generators. The hydro units provide almost all of the energy (99% in 1981) with the thermal plants being kept for standby use only. In the Northern Region, an additional 1.9 MW of diesel plant is used to provide electricity to the townships of Karonga, Kasungu and

Mzuzu which lie outside the interconnected distribution system.1/ ESCOM's maintenance practices for its generation and transmission facilities are satisfactory and the overall level of system losses (around 10%) is reasonable.

4.05 In addition to ESCOM's facilities, there are an estimated 24 MW of private generating plant located on the tea, sugar and tobacco estates, religious missions and Government buildings. About half of this capacity is based on bagasse (in the sugar industry). The rest is diesel based with the exception of one or two minihydro plants. Although only limited investigations have been done, it appears likely that additional mini hydro sites could be developed to replace isolated diesel generation. This question is discussed further in paras. 6.05-06 below. A complete list of ESCOM's generating plant and of the known private plants is included in Annex 4.

4.06 There is no large scale program of rural electrification in Malawi. Under the district center electrification program ESCOM provides service to Government offices and buildings such as schools, hospitals and clinics in selected rural growth centers but so far only a dozen or so areas have been covered by this program. Over the 1981-85 period ESCOM plans to spend an average of K1.8 million per year (about 7% of proposed energy sector investment) on the development of rural electrification. This should be feasible within its overall level of operation.

Consumption

4.07 Per capita electricity consumption in Malawi - 64 kWh/yr in 1980 - is one of the lowest in the world and ESCOM has less than 20,000 domestic consumers. However, both the number of consumers and total electricity consumption have been rising rapidly in recent years and, provided that the Government's program of economic recovery is successful, this strong growth is expected to continue in the 1980's. Since 1975, total electricity sales have grown at an average annual rate of 7.8% with sales to the household and commercial sectors growing at a slightly higher rate. For 1981-85 total sales are projected to continue growing at about the same rate - 7.3% p.a. - and the domestic and commercial sectors are expected to increase their share in the total but not in any dramatic way. Because of the predominant share of the industrial sector in electricity demand, it is important to emphasize the sensitivity of these projections to changes in the overall economic climate. The mission has assumed that the Government's program of economic stabilization will not entail any serious dislocations and will produce early results. Projections of electricity demand beyond 1985 are subject to even more uncertainties and the growth rate used by the mission - an average of 6 percent per annum - should be viewed as indicative only.

1/ The interconnection to Mzuzu was completed in June 1982.

4.08 These projections of electricity demand also depend critically on the final decision taken by the Government on a proposed fertilizer project whose estimated annual electricity consumption of 375 GWh - equal to total electricity consumption in the country now - has not been included in the figures in Table 4.1. This is because, although the project has been under study for some years, there still remain a number of uncertainties which cast serious doubt on the project's technical and economic viability.

4.09 As initially envisaged, the project's attractiveness rested on its ability to use primarily cheap off-peak electricity by employing a relatively uncommon electrolytic process which would theoretically permit substantial variations in the daily demand for power from the plant. The initial project study had envisaged an off-peak demand for the project of 60 MW which would be reduced to about 7 MW during the on-peak periods. However, more recent studies have shown that such large variations in daily demand are both technologically inadvisable and difficult to achieve in practice and it is considered much more likely that the project would use between 60 and 80% of its power requirements during the peak period. On this basis, the average economic cost of electricity supplied to the project will be about 3.5-4.0 cents/kWh which is nearly three times the cost of power the project could pay and still be economically viable.

TABLE 4.1

Sectoral Electricity Demand 1975-90

					Annual Average Growth Rate		
	---- Percentage Share----				----------Percent----------		
Sector	1975	1981	1985	1990	1975-81	1981-85	1985-90
Industry	73.8	71.9	69.6	69.5	6.9	6.3	6.0
Domestic	16.5	17.4	19.8	19.9	8.4	10.2	6.0
Commercial	9.7	10.4	10.6	10.6	8.6	7.4	6.0
Total	100.0	100.0	100.0	100.0			
GWh	236	370	491	656	7.8	7.3	6.0

Notes: (a) Sales from isolated undertakings considered to be in same proportion as those from interconnected system.
(b) Excludes the operation of about 24 MW of private generating industry.
(c) Projections do not include the demand from a proposed fertilizer project (see text).

Source: ESCOM. See Annex 4 for details.

4.10 Given these factors, it is now highly unlikely that this project will be developed in the foreseeable future. Therefore, the future electricity demand projections and illustrative energy balances prepared by the mission exclude the potential demand from the proposed fertilizer project.

Demand Management and Pricing

4.11 Electricity tariffs are set by ESCOM with Government approval. All proposals for tariff increases are reviewed by the DSB and the Ministry of Trade and Industry in consultation with other concerned Departments. The future allocation of responsibility for electricity pricing policy between DSB and the Ministry of Trade and Industry is still unclear and will in a large part be determined by the Government's decisions on the staffing and functions of a central energy planning and policy unit.1/

4.12 The structure of tariffs has remained largely unchanged for several years although annual surcharges have been levied to meet increased operating costs and ESCOM's financial performance has consequently been generally satisfactory. In 1981, ESCOM submitted a proposal to restructure tariffs and this has been approved by the Government to come into effect at the beginning of 1982. The proposed new tariffs are a significant improvement on the previous ones, particularly in their treatment of industrial consumers for whom a complex rate structure has been partially rationalized. However, a number of anomalies remain. The first problem stems from the division of domestic consumers into "high density" and "low density" areas - supposed to act as proxies for low income and high income neighbourhoods respectively - which determines the particular tariff on which they are charged (see Table 4.2). The problem with this system is that households with the same monthly consumption level have different electricity bills simply because they choose to live in different areas. Second, there is no clear rationale for retaining a declining block charge for units consumed in three of the four tariff categories. Finally, there is the question of the effectiveness of the high density tariff in achieving its prime objective of providing a limited amount of electricity at low cost to the poorer consumers. No detailed statistics are available but a limited market survey done by ESCOM suggests that more than a third of the high density consumers have a monthly consumption level between 0-20 kWh. Because of the fixed minimum charge of K 0.75/mo., many of these poorest consumers could actually be paying a higher average price for their electricity than those that are better off.

4.13 The high initial connection charge of K80 ($86) is also a deterrent to electricity use by low income families who do not live in areas where this charge is paid by the housing developer. ESCOM should examine whether there are viable options for increasing household access

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1/ See also paras. 7.16-7.20.

to electricity by, for example, amortizing the connection charge over a number of monthly payments. It is also worth exploring whether less conventional electricity connection and distribution mechanisms could be employed to bring the benefits of this resource to a wider segment of the population. Given that Malawi's electricity supply system is essentially run-of-the-river hydro based and that planned system growth is to meet capacity rather than energy constraints, the marginal costs of supplying kilowatt-hours are negligible. Thus, it may be useful to examine whether connection and metering charges could be reduced by replacing conventional electricity meters for poorer households with a simple connection with, for example, a current limiter which would enable them to use one light bulb and a small domestic appliance but which would trip if the load exceeded the prescribed limit. The fixed monthly charge would be based on the capacity of the current limiter and not on the consumption of kilowatt-hours. There is always a risk of power theft under this kind of system where there is no regular meter reading but this could be reduced by trying the system on a neighbourhood basis and by making it clear that the continuation of this experimental exercise depended on compliance by all households in the neighbourhood with the rules of the system.

TABLE 4.2

Domestic Consumers Electricity Tariff
(Effective April 1982)

Low density:	Minimum charge:	K 5.00 per month.
	Unit charge:	0-225 kWh/mo.@ 7.8 T/kWh
		more than 225 kWh/mo. @ 5.7 T/kWh
High density:	Minimum charge:	K 1.00 per month.
	Unit charge:	0-150 kWh/mo.@ 5.0 T/kWh
		more than 150 kWh/mo. @ 7.5 T/kWh

Source: ESCOM. Full details of the proposed tariffs are included in Annex 4, Table 13.

4.14 The next round of tariff revisions, planned for the end of 1982, should examine these questions. However, it is important that this examination take place within the context of up-to-date estimates of the structure and level of the marginal costs of electric power supply in Malawi. A similar study of marginal costs in the power sector was undertaken in 1977 and would provide a useful basis for this work but the shortage of staff, in both the Government and ESCOM, trained in the field of energy pricing implies that some technical assistance will be needed to carry out this task.

4.15 The proposed tariff study should also consider whether any measures can be taken to reduce the daily peak demand for electricity by providing incentives to consumers to shift to the off peak period. This would have the effect of postponing the installation of new generating capacity. While the existing daily load curve is affected by seasonal changes in the operating regimes of two large consumers (the Blantyre Water Works and the SUCOMA Sugar Estates), one constant feature is a pronounced valley of between 10 MW and 25 MW from eleven p.m. to six a.m. ESCOM has been successful in persuading SUCOMA, through a special tariff agreement, to keep its load off-peak as far as possible but a similar arrangement has not been worked out for the Blantyre Water Works which maintains that little change is possible in the operating regime for its substantial pumping load. It is not clear, however, that there is no possibility at all for altering the Blantyre Water Works' demand pattern and, given the importance of this consumer in affecting total demand, this matter needs to be clarified.

4.16 More could also be done to persuade other industrial and commercial users to reduce their consumption during the peak afternoon period by offering them special time of day tariffs. In the household sector, the potential for shifting the daily demand pattern is more limited but one option which should be explored is the use of storage type water heaters which would operate primarily during the night and for which separate metering on a special tariff could be offered to the 8-9,000 households which currently use electricity for water heating. Because of lead times, these options need to be explored soon even though the recent commissioning of the Nkula B units means that the reduction of peak demand will not have any immediate benefits.

Supply and Development Program

4.17 With the commissioning of the second stage of the Nkula scheme in 1981, there is now a comfortable balance between electricity supply and demand and no new generating plant will be required until 1985. At that time the fourth 20 MW unit will need to be installed at Nkula followed by the fifth and last unit in 1986-87.

TABLE 4.3

Interconnected System Electricity Supply 1975-90

	1975	1981	1985	1990
Installed Capacity (MW)	69.2	144	164	184
Hydro (MW) a/	40.0	124	144	164
Thermal (MW)	29.2	20	20	20
Firm Capacity (MW) b/	43.0	94	114	144
Maximum Demand (MW) c/	48.2	72	111	142
Generation: (GWh)	262.7	413	546	729
Hydro (GWh)	256.0	412	545	728
Thermal (GWh) d/	6.7	1	1	1

Notes: a/ Fourth and fifth 20 MW units at Nkula added in 1985 and 1987.

b/ Firm Capacity excludes thermal plant and one hydro unit up to 1984; two hydro units beyond 1984.

c/ Maximum demand and generation growth is without the fertilizer load as discussed above.

d/ Excludes a small amount of thermal generation in isolated systems which equals 1.7 GWh in 1975, 15.5 GWh in 1981, 24.3 GWh in 1985 and 32.0 GWh in 1990. Some of this may be replaced by hydro generation as these systems are connected to main grid.

4.18 Beyond Nkula, the current power generation development program is based entirely on continued development of the Middle Shire River and the next identified project in this program is the Kapachira scheme, which would have an ultimate capacity of 120 MW. Preliminary estimates indicate that the capital costs of the scheme would be about K 120-130 million to cover the civil works for the entire project and the installation of the first two 30 MW units. This would result in a unit cost of electricity from the scheme of about 5.0 USç per kWh.1/ On the basis of these estmates, Kapachira appears to be a sensible choice for the next generation project. However two points should be considered in planning for capacity expansion in the 1990's. First, the choice of future projects should be made from the whole range of potential hydro pojects in Malawi and not just those located on the Middle Shire river, wich is the only area to have been investigated systematically to date. Diversification of the hydro system away from the Middle Shire would also allay the concerns about security of supply which stem from the fact that there was no flow in the Shire River between 1915 and 1935 due to a fall in the level of the lake. While the possibility of this happening now is lower due to regulation at the Liwonde Barrage, the probability of a significant reduction in flow cannot be entirely ruled out and has been quoted as one in eighty years. Diversification is also a feasible policy in a country like Malawi which possesses a number of rivers with hydropower potential. However, it is important that this potential be better defined through a systematic and comprehensive study to identify and rank all the potential major hydro sites. ESCOM should obtain input from the Department of Lands, Valuation and Water which is currently preparing, with UNDP assistance, the first phase of a master plan for Malawi's water resources. This information would also provide some basis for evaluating mini-hydro schemes (see para. 6.05-06).

4.19 The second point that should not be ignored is the possibility of importing power from neighbouring countries which have large and low cost hydro reserves. An example is the Cabora Bassa scheme in neighbouring Mozambique which could be tied into the Malawi grid through a 220 km transmission line from Tete to Blantyre at a cost of about K 35 million (1981 prices).2/ The Mozambique Government has plans to develop an additional 2000 MW of capacity at Cabora Bassa and has had preliminary discussions on interties with the Governments of Malawi, Zimbabwe and South Africa. There are other possibilities for regional power projects which could be explored and which might well form part of Malawi's least cost power development program for the 1990's.

1/ Assuming 40 year plant life; 12% discount rate; annual operating and administration costs of 1% of capital cost; and an annual generation of 340 GWh from the scheme.

2/ Cost for two single circuit 220 kV lines erected on lattice steel towers with substations at both ends.

CHAPTER V

COAL

Supply and Consumption

5.01 Malawi currently imports about 45-55,000 tonnes of coal per year primarily from Mozambique and South Africa but also in small quantities from Zimbabwe and Zambia. Ninety percent of this coal is used as industrial fuel with two firms (Portland Cement and David Whitehead Textiles) accounting for over half of total consumption and about twenty smaller industrial and commercial users accounting for the rest. Almost all of these users are located in and around Blantyre in the Southern Region. Because of the small number of users, the low volume of coal demand and data discrepancies, the annual consumption figure can vary considerably from year to year and historical trends are difficult to establish. Stock changes and variations in coal quality are also important factors underlying annual variations in reported consumption data. For example, between 1979 and 1980 there was a reported drop in coal consumption from 57,600 tonnes to 46,600 tonnes which can be partly explained by reduced output at the cement plant but still conflicts with coal import statistics which show an increase from 34,000 tonnes in 1979 to 74,000 tonnes in 1980.1/ Given these data problems, the consumption figures for these two years in particular and the consequent apparent reduction in coal consumption between 1975-80 should be viewed with some caution. However, one element which does not appear to be temporary is the 4,000 ton per year drop in coal use in the tea industry since 1978. This is the result of efforts by a number of tea estates to switch, for cost and reliability reasons, to fuelwood grown on their own plantations.

5.02 In recent years coal imports have been subject to the same type of logistical difficulties that have characterized the supply of petroleum, with additional disruption in 1977 caused by the closure of the main supplier at Tete in Mozambique. However, in this case the worst effects of these problems have been alleviated by the work of the Coal Users Committee (CUC), an association of all the known users except for Portland Cement. The CUC has organized the import, distribution and allocation of coal supplies since 1977 and continues to exist even though the Tete mine has reopened. Both small and large coal users appear to be generally satisfied with the way that the Committee has been operating, although some Government agencies believe that it would be better to revert to the pre-1977 system of independent suppliers importing and selling coal to individual users. In the mission's view there is little to be gained from enforcing such a change as long as the users are happy

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1/ Adding the tonnages reported for 1979 and 1980 gives better agreement: consumption was 104,200 tonnes compared with imports of 108,100 tonnes.

with the way the system works now. Otherwise, the Government may well find itself having to devote considerable time and resources to ensuring that the independent suppliers maintained an uninterrupted flow of imports and being held responsible for any shortages that might occur. However, the effectiveness of the Committee could be improved if it employed the services of a technical person who would be better able to negotiate the quality and characteristics of coal imports with suppliers in the neighbouring countries. Currently the coal imported contains an excess amount of fines which the boilers are unable to use with the result that increased quantities are necessary for generating a given amount of heat.

TABLE 5.1

Coal Consumption by Sector
(Thousand Tonnes)

Year	Textiles	Tea	Tobacco	Cement	Other	Total Consumption
1970			not available			44.0
1975			not available			71.3
1978	11.6	6.8	6.3	20.6	9.0	54.3
1979	10.6	4.0	8.9	22.6	11.5	57.6
1980	9.3	2.5	7.1	18.4	9.3	46.6
1981a/			not available			55.8

a/ Provisional estimate based on nine month's consumption.

Source: Coal Users Committee; National Statistical Office.

Costs and Prices

5.03 The cost of imported coal varies considerably depending on source and quality. NSO data for coal imports show an average CIF cost for the first half of 1981 of K58 ($62) per tonne which is consistent with the K60 per tonne average figure obtained from the users. The Portland Cement Company purchases its coal directly from the agents for the Moatize mine in Mozambique at a delivered cost in 1981 of K49/tonne ($52) for 6300 Kcal/kg coal. The CUC (i.e., excluding Portland Cement) obtains its supplies from various sources and in 1981, its average landed cost at the border was K73/tonne. Coal is not subject to import duties or surtax.

5.04 The individual users in the CUC are charged on the basis of the quality of the coal they receive which varies considerably depending on the source of the particular shipment. The FOR cost at the border and the amount of coal received from the different sources in 1981 was as follows:

Source	K per tonne	tonnes
South Africa	80	15,454
Mozambique	65	17,353
Zimbabwe	80	2,989

The price which Portland Cement pays for Moatize coal is lower than the CUC price because it accepts lower quality, unsized coal.

Consumption Projections

5.05 Future demand for coal is likely to be affected more by the level of consumption in existing users than by the conversion of many new users to this fuel but there is considerable uncertainty on both counts. The most important existing user is the Portland Cement Company. Over the 1975-80 period cement production has varied between 85,000 and 113,000 tonnes, while total consumption has grown at 3.8% per year to 123,000 tonnes. Over the next five years the demand for cement is expected to grow at an average annual rate of around 2.5%, accelerating to an average of 4% per year for the second half of the decade as a result of faster overall economic growth. However, it is not possible to determine what proportion of this additional demand will be supplied from domestic cement production or by imports.

5.06 There are similar uncertainties for the other users. In the industrial sector attempts to increase the efficiency of fuel use will counteract higher fuel demand stemming from increased production. For example, David Whitehead Textiles, the second largest coal user, has taken measures to improve boiler and steam system efficiency but it is also planning an expansion to produce polyester/cotton fabrics. In the tea industry, coal consumption could fall further as a result of continued displacement by fuelwood but the effect is difficult to quantify. In the tobacco industry coal consumption is concentrated in a few barns which are located near the urban centers where sufficient fuelwood is difficult to obtain and which are also close enough to the railway system to make coal transport viable. No additional barns are likely to convert to coal but coal consumption in the existing barns may still grow as their output expands. Another factor which could affect the volume of coal consumption is improved coal quality. If, as recommended above, the CUC negotiates to obtain coal which is more appropriately sized for use in industrial boilers, there would be less coal wasted and a commensurate reduction in imports.

5.07 In addition to higher demand from existing users, there is some limited potential for coal conversion in the small and medium sized industrial plants in the Blantyre area which currently use diesel as boiler fuel. The amount of fuel consumed by these small industrial plants is not well known and it is difficult to quantify the potential for substitution. However, if two or three such users convert to coal each year for the next four years, this would add between 1500 and 2000 tonnes to coal demand per year up to 1985.

5.08 In view of these uncertainties, the mission has prepared a "low coal" and "high coal" scenario for 1985 and 1990, which are shown in Table 5.2 below.1/ While the difference between the two scenarios - 13,800 tonnes in 1985 and 17,800 tonnes in 1990 - is substantial in terms of the coal trade, it is important to emphasize that under both scenarios the contribution of coal to the overall energy supply mix will continue to be small.

TABLE 5.2

Coal Consumption Projections
(Thousand Tonnes)

	1985		1990	
Sector	"Low Coal"	"High Coal"	"Low Coal"	" High Coal"
Cement	21.5	23.0	25.0	28.0
Tea and Tobacco	9.6	13.0	9.6	15.1
Other	18.0	26.9	20.9	30.2
Total	49.1	62.9	55.5	73.3

Source: Mission estimates. See Annex 4 for details.

Prospects for Indigenous Supply

5.09 There are five known deposits of coal within Malawi and their development has periodically been suggested as an alternative to imports. Only the most promising of these deposits, Ngana, in the far north, has been explored sufficiently to warrant a study of mining feasibility although even this deposit has not been fully delineated. The other four deposits are in remote or geologically disturbed areas and coal quality and lack of seam continuity appear to rule out early prospects of development. The Ngana field was initially explored in 1955 as an extension of work on the Songwe field in Tanzania, with drilling performed in 1977 and 1978. Coal occurs in upper and lower seams with the latter containing four leaves of coal interbedded with mudstone with a total thickness of 3.87 metres and a coal thickness of 2.24 metres. The coal is low quality sub-bituminous with a heating value of 19.6 MJ/kg (4700 kcal/kg) and 35% ash content. Total proven reserves in place amount to 12.2 million tonnes. However, the extent of mineable reserves is much lower because of the geological structure of the deposit and the limitations on mining depth imposed by potential water logging

1/ The detailed assumptions underlying these projections are listed in the footnotes to the Projected Energy Balance Tables in Annex 4.

problems. The estimates of mineable reserves are in the range of 1.6-1.8 million tonnes depending on whether surface or underground mining methods are employed. Further exploration could identify larger reserves but the following preliminary analysis is based on these estimates.

5.10 Two possible uses for the Ngana coal deposit are substitution for imported coal used by industry and mine mouth generation of electricity. For industrial uses in Malawi, the coal would have to be washed to upgrade it to 24 MJ/kg (5730 kcal/kg) and 18% ash and the saleable reserves would be reduced considerably. By surface methods at a rate of 80,000 tonnes per year (tpy), saleable reserves would be about 600,000 tonnes and the costs at the mine for the upgraded coal would be K85.0 per tonne.1/ Underground mining, at the same rate, would cost less: K50 per tonne for 800,000 tonnes of saleable reserves. To this must be added the high transportation costs to Blantyre, the main market, which are estimated at K40 per tonne giving total delivered costs of between K90 and K125 per tonne. These estimated costs are substantially higher than the average K65-70 per tonne currently paid for imported coal of equal quality delivered to Blantyre. Thus unless the cost of imported coal were to escalate rapidly or the country were to experience prolonged disruptions in supply, the development of the Ngana deposit for industrial markets appears to be unfeasible at this time. This conclusion is reinforced by the large investment requirements for the project. Although the actual mining project itself would cost less than K10 million, once the cost of the coal washing plant and transport and handling facilities is included, the overall project cost rises to about K40 million. Such an investment would be difficult to accommodate given Malawi's overall resource position and it is certainly one which is difficult to justify for a project whose economic justification is so weak.

5.11 The main alternative is to use run-of-mine coal in a mine-mouth thermal power plant which would generate electricity for transmission to the load centers in the Central and Southern Regions. However, the problem here is one of relative costs. The extent of proven mineable reserves - 1.8 million tons by surface mining or 1.6 million tons through underground operation 2/ - would limit the size of a coal-fired power station to about 20 MW and entail high unit investment and operating costs. Making reasonable assumptions about these costs results in an estimated cost of electricity from such a plant of about US¢6.0-7.0/kWh.3/ In many countries this cost of electricity production would

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1/ All figures in 1981 prices.

2/ With allowances for pillars and losses.

3/ Based on capital costs of $1500/kW with a 20 year recovery period and a 12% discount rate. Annual operating, maintenance, and administration costs at 3% of capital costs, annual plant factor of 65%; coal consumption of 0.6 kg/kWh and coal cost of $35/tonne.

be acceptable because of the lack of cheaper alternatives for electricity generation. This is not the case for Malawi which has a large and relatively inexpensive hydro potential still to be developed. For example, the costs of power from the proposed Kapachira scheme, while still subject to review, are estimated at between 3.5¢ and 5.0¢ per kWh. For these reasons it is recommended that no further work be done on the Ngana deposit at this time.

TABLE 5.3

Ngana Coal Field

	Surface Mining	Underground Mining
Total Proven Reserves in Place (million tonnes)	12.2	12.2
Mineable Reserves (19.6 MJ/kg; 35% ash) (million tonnes)	1.8	1.6
- Cost per tonne at minemouth (1981 K)	36.0	32.5
Saleable Reserves (upgraded to 24 MJ/kg; 18% ash) (million tonnes)	0.6	0.8
- cost per tonne at site (1981 K)	85.0	50.0
- transport costs to Blantyre (1981 K)	40.0	40.0
- delivered cost per tonne at Blantyre (1981 K)	125.0	90.0

Source: Staff estimates.

5.12 As for the four other known deposits, there is only limited available information but it is not encouraging. They suffer from the same problems of inaccessibility and at least two of the sites are badly faulted and likely to be difficult to mine. As part of its ongoing work, the Geological Survey should attempt to augment the information on these deposits but this is not a high priority task for the Government. One important phase of the ongoing work is the establishment of a testing laboratory for analysis of the samples recovered during the drilling program.

CHAPTER VI

NON-CONVENTIONAL ENERGY SOURCES

Overview

6.01 Malawi has access to a variety of non-conventional, renewable energy sources whose development could help to moderate the demand for conventional fuels or increase productivity and the quality of life in areas which do not have access to these fuels now. However, the contribution of most non-conventional energy forms is likely to be limited in the near future because their development is hampered by high cost and technical uncertainties. A number of individuals and agencies are active in this field but their isolated efforts need to be harnessed into a coherent national program with clear and well defined sectoral priorities. To achieve this the institutional framework for renewable energy development must be strengthened and clarified and public funding and support should be channeled primarily,into those applications which have the greatest potential and relevance for Malawi's needs.

6.02 While a complete inventory of Malawi's non-conventional energy resources would require much more information than is currently available, the main applications which appear to hold potential for early development can be identified. These are discussed in turn below.

Ethanol Production to Replace Gasoline

6.03 This program is already underway with the construction of a 41,000 litres/day ethanol distillery at the Dwangwa Sugar Estate.1/ Production is expected to begin in spring 1982 at the rate of 7.5 million litres per year and will result in the marketing of a 13:87 ethanol-gasoline blend throughout the country. After four years ethanol production is expected to stabilize at about 6 million litres. The $10.4 million project is being assisted by the IFC.2/ Because of the remote location of the Dwangwa estate the opportunity cost of the molasses feedstock is low and this, combined with the fact that the plant's energy requirements will be met from bagasse results in an estimated cost of production for the ethanol ($52 per barrel in 1981 $) which compares favourably with the landed cost of gasoline of $58 per barrel in September 1981.

1/ The distillery unit itself has an ultimate capacity of 60,000 litres/day and the output from the plant could be increased at limited cost by adding sugar to the molasses or installing addditional yeast fermentation equipment which is the limiting factor on output.

2/ The project was recently expanded from 4.8 million litres/year because of increased molasses production. The expansion accounts for $2.2 million of total costs.

6.04 Because the ethanol plant will be capable of processing other feedstocks during the six months when the sugar plant is not operating and because up to fifty percent more ethanol could be blended into the existing size of the gasoline pool (to a maximum 20% blend), the Government is anxious to investigate the possibility of expanding the feedstocks for ethanol production to include crops such as cassava. Preliminary estimates have been made of the costs for additional plant equipment and for establishing a cassava estate but additional work is required to establish its economic feasibility.

Mini-hydro Schemes

6.05 Some agro-industries (primarily tea estates) already generate electricity from mini-hydro stations but the bulk of Malawi's captive industrial generating capacity and a small amount of its public electricity supply continue to rely on diesel-based power. To the extent that suitable mini-hydro sites are available in the proximity of these stations, their development could result in significant diesel fuel savings. However, despite the promising potential of this resource, there is only scanty information available on it. In the Northern Region there are a number of potential mini-hydro sites with capacities of 100 kW to 500 kW particularly on the North Rukuru and the Manchewe and Chilumba Rivers. Three such sites were recently investigated by a UN team and, on the basis of their findings two of the sites are believed to be promising. The first is on the North Rukuru about 20 kilometres from the town of Karonga. It is a run-of-river scheme with a good head and a capacity of about 500 kW. Capital costs would be about US$1.5 million and the cost of power would be in the range of 8-9 Tambala per kWh. This is a likely source of power for Karonga which currently gets its electricity from a 240 kW diesel power station at a cost of around 41 Tambala per kWh. The second scheme is in the Manchewe Falls area below the confluence of the Manchewe and Chilumba Rivers. The fall is about 600m down the escarpment and there seems to be good potential for providing a supply to the towns of Livingstonia and Chilumba and to a small number of private thermal plants in the area.

6.06 Preliminary investigations have also identified several other sites in the Central and Southern Region which have the potential for small hydro schemes. However, no detailed work has been carried out on them and their precise potential and likely development costs are unknown. Some initial work has also been done by the Department of Lands, Valuation and Water but these efforts need to be better coordinated with ESCOM to ensure that viable schemes are included in the power development program. The potential contribution of mini-hydro schemes in replacing existing diesel generation and providing affordable electricity in isolated areas which do not now have it, makes it all the more urgent that the Government and ESCOM, begin to identify potentially viable sites and develop estimates of their likely costs.

Solar Energy Applications

6.07 Malawi's location assures it of fairly high levels of solar radiation throughout the year. This resource could be harnessed for a variety of applications. The first is the use of solar water heaters to replace (primarily) electricity. Two private firms are currently involved in designing and marketing solar water heaters but their output is small and their designs need improvement. The potential market for solar water heaters is substantial; about 8,000 electric water heaters are believed to be in use in the residential sector alone. However, before the Government embarks on a national program to popularize solar water heating, its economic feasibility should be explored in detail. Because Malawi's electricity supply system is based on run-of-the-river hydro schemes, the installation of solar units would not imply any fuel savings but could reduce the system's peak demand and therefore delay the timing of new generating capacity. The magnitude of this effect will depend on the extent to which the existing units are used during the peak hours, for which no data are available. If up to half the existing units were working at any given moment during the peak hours, the replacement of all domestic electric water heaters by solar units would result in a 4 MW reduction in peak demand.1/ Offset against these savings would be the costs of installing the solar water heaters themselves, which are estimated to range from K600-850 (US$650 - 910) per household unit. On this basis, the total costs of the program would be around $5-7 million. This is considerably higher than the cost of capacity expansion under the two remaining Nkula units ($600/kW) which will be adequate to meet load growth until the end of the decade. The assumptions underlying this preliminary analysis need to be verified but on the basis of available information it does not appear that the promotion of solar water heaters is a high priority task for the energy sector.2/

6.08 The second possible application of solar energy is for crop drying. While there is some open air drying of both tobacco and tea, no use is made of modern enclosed solar crop dryers in the country. This technology is a potential substitute for part of the fuelwood and fossil fuels used in agro-processing and its widespread applicaton could have a substantial impact on their demand. Consequently the mission recommends that additional work be done to assess the feasibility of this

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1/ This assumes that 8,000 2 kW electric water heaters would be replaced by solar units with a 1 kW electric booster element which would itself draw current in the same pattern as the existing electric heaters. The marketability of solar water heaters without electric booster elements is believed to be difficult in Malawi.

2/ Another possibility for reducing electricity demand for water heating during the peak period would be to introduce storage type electric water heaters which would be metered separately and would draw electricity only during the night time off peak period. The costs and benefits of this option need to be explored further.

technology. Finally, photovoltaic cells could be used to a limited extent to provide a reliable supply of electricity to isolated telecommunications posts and other similar devices. The Telecommunication Department has installed five photovoltaic systems to replace diesel generation at isolated repeater stations and claims that substantial savings have accrued in terms of reduced fuel costs and lower maintenance requirements. However, the overall impact of photovoltaic applications is unlikely to be large.

Agricultural Wastes

6.09 Bagasse, cotton seed husks and rice hulls are used in small quantities as industrial fuels.1/ Bagasse is used by the sugar industry to generate sufficient steam and power for plant operation but its contribution could be increased. For example, SUCOMA sugar estates' 6 MW on-peak demand for power from ESCOM could be substantially reduced if it used its bagasse more efficiently. However, this would require investment in rehabilitating and improving the generating facilities at SUCOMA and the relative costs of self-generated power vs. capacity expansion for ESCOM's system need to be evaluated. Similarly, a study should be carried out to examine the feasibility and potential impact of improving the efficiency of the boiler at the NOIL cotton seed processing plant which would free up additional quantities of cotton seed husks for use in the boilers of nearby industrial units.

Other Renewable Sources

6.10 Some research is being performed on the use of digesters for producing biogas from animal and agricultural wastes but the contribution from this source will not be significant during this decade (see the following section on research priorities). Also, data on wind velocities has been collected and the Posts and Telecommunications Department is considering using hybrid windmill/photovoltaic systems for generating electricity at remote sites. Again, the contribution will be small. Hot springs have been identified in Malawi but no detailed exploration has been performed to determine the extent of the geothermal resource. In any case electricity from geothermal energy would probably not be competitive with hydropower and further work in this area, therefore, has a low priority.

Renewable Energy Research and Development

6.11 Considerable time, effort and energy are currently being devoted to research and development work in the new and renewable energy field. However, this work is unlikely to have a major impact because the efforts of individual researchers are isolated, diffused across too many different projects and undertaken without a sense of relative

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1/ Maize cobs and other wastes are used for cooking in some areas but this use is difficult to quantify.

priorities. Moreover, much of this work is supply driven and not enough attention has been devoted to ensuring that the technology under investigation is a relevant one in the Malawian context. Thus, experiments are underway to determine the optimal input mix for biogas plants when there is no evidence that biogas would be widely accepted in a country which has no tradition of using animal manure for fuel. Similarly, considerable data have been collected on solar insolation and wind velocity levels but little has been done to analyze these data or to quantify the potential for developing these technologies.

6.12 To a large extent these problems result from the complete absence of a national policy on energy research and development and of an effective institutional framework for guiding and directing the efforts of individual researchers. This task is nominally the responsibility of the National Research Council's (NRC) Energy Subcommittee but this arrangement does not appear to have been effective in practice. The situation is complicated by the fact that the University, where a lot of this work is being carried out, has considerable flexibility in setting its work priorities and funding individual projects. Similarly, a number of Government departments with separate budgetary and reporting mechanisms are also active in this field (the Energy Studies Unit in the Ministry of Forestry and Natural Resources, the Meteorological Service, the Post and Telecommunication Department, the Ministry of Works and Supplies, etc.).

6.13 To improve this situation the following actions are required. First, the Government should develop clear guidelines and priorities for renewable energy development and funding. While a better inventory of needs and resources will be required to develop comprehensive guidelines, which should in any event be flexible enough to take account of changing circumstances, work can begin now on some priority areas, such as minihydro, solar crop drying and further investigation of wind energy potential. Second, the institutional framework for renewable energy research and development should be strengthened and clarified to ensure that individual researchers are aware of and responsive to overall sectoral priorities. In this context, clarification of the role of the NRC and of its relationship with the other agencies active in this field is a particularly urgent task. Similarly, the relationship of non-conventional energy research and development to the issues in fuelwood and to the energy sector as a whole needs to be clarified. The overall institutional implications of this question are considered further in the following chapter.

CHAPTER VII

CONSTRAINTS TO SECTOR DEVELOPMENT

Overview

7.01 Thus far the analysis in this report has been structured around the issues and prospects surrounding the various fuels that supply energy in Malawi. However, there are three particular issues of concern to national policy makers which relate not to any specific fuel but to the energy sector as a whole and its interaction with the rest of the economy. These are (i) the cost of future energy imports and their impact on the overall external payments situation; (ii) the financial impact of the energy sector on the Government's current and capital budgets, and (iii) the institutional arrangements for effective policy formulation and management of the energy sector. These issues are the principal subject of this chapter but their discussion is preceded by an illustration of the prospective energy balances for 1985 and 1990 which bring together the supply and demand projections made earlier for the different fuels.

Illustrative Energy Balance - 1985, 1990

7.02 Table 7.1 presents two illustrative supply-demand balances for 1985 and 1990 based on the specific consumption projections discussed in earlier chapters. The first scenario is a combination of the high petroleum product projection and the low case for coal with no improvements in the tobacco industries' efficiency of fuelwood use. The second scenario combines the low petroleum and high coal cases with the projection of fuelwood demand assuming improved efficiency in tobacco processing. The low petroleum case assumes, in addition to coal substitution, that consumption in 1981 has fallen due to completion of several construction projects and the growth will be from this lower base. For both cases, ESCOM's electricity sales forecast is used assuming ten percent transmission and distribution losses. The two scenarios represent probable bounds on the energy demand during the decade and are used for illustrative purposes and to calculate the likely cost of energy imports.

7.03 These scenarios illustrate the continued dependence on wood as the predominant energy source for Malawi during the foreseeable future. By the end of the decade fuelwood will still account for 85% of primary energy supply and the rate of growth of total energy consumption will be critically affected by the speed at which measures to improve the efficiency of fuelwood consumption are implemented. Within the commercial energy sector, total consumption is projected to increase at an average rate of 3-4% per year with the only major structural change in the pattern of supply being an increasing reliance on hydropower which will approximately double its contribution as an energy source.

TABLE 7.1

Illustrative Supply of Energy by Source
(Thousand toe and Percent)

	1980		1985 Scenario I a/		1985 Scenario II b/		1990 Scenario I a/		1990 Scenario II b/	
Total Demand	3388.4		3796		3490		3990		3340	
Supply by Source										
Petroleum	148.7	(4.4)	158	(4.2)	137	(3.9)	174	(4.4)	152	(4.6)
Coal	31.2	(0.9)	33	(0.9)	42	(1.2)	37	(0.9)	49	(1.5)
Hydroelectricity c/	96.1	(2.8)	136	(3.6)	136	(3.9)	182	(4.6)	182	(5.4)
Ethanol	-		4	(0.1)	4	(0.1)	4	(0.1)	4	(0.1)
Subtotal	276.0		331		319		397		387	
Fuelwood	3,029.0	(89.4)	3,382	(89.1)	3,088	(88.5)	3,510	(88.0)	2,870	(85.9)
Biomass	83.4	(2.5)	83	(2.2)	83	(2.4)	83	(2.1)	83	(2.5)
Total Supply	3,388.4	(100.0)	3,796	(100.0)	3,490	(100.0)	3,990	(100.0)	3,340	(100.0)

a/ Combination of the high petroleum and low coal forecasts with no improvement in fuelwood consumption by tobacco processors.

b/ Combination of the low petroleum and high coal forecasts with improvements in fuelwood consumption by tobacco processors.

c/ As forecast by ESCOM with assumed 10% transmission and distribution losses.

Source: Bank staff estimates.

The Energy Import Bill

7.04 These projections of energy demand can be used to derive estimates of the future cost of imported energy. These are presented in Table 7.2 below which shows the projected cost of energy imports in 1985 under the two scenarios on the basis of two sets of assumptions about the future movement of international energy prices. The first line shows the cost of energy imports in 1985 assuming that real energy prices remain at their 1981 levels of $65/tonne for the average of coal imports and $58/barrel for petroleum product imports as a whole. The second line is based on the assumption that real oil and coal prices rise at average annual rates of 3% and 1% respectively from their 1981 levels. While the current uncertainty in international energy markets makes it difficult to predict the precise movement of energy prices in the future, it is important to note that in all these cases the projected increase in the cost of energy imports is more modest than has been the case n the past. Even under the most conservative scenario, the 1985 energy import bill will be 40% higher than the 1980 level of $60 million and the proportion of export earnings devoted to importing energy could well decline from its 1980 level of 23% to about 19% if the growth in total export revenues materializes as expected at around 5.5 - 6.0% per year in real terms.

TABLE 7.2

Projected Energy Imports 1985
(Millions of 1981 $)

	Scenario I	Scenario II
Real Energy Prices at 1981 levels	70.3	62.5
Real Energy Prices Increase at 3% p.a. for oil and 1% p.a. for coal	78.9	70.0

Source: Staff estimates.

Energy Sector Investments and Financing

7.05 The Government has attempted to cope with the country's energy problems through price/tax policies to limit the consumption of petroleum and through investments aimed at developing new energy sources. As a result, the energy sector has been a contributor to the Government's current account revenues but an important item in its capital expenditures. The main source of current account revenues has been the import duties and surtax levied on petroleum imports. Since 1973, their contribution to the exchequer has remained largely constant as a percentage of both total Government revenues and the total collection from import duties. This is because, unlike many other countries, Malawi has regularly passed on increases in international energy prices fully to final consumers and there has not been any attempt to hold down prices artificially by absorbing international cost increases through reduced public revenues. This policy is to a large extent at the root of the Government's success in limiting commercial energy growth to the moderate levels of recent years.

TABLE 7.3

Revenue from Energy Imports

		1970	1975	1979
(i)	Import Duty & Surtax on Energy (K million)	1.8	6.4	15.0
(ii)	as a percentage of total import duties & surtax	17.0	28.4	28.3
(iii)	as a percentage of total Government revenue	4.3	7.4	8.5

Source: NSO, GOM.

7.06 The contribution of the energy sector to the current budget has been more than offset by the heavy capital requirements for indigenous energy development. Between FY75 and FY80, energy sector investments totalled K 117 million of which K41 million was contributed by the Government amounting to 6.3% of overall public investment for the period. The remainder was raised by ESCOM through internal cash generation and borrowing. The amounts invested by OILCOM in storage and distribution facilities are not included in this total. The requirements of the power sector dominated the energy investment budget and this is likely to continue in the near future, although to a somewhat lesser extent because the next major power project is not required until late in this decade.

7.07 Between FY82-86 proposed investment in the energy sector is estimated to total about K81 million, growing from 16.9 million in FY82 to K20.5 million in FY86.1/ Sixty-five percent of the energy investment

1/ The Government's investment program for all sectors is currently being revised.

program is in hydropower development, K 21 million to extend the capacity of the Nkula Falls hydro station and K 31 million for further hydro-electric power development. The balance is for fuelwood and poles production (8%) the wood energy project (17%), rural fuelwood research (1%), district centre electrification (7%) and nominal amounts for training and feasibility studies.

7.08 This composition is broadly appropriate for the sector's needs, although consideration will need to be given to increasing the allocation for fuelwood and other renewable energy development as further work proceeds in these areas.

7.09 The proposed level of investment in the energy sector amounts to about 11% of the overall public investment program over the FY82-86 period (K 710 million) which should be feasible in the light of past experience and the requirements of the other sectors.

7.10 Financing these investments will also depend heavily on a continuation of the relatively high level of external assistance which Malawi has had access to in the past. At present, Malawi receives around K 100 million in development assistance annually. Some K 45 million is in the form of grants and reimbursements and K 55 million is in loans and concessional assistance. The real growth rate for asistance was a very high 30% per annum between 1977 and 1980 but there is expected to be no growth in the next four years.

7.11 The major external donors in the energy sector have been the Bank group (Wood Energy Project, Ethanol Project and Nkula Falls), the UK Government (Rural Fuelwood and Poles Project), the German Government and the European Economic Community (Nkula), and the African Development Bank (rural electrification). Other donors such as USAID, UNDP, etc., fund important training and technical assistance activities but the financial contribution is small.1/ In FY82/83, it is estimated that around 60% of the K 16 million to be spent on energy will be supported from external assistance. By FY85/86 it is expected that around MK 15 million or 75% of the projected capital investment program will be externally funded. This represents a real increase in the total volume of assistance for energy development and underscores the high priority attached by donors to the sector. As new projects are identified which are financially and economically sound, external financing and suppliers credits will become available. The major constraint is not financial but institutional, and depends on the development of new project proposals.

7.12 In the past, there has been comparatively little duplication or competition in the funding of energy investments. Large scale hydro projects have been co-financed and renewable energy investments (wood, etc.) have been funded on a pilot basis. However, as the needs of the

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1/ A list of current and prospective external assistance in the Energy Sector is attached as Annex 1.

sector grow, the Government should give serious consideration to establishing a more formal mechanism (such as donor review meetings) for coordinating external assistance and ensuring that scarce domestic and external resources are optimally utilized.

Institutional Framework 1/

7.13 One of the main problems in Malawi's energy sector is its currently weak and fragmented institutional structure. A number of Government departments and agencies are active in the sector but their roles and relationships are not clearly delineated and their work is carried out in the absence of well defined sectoral priorities. Consequently, energy planning and management are carried out on a fragmented and ad-hoc basis with the result that some activities are duplicated and other important issues get less attention than they deserve. While this situation needs to be improved, any proposals to strengthen the institutional framework for energy must take into account the equally pressing need for improved planning in other sectors and the overall shortage of trained manpower in the country. Thus, it is neither feasible nor appropriate to develop a large and all encompassing planning apparatus for energy in Malawi today.

7.14 Nevertheless, there are a number of specific areas where the inadequacy of existing institutional arrangements is the binding constraint for efficient resource allocation and management and it is on these areas that a program of institutional improvements must focus. To bring about these improvements will require the allocation of some additional resources to the energy sector but in many instances the proposed changes could be accomplished merely by reallocating the manpower already devoted to the sector.

7.15 At the subsector level, there are three such areas where a resolution of institutional issues is an urgent task. These are:

(a) Fuelwood Management. The Energy Studies Unit and the Wood Energy Division are now both located in the Ministry of Forestry and Natural Resources and their work is being coordinated. However, the focus of their work needs to be broadened to include the use of wood in the tobacco industry and they should work much more closely with the TRA. A mechanism for diffusing the results of TRA's work on energy efficiency improvements in tobacco curing needs to be developed. The agricultural extension network is one such vehicle.

(b) Petroleum Supply Management. A focal point for petroleum supply issues is needed in the Government and one of its

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1/ This section has been revised to reflect institutional developments between September 1981 and June 1982.

tasks should be to help streamline the existing supply system. Specific recommendations on this question are made in para. 3.07 above and in para. 7.18 below.

(c) Renewable Energy Research and Development. It is necessary to clarify the role of to National Research Council and the develop an effective mechanism to determine priorities for R&D work and to allocate funds in the light of these priorities. This could be done through a strengthened Research Council or through a broadening of the focus for the Energy Studies Unit in the Ministry of Forestry and Natural Resources which is already monitoring non-wood renewable energy issues to some extent. Mini-hydro development could be done through ESCOM which has related expertise on its staff with hydrologic input from the Department of Lands, Valuation and Water.

7.16 In addition to these specific subsector issues, there is also the question of strengthening the institutional framework for energy sector planning as a whole. Given the overall shortage of manpower and the nature of the energy issues facing Malawi, the work of a national energy planning unit should not be to duplicate the functions of the subsector agencies. Neither is the preparation of a comprehensive long-term national energy plan a high priority task for the country. Rather, what is required is a small unit which can act as a focal point in the central Government for coordinating the efforts of the subsector agencies and for relating energy sector issues to overall national economic planning.

7.17 A number of Government departments are currently involved in different aspects of national energy planning and management. The Ministry of Trade and Industry is primarily responsible for receiving and analyzing the submissions for price increases made by ESCOM and the oil companies. This Ministry also acts as the main link with the oil companies on financial matters and until recently it exercised financial and administrative control over ESCOM as well. However, ESCOM now reports to the newly formulated Department of Statutory Bodies (DSB) in OPC for administrative, personnel and financial affairs and, in time, DSB hopes to extend its role to providing policy guidance and support to the parastatal agencies. In the area of energy policy formulation, the most active agency is the Economic Planning Division (EPD) which is the Government's national planning, monitoring and economic advisory unit. In preparation for the Energy Assessment Mission, EPD set up a four man energy inventory team to collect historical data and to undertake preliminary analysis. This team was initially set up as a one-time exercise, but since the Assessment Mission EPD has been given formal responsibility for energy policy work and an Energy Unit has been established therein. However, only one of the four staff from the energy inventory team is assigned to this Energy Unit and as discussed below this unit will need considerable strengthening if it is to discharge its responsibilities effectively. Finally, the Contingency Planning Unit in OPC is responsible for monitoring petroleum imports and for supervising their allocation during periods of scarcity. (Until recently this unit was called the Energy and Contingency Planning Department and it was formally charged with formulating energy sector policy as well as contingency planning. This arrangement did not work well because, with limited staff resources, the Department focussed almost exclusively on the contingency planning aspect of its mandate. Consequently the Government decided to transfer the sector planning responsibilities to a new Energy Unit in EPD.)

7.18 These recent changes have reduced the complexity of the existing institutional framework for the energy sector and institutional responsibilities are now more clearly allocated. In revising these arrangements the Government has wisely followed the principle of capitalizing on the relative strengths of existing agencies. Thus, the Contingency Planning Unit can now focus on the important task of minimizing disruptions in fuel supply. As the issues involved here are very similar for all essential commodities, there are likely to be economies of scale in having one Government department deal with supply planning for all such commodities. In its new role, it should be this unit which is the principal Government representative on the tripartite petroleum supply committee discussed earlier in the report.

7.19 The transfer of responsibility for energy policy formulation and overall coordination of subsector agencies to EPD also has strong comparative advantages. This will enable the Energy Unit staff to interact closely with those working on the other economic sectors and to ensure that energy considerations are taken into account in EPD's review of projects and policies in industry, agriculture and other economic sectors. This group would also serve as a focal point in the central government for the subsector agencies and those agencies in turn would have to appoint a liaison officer at a senior level to respond to EPD's concerns and queries on a regular basis. Finally, this group would act as the core of a technical secretariat which would examine specific energy issues of concern to national policy makers. In this context the unit would be closely concerned with monitoring and reviewing the pricing policies for the various fuels to ensure that the Government's energy pricing policies continue to provide the right signals to energy consumers and assist in the efficient management of energy demand.

7.20 While an appropriate framework for the energy sector is now being established, considerable effort and resources will be required to transform this into an effective national energy planning capability. In particular, the Energy Unit in EPD needs to be strengthened through additional national staff and the provision of technical assistance. While the scope of this technical assistance package will need to be defined in detail by the Government, it is likely to comprise of three elements. The first will be the services of an experienced energy economist/planner for an 18-24 month duration to help establish the unit, define its work program and provide on the job training to counterpart staff. The resident advisor would also be responsible for identifying and arranging for the provision of short term expertise which may be required to examine specific energy issues as they are identified. A budget for carrying out these studies would comprise the second element in a potential technical assistance package.1/ Finally the package would also include a small amount of funds to enable national staff working in the unit to proceed on formal and practical training courses to enhance their professional skills in energy policy formulation and sector management.

7.21 However, if the work of this group is to produce results, it will need the support and committment of policy makers at the highest level. It may also be useful to appoint a high level Energy Council or Committee which would meet periodically (twice a year?) to review outstanding energy policy issues and resolve differences in the approach to these issues. Such a committee could be chaired by the secretary to the Office of the President and Cabinet and include representatives of the Ministries of Finance; Trade, Industry and Tourism; Agriculture; Forestry and Natural Resources; Transport and the main energy supply agencies. The Chief Economist and the Energy Unit in EPD would serve as the technical secretariat to such a committee.

7.22 This strengthening of the institutional framework for energy will undoubtedly be a difficult task for the Government at a time when its overall resource position is strained and the competing needs of other sectors are equally urgent. However, it is feasible to embark upon such a program because its resource requirements are relatively modest, its anticipated benefits are likely to be large and because a variety of multilateral and bilateral donor agencies are likely to be willing to provide technical assistance for this important sector. Malawi has successfully contained its energy problem to date by identifying and acting upon the major sector issues. It is important that this momentum be maintained if the limited energy options that are now open to the country are to be fully realized.

1/ Annex 2 of this report provides a list of some of the priority studies which need to be undertaken. This list will be supplemented through the work of the Energy Adivsor and the other staff of the Energy Unit.

ANNEXES

MALAWI

External Assistance in Energy Sector

USAID -	Has budgeted around US$0.6 million for energy in FY82/83 out of a proposed US$10 million development assistance program. Money is for technical assistance and studies and is to be flexibly applied in support of renewable sources.
UNDP	Has programmed US$50,000 in FY82/83 for energy studies and consultancies out of a total development assistance program of around US$9 million.
EEC	Under Lome' I contributed around 12 percent of 70 million European units of account to Nkula B and strategic fuel reserves study. For period FY81-85 (Lome' II) expects to spend around 10 percent of 100 million units of account on further hydro development at Nkula, on mini-hydro schemes in the north and on strategic storage. Contributed to NRDP.
German	Out of a total FY81 and FY82 allocation of DM 91 million, co-financed Nkula B and have recently contributed 10 million DM for fourth and fifth generators at Nkula B. In FY83 and FY84 expect to continue to support hydro as well as projects designed to reduce oil consumption. Also helped finance rural growth centers forestry.
French	Small external assistance program (around K400,000 grant annually) but prepared to extend soft loans in energy (particularly solar) and telecommunications fields.
British	Expect to provide K108 million to Malawi over next four years. Of this around K 18.6 million used for financing technical assistance (50 percent) and project aid for FY82/83 in agriculture, education and telecommunication sector. Major investment in energy is rural fuelwood and poles project which they financed for around K300,000 in period FY79-81.
Canadian	No major investments in energy sector, but considerable interest as projects materialize. Funded IDRC rural fuelwood research project (around US$200,000). Total development assistance program US$4.4 million.
African Dev. Bank	Finances rural electrification (around $1.5 million) and co-financer of Nkula Phase II. Also contributed to financing of NRDP.

Technical Assistance Required for Energy Planning in Malawi

The following studies will be necessary in the next few years and technical assistance to the agency concerned will be required.

I. Data Collection

A. The data collected by EPD for 1980 needs to be enhanced to allow better analysis of consumption by sector and by end use (process heat, transport, motive power, lighting, etc.). Regular data collection on an annual basis is essential for determining trends in energy use.

II. Energy Resources Development

A. A survey to identify and rank all hydro sites, including mini hydro, is needed. One objective of such a study should be to help diversify the power system away from the Shire River.

B. A study of the feasibility of increasing the amount of electricity generated from bagasse at SUCOMA's sugar factory is warranted. The study could also evaluate the alternative of drying bagasse for use as a boiler fuel in industrial plants located in the Blantyre area.

C. An evaluation of the benefits of introducing solar water heaters on a large scale to replace electric heaters.

D. A feasibility study of the production of ethanol from cassava at the Ethco distillery.

III. Energy Conservation and Demand Management

A. The most important work necessary is in reducing fuelwood consumption by the tobacco industry. The Tobacco Research Authority and the Energy Studies Unit/Wood Energy Division would be involved but assistance is necessary to determine the best implementation methods.

B. A feasibility study of improving energy use at NOIL's plant is necessary. This study would also identify other plants in the area which could purchase surplus cotton seed husks or rice hulls as boiler fuel.

C. Perform quick surveys (audits) of energy use in industrial plants and determine the scope for energy saving. Possibly establish some form of extension service to provide advice.

D. Develop a plan for allocating fuels in case of supply disruptions. This plan should use the data collected in I (A) above as an input and take account of the economic contribution of each activity when establishing priorities.

IV. Energy Pricing and Taxes

A. A tariff study for ESCOM is necessary. This would include:

(i) a determination of long range marginal costs;

(ii) evaluation of the effects of introducing a single kWh rate;

(iii) evaluation of the effects on low income users of the monthly fixed charge; and

(iv) evaluation of measures to smooth out the daily load curve, including possible incentives for Blantyre Water Works.

B. A rational pricing policy for all wood products needs to be developed.

C. Petroleum pricing policy needs to be studied to establish some incentive for the companies to hold larger stocks in the country. This would be a continuation of the work at the Ministry of Trade and Industry.

FUELWOOD SUPPLY

Fuelwood constitutes by far the largest and most important source of energy in Malawi today, meeting about 90 percent of Malawi's energy needs. Around 50 percent 1/ of Malawi's total land area is covered by indigenous forests and woodlands, which supply fuelwood and building poles to the rural population and represent the major source of cooking and heat energy for over 90 percent of the population. Of the 5 million hectares of wooded land, around 20 percent consists of national parks and game reserves and 80 percent natural woodland of which 20 percent is forestry reserves and protected hill slopes. At present, about 80,000 hectares are under plantation management of which about 54,000 hectares are a man-made forest of largely pine trees for commercial use on the Viphya plateau. However, the Viphya resources are not included in the following estimates of supply for fuelwood and poles because their distance from demand centers precludes this use.

Accurate estimates of sustainable fuelwood supply are difficult to make because of definitional problems and data inadequacies. The 1978 study for the IDA-assisted Wood Energy Project estimated the 1980 level of sustainable supply from the various sources to be around 8.9 million m^3 as shown in the table below.

Fuelwood Supply, 1980
(thousand m^3)

Source	Southern Region	Central Region	Northern Region	Total
1. Indigenous Reserves	137.7	320.5	357.7	815.9
2. Indigenous Proposed Reserves	7.4	39.1	258.2	304.7
3. Indigenous Customary Land	377.2	689.2	1,340.2	2,406.6
4. Customary Land Clear Fell	849.3	1,826.1	2,647.0	5,322.4
5. Reserves Clear Fell	1.3	55.8	-	57.1
6. District Councils	2.1	7.4	-	9.5
7. Plantation Residuals	2.0	3.4	-	5.4
8. Sawmill Waste	2.8	2.0	1.4	6.2
Total	1,379.8	2,943.5	4,604.5	8,927.8

1/ According to the British Overseas Development Administration (ODA) report "about 53% of the land area is wooded to varying grades"; but there are large sections of savannah included with relatively few trees. (Viphya Forest Resources Utilization Study Report by ODA Mission to Malawi, September 1980). However, the Forest Industries Advisory Group for Africa indicated that of the total land area about 23% is forested including 80,000 ha of established plantations of exotic trees. (FIAG Report No. 80/24, October 1980).

The largest source is clear felling of customary land which is not a sustainable yield and as this practice is reduced the supply will diminish.

A more recent estimate made by the Ministry of Forestry and Natural Resources suggests that the supply from natural woodlands on customary lands (item 3 in the table) could be as low as 1.3 million m^3. The total supply based on that estimate would be about 8.0 million m^3.1/

Over the past few years the Government has taken several steps to increase the supply of fuelwood. Most of the work has been performed through the Department of Forestry, much of it with external assistance. The following programs were undertaken.2/

1. Rural Fuelwood and Poles Project
   - eucalyptus plantations with UK Government assistance.
   - ended March 31, 1980

2. National Tree Planting Day
   - main purpose is educational.

3. Viphya Forest Industry Trials
   - species identification for high rainfall areas.
   - ended March 31, 1981

4. Rural Fuelwood Research Project
   - species trials for drier areas and areas with deforestation problems.
   - ended September 30, 1981

5. Kasungu Flue-Cured Tobacco Authority
   - plantations for tobacco processing.
   - species trials with results used in other areas.
   - no new planting.

6. National Rural Development Program
   - includes IDA Wood Energy Project
   - supports nurseries, plantations, charcoal production trials, and institution building.

In addition to these steps, the Government is considering a method for enforcing existing regulations which require tobacco growers to establish plantations to provide a portion of the fuelwood needs.

1/ J.A.D. Jackson, "Woodfuel in Malawi", The Zimbabwe Science News, Vol. 15, No. 1, January 1981.

2/ For the projects which have ended the planted trees are being tended.

ANNEX 4

Statistical Data on the Energy Sector

List of Tables

TABLE 1

MALAWI

ENERGY BALANCE 1980
('000 toe)

	Petroleum Products	Coal	Electricity Hydro 1/	Electricity Thermal	Electricity Total	Total Commercial Energy	Fuelwood	Biomass 2/	Total
1. Primary Supply									
Production	-	-	96 1	-	96.1	96.1	3029.0	83.4	3208.5
Imports	148.7	31.2	-	-	-	179.9	-	-	179.9
Total	148.7	31.2	96 1	-	96.1	276.0	3029.0	83.4	3388.4
2. Transformation									
Power Generation	-1.3	-	96.1	1.3	97.7				
Losses in Generation 1/	-	-	-64.1	-0.9	-65.1				
3. Total Supplies	147.4	31.2	-	-	32.3	210.9	3029.0	83.4	3323.3
4. Transmission and Distribution Losses	-	-	-	-	-2.8				
5. Net Supply to Consumers	147.4	31.2	-	-	29.5	208.1	3029.0	83.4	3320.5
6. Final Consumption 3/									
Industry	60.4	29.6	-	-	21.6	112.6	1527.0	83.4	1723.0
Transport	80.6	-	-	-	-	80.6	-	-	80.6
Commercial	0.1	1.6	-	-	3.2	4.9	9.0	-	13.9
Residential	6.3	-	-	-	4.7	11.0	1493.0	-	1504.0

1/ Hydro is converted at 10,250 Btu/kWh and theoretical losses are two-thirds.

2/ Bagasse and cotton seed husks.

3/ The sectoral allocation for petroleum products is based on information from the Energy Inventory Group's work plus the following assumptions:

(i) All gasoline and jet fuel are used in transport;
(ii) All kerosene is for domestic use;
(iii) All fuel oil is for industry;
(iv) LPG is divided 20%, 40%, 40% for domestic; commercial and industrial uses and
(v) Diesel is divided 70% industrial and 30% transport.

Source: Government of Malawi, Oilcom, Excom, Coal Users' Committee, and Bank Staff estimates.

TABLE 2

MALAWI

CONVERSION FACTORS

1 tonne of oil equivalent = 41 Million Btu
= 43.3 GJ (gigajoules)

Petroleum Products

Product	MJ/litre	toe/m3
Gasoline	34.4	0.794
Kerosene	35.1	0.811
Diesel	38.7	0.894
Furnace Oil	40.0	0.924
Jet Fuel	37.0	0.855
Aviation Gasoline	33.8	0.781

LPG = 45.2 MJ/kg; 1000 kg LPG = 1.044 toe.

Other Fuels

Coal	0.67 toe per tonne
Electricity	4,000 kWh per toe
Cotton Seed Husks	0.33 toe per tonne
Bagasse	0.22 toe per tonne
Wood	0.29 toe per m^3 (solid, dry)
Ethanol	0.794 toe per m3 (allows for higher efficiency of ethanol use in spark combustion engines which results in effective unitary volumetric substitution for gasoline).

TABLE 3

MALAWI

END USE EFFICIENCIES 1/
(Fraction)

Sector	Petroleum Products						Coal	Electricity	Fuelwood	Biomass
	LPG	Gasoline	Diesel	Furnace Oil	Kerosene	Jet Fuel/ Av. Spir.				
Industry	0.70	-	0.60	0.70	-	-	0.65	0.90	0.15	0.33
Transport	-	0.20	0.25	-	-	0.25	-	-	-	-
Commercial	0.70	-	-	-	-	-	0.65	0.80	0.15	-
Residential	0.30	-	-	-	0.30	-	-	0.80	0.07	-

1/ These efficiencies reflect the amount of "useful energy" delivered to the end use. For example, industrial boilers transfer 70% of the energy in furnace oil to the steam whereas only 15% of the energy in fuelwood is "used" in tobacco curing barns. Similarly, internal combustion engines used in transport can only transfer a small portion of the energy in liquid fuels to the driving wheels due to inherent inefficiencies.

TABLE 4

MALAWI

ILLUSTRATIVE ENERGY BALANCE, 1985
SCENARIO I
('000 toe)

	Petroleum Products 1/	Ethanol	Coal 2/	Hydro-Electricity 3/	Total Commercial Energy	Fuelwood 4/	Biomass 5/	Total
1. Primary Supply								
Production	-	4	-	136.0	140	3,382	83	3,605
Imports	158	-	33	-	191	-	-	191
Total	158	4	33	136	331	3,382	83	3,796
2. Transformation								
Power Generation				136				
Losses in Generation 6/				-91				
3. Total Supplies	158	4	33	45	240	3,382	83	3,705
4. Transmission and Distribution Losses				-5				
5. Net Supply and Final Consumption	158	4	33	40	235	3,382	83	3,700

1/ The petroleum product consumption is taken from the high scenario described in para. 3.18.

2/ The coal consumption for scenario I is based on the following assumptions:

(i) Consumption by the cement plant grows to 21,500 tonnes in 1985 and 25,000 tonnes 1990;
(ii) Consumption by tobacco processors remains constant at 7,100 tonnes;
(iii) Consumption by tea processors remains constant at 2500 tonnes; and
(iv) Consumption by other users remains constant at 18,000 tonnes until 1985 and grows at 5% per annum thereafter.

3/ Hydroelectricity is from ESCOM's forecast not including the proposed fertilizer project.

4/ Fuelwood consumed by the tobacco industry is assumed to be reduced by improving the efficiency.

5/ Biomass includes bagasse and cotton seed husks. In 1985 bagasse will be used more efficiently at the Dwangwa Sugar Company because steam and electricity will be supplied to the ethanol plant without increasing fuel use.

6/ Hydroelectricity was converted at 10,250 Btu/kWh with theoretical generation efficiency of 0.33.

TABLE 5

MALAWI

ILLUSTRATIVE ENERGY BALANCE, 1985
SCENARIO II
('000 toe)

	Petroleum Products 1/	Ethanol	Coal 2/	Hydro-Electricity 3/	Total Commercial Energy	Fuelwood 4/	Biomass 5/	Total
1. Primary Supply								
Production	-	3.8	-	136.0	139.8	3,088	83.4	3,311.2
Imports	136.4	-	42.1	-	178.5	-	-	178.5
Total	136.4	3.8	42.1	136.0	318.3	3,088	83.4	3,489.7
2. Transformation								
Power Generation				136.0				
Losses in Generation 6/				-90.7				
3. Total Supplies	136.4	3.8	42.1	45.3	227.6	3,088	83.4	3,399.0
4. Transmission and Distribution Losses				-4.5				
5. Net Supply to Consumers	136.4	3.8	42.1	40.8	223.1	3,088	83.4	3,394.5

1/ The petroleum product consumption is taken from the low scenario described in para. 3.18.

2/ The coal consumption is based on the following assumptions:

(i) Consumption by the cement plant grows to 23,000 tonnes in 1985 and to 28,000 tons in 1990.
(ii) Substitution for diesel oil adds 6,000 tonnes by 1985;
(iii) Consumption by tobacco processors grows at 4% per annum from 8000 tonnes in 1980;
(iv) Consumption by tea processors remains constant at 3300 tonnes; and
(v) Consumption by other users grows at 3% per annum.

3/ Hydroelectricity is from ESCOM's forecast not including the proposed fertilizer project.

4/ Fuelwood consumed by the tobacco industry is assumed to be reduced by improving the efficiency.

5/ Biomass includes bagasse and cotton seed husks. In 1985 bagasse will be used more efficiently at the Dwangwa Sugar Company because steam and electricity will be supplied to the ethanol plant without increasing fuel use.

6/ Hydroelectricity was converted at 10,250 Btu/kWh with theoretical generation efficiency of 0.33.

TABLE 6

MALAWI

ILLUSTRATIVE ENERGY BALANCE, 1990
SCENARIO I
('000 toe)

	Petroleum Products 1/	Ethanol	Coal 2/	Hydro-Electricity 3/	Total Commercial Energy	Fuelwood 4/	Biomass 5/	Total
1. Primary Supply								
Production	-	4	-	182	186	3,510	83	3,779
Imports	174	-	37	-	211	-	-	211
Total	174	4	37	182	397	3,510	83	3,990
2. Transformation								
Power Generation				182				
Losses in Generation 6/				-121				
3. Total Supplies	174	4	37	61	276	3,510	83	3,869
4. Transmission and Distribution Losses				-6				
5. Net Supply to Consumers	174	4	37	55	270	3,510	83	3,863

1/ The petroleum product consumption is taken from the high scenario described in para. 3.18.

2/ The coal consumption is based on the following assumptions

(i) Consumption by the cement plant grows to 21,500 tonnes in 1985 and 25,000 tonnes 1990;
(ii) Consumption by tobacco processors remains constant at 7,100 tonnes;
(iii) Consumption by tea processors remains constant at 2500 tonnes; and
(iv) Consumption by other users remains constant at 18,000 tonnes until 1985 and grows at 5% per annum thereafter.

3/ Hydroelectricity is from ESCOM's forecast not including the proposed fertilizer project.

4/ Fuelwood consumed by the tobacco industry is assumed to be reduced by improving the efficiency.

5/ Biomass includes bagasse and cotton seed husks. In 1985 bagasse will be used more efficiently at the Dwangwa Sugar Company because steam and electricity will be supplied to the ethanol plant without increasing fuel use.

6/ Hydroelectricity was converted at 10,250 Btu/kWh with theoretical generation efficiency of 0.33.

TABLE 7

MALAWI

ILLUSTRATIVE ENERGY BALANCE, 1990
SCENARIO II
('000 toe)

	Petroleum Products 1/	Ethanol	Coal 2/	Hydro-Electricity 3/	Total Commercial Energy	Fuelwood 4/	Biomass 5/	Total
1. Primary Supply								
Production	-	4	-	182	186	2,870	83	3,139
Imports	152	-	49	-	201	-	-	201
Total	152	4	49	182	387	2,870	83	3,340
2. Transformation								
Power Generation				182				
Losses in Generation 6/				-121				
3. Total Supplies	152	4	49	61	266	2,870	83	3,219
4. Transmission and Distribution Losses				-6				
5. Net Supply and Final Consumption	152	4	49	55	260	2,870	83	3,213

1/ The petroleum product consumption is taken from the low scenario described in para. 3.18.

2/ The coal consumption for Scenario II is based on the following assumptions:

(i) Consumption by the cement plant grows to 23,000 tonnes in 1985 and 28,000 tonnes 1990;
(ii) Substitution for diesel oil adds 6,000 tonnes by 1985;
(iii) Consumption by tobacco processors grows at 4% per annum from 8000 tonnes in 1980;
(iv) Consumption by tea processors remains constant at 3300 tonnes; and
(v) Consumption by other users grows at 3% per annum.

3/ Hydroelectricity is from ESCOM's forecast not including the proposed fertilizer project.

4/ Fuelwood consumed by the tobacco industry is assumed to be reduced by improving the efficiency.

5/ Biomass includes bagasse and cotton seed husks. In 1985 bagasse will be used more efficiently at the Dwangwa Sugar Company because steam and electricity will be supplied to the ethanol plant without increasing fuel use.

6/ Hydroelectricity was converted at 10,250 Btu/kWh with theoretical generation efficiency of 0.33.

TABLE 8

PETROLEUM PRODUCT IMPORTS
('000 toe)

Year	LPG	Petrol	Kerosene	Diesel	Furnace Oil	Jet Fuel 1/	Total
1970	0.2 1/	32.8	11.9	51.7	4.6	7.9	109.1
1971	0.3	35.4	13.5	55.8	5.0	9.1	119.1
1972	0.3	39.2	14.9	57.9	5.6	11.1	129.0
1973	0.3	40.2	15.2	61.9	5.1	11.7	134.4
1974	0.4	36.4	13.0	55.9	5.1	16.3	127.1
1975	0.4	39.1	13.5	62.8	4.2	19.6	139.6
1976	0.3	43.5	11.3	71.2	3.1	13.6	143.0
1977	0.4	38.9	8.8	67.0	3.2	13.7	132.0
1978	0.3	43.8	9.5	74.2	3.9	14.4	146.1
1979	0.3	45.6	7.9	78.7	3.2	17.3	153.0
1980	0.3 2/	43.0	6.2	82.7	3.7 2/	12.8 2/	148.7

1/ Includes small volumes of aviation gasoline.

2/ Estimates.

Source: National Statistical Office, Oilcom.

TABLE 9

COAL CONSUMPTION 1/

Year	'000 tonnes	'000 toe
1970	44.0	29.5
1971	45.4	30.4
1972	53.3	35.9
1973	43.4	29.1
1974	52.7	35.3
1975	71.3	47.8
1976	62.5	41.9
1977	56.5	37.9
1978	54.3	36.4
1979	57.6	38.6
1980	46.6	31.2

1/ Years 1970-77 are imports as reported by NSO while years 1978-80 are consumption figures estimated from Coal Users' Committee data and cement production figures. Preliminary 1981 figures indicate consumption of 52,000 tonnes.

Source: NSO, Coal Users' Committee.

TABLE 10

COMMERCIAL FUELS CONSUMPTION
('000 Toe and %)

Year	Petroleum Products		Coal		Hydroelectricity 1/		Total	
1970	109.1	(64.5)	29.5	(17.4)	30.5	(18.1)	169.1	(100.0)
1971	119.1	(65.3)	30.4	(16.7)	33.0	(18.1)	182.5	(100.0)
1972	129.0	(63.0)	35.9	(17.5)	39.9	(19.5)	204.8	(100.0)
1973	134.4	(64.1)	29.1	(13.9)	46.1	(22.0)	209.6	(100.0)
1974	127.1	(59.2)	35.3	(16.4)	52.4	(24.4)	214.8	(100.0)
1975	139.6	(55.5)	47.8	(19.0)	64.0	(25.5)	251.4	(100.0)
1976	143.0	(56.6)	41.9	(16.6)	67.6	(26.8)	252.5	(100.0)
1977	132.0	(54.3)	37.9	(15.6)	73.3	(30.1)	243.2	(100.0)
1978	146.1	(56.4)	36.4	(14.1)	76.4	(29.5)	258.9	(100.0)
1979	153.0	(54.6)	38.6	(13.8)	88.6	(31.6)	280.2	(100.0)
1980	148.7	(53.9)	31.2	(11.3)	96.1	(34.8)	276.0	(100.0)
Average Annual Growth Rate, %:								
1970-75	5.1		10.1		16.0		8.3	
1975-79	2.3		-5.2		8.5		2.7	
1979-80	-2.8		-19.2		8.5		-1.5	

1/ Generation converted at 4,000 kWh per toe (10,250 Btu/kWh).

Source: NSO, ESCOM, Oilcom, Coal Users'Committee.

TABLE 11

Electricity Supply Commission of Malawi

Actual Sales of Electricity and Number of Consumers

	Interconnected System																	Isolated Undertakings		Total ESCOM		
	Domestic				General & Commercial		Power				Special Agreements		Export		Total Interconnected System		% Growth Sales in GWh					Overall % Growth Rate
	Low Density		High Density				Small		Large													
Year	No. of Con-sumers	GWh	No. of Con-sumers	GWh	No. of Con-sumers	GWh	No. of Con-sumers	GWh	No. of Con-sumers	GWh	No. of Con-sumers	GWh	No. of Con-sumers	GWh	Con-sumers	GWh		Con-sumers	GWh	No. of Con-sumers	GWh	
1970	3772	20.33	2518	1.27	1686	19.58	105	19.84	7	52.01	1	0.42	1	1.28	8090	114.73		619	7.19	9709	121.92	
1971	3892	21.49	2972	1.72	1790	22.20	112	21.10	8	55.33	1	0.46	1	1.47	8776	123.27	7.8	763	8.67	10539	132.44	8.6
1972	4013	23.06	3411	2.37	1967	25.01	108	24.37	8	70.95	2	0.52	1	1.90	9509	148.18	19.8	2189	10.95	11698	159.13	20.2
1973	5006	26.97	4580	3.15	2434	31.78	127	31.89	8	79.41	1	0.03	1	2.19	12157	175.38	18.5	657	2.65	12814	177.94	11.8
1974	5313	30.03	5552	4.24	2556	32.71	135	37.13	8	82.13	1	1.25	1	1.73	13566	189.22	8.0	746	3.05	14312	192.27	8.3
1975	5969	33.19	5953	5.46	2887	22.68	174	57.76	10	112.58	6	1.34	1	1.46	15000	234.47	23.8	553	1.70	15553	236.17	22.8
1976	6219	36.86	6470	6.53	2995	24.79	182	61.71	10	117.88	22	1.52	1	1.51	15899	250.80	6.9	688	2.20	16587	253.00	7.2
1977	6869	37.72	7561	8.29	3268	26.76	196	67.83	10	119.49	24	1.50	1	1.20	17929	262.79	4.8	566	2.53	18617	265.32	4.9
1978	7257	38.45	7981	8.11	3528	33.19	215	78.16	11	126.49	2	0.14	1	1.33	18995	285.87	8.8	675	2.25	19670	288.12	8.6
1979	7777	42.82	8654	8.66	3782	33.96	231	87.49	13	152.72	2	0.20	1	1.28	20460	327.13	14.5	790	3.25	21250	330.38	14.7
1980	8457	46.06	9062	9.93	4058	37.85	241	90.53	13	164.29	2	0.14	1	1.35	21834	350.15	7.0	1054	3.89	22888	354.04	7.2

Note: Inconsistencies in growth rate of small power consumers and general and commercial are presumably due to switching between these tariffs.

Average growth for 1970-1980 was 11.2%.

Average growth for 1975-1980 was 8.4%.

TABLE 12

Electricity Supply Commission of Malawi

Actual GWh Generated , Sent Out and Sold, System Losses
Installed and Firm Capacity, Maximum Demand and Load Factor 1970-1980

Interconnected System

	GWh Generated							% System Losses On Units Sent Out	Installed Capacity MW		Firm Capacity MW		Total Firm Capacity	Max. Demand MW	Load Factor (Sent Out)
Year	Hydro	Diesel	Steam	Gas Turbine	Total	GWh Sent Out	GWh Sold		Hydro	Thermal	Hydro	Thermal			
1970	122.07	0.18	2.84	-	125.09	123.92	114.73	7.4	24	9.4	16	5.8	21.8	21.9	65.3
1971	131.85	3.06	0.39	-	135.30	134.15	123.77	7.9	24	9.4	16	5.8	21.8	24.2	63.8
1972	159.51	0.90	6.38	-	166.79	165.42	148.18	10.5	24	9.4	16	5.8	21.8	28.5	66.6
1973	184.29	3.87	4.13	-	192.29	190.65	175.38	8.0	40	15.9	30	12.4	42.4	30.3	64.0
1974	209.37	2.15	0.43	-	211.95	210.64	189.22	10.2	40	15.9	30	12.4	42.4	39.3	61.6
1975	255.97	4.58	2.13	-	262.68	261.09	234.47	10.3	40	29.2	30	13.0	43.0	48.2	62.2
1976	270.28	4.37	3.54	1.95	280.14	278.48	250.80	10.1	54	29.2	44	13.0	57.0	50.2	63.5
1977	293.15	0.51	0.12	0.16	293.94	292.34	262.79	10.3	64	21.0	54	6.0	60.0	51.4	64.9
1978	305.41	1.80	-	1.49	308.70	307.28	285.87	7.2	64	21.0	54	6.0	60.0	54.2	64.7
1979	354.30	0.29	-	0.04	354.62	353.15	327.13	7.4	64	21.0	54	6.0	60.0	60.4	67.0
1980	384.53	0.96	-	0.16	385.65	383.88	350.15	8.8	104	21.0	84	-	84	66.2	66.3

Notes:

(1) System losses are actually running at around 11% per annum. The reason for the low figures in 1978 through 1980 is because contractors consumption for Nkula II were charged to construction but were not metered at the power station and thus not recorded as kWh sent out.

(2) The earlier low figures of around 8% per annum were, it is suspected, due to arrears of meter reading.

(3) Thermal plant has been excluded from firm capacity from 1980.

(4) The old 600 kW hydro station at Zomba and the smaller diesel installations at thermal stations connected to the system have not been included in plant availability figures.

TABLE 13

ELECTRICITY SUPPLY COMMISSION OF MALAWI

PLANT CAPACITY AS AT 31ST DECEMBER 1980

Location	Year of Manufacture	Date Installed	Rating of Units (KW)	Type	Total Installed Capacity (KW)
Interconnected System					
Tedzani Falls	1973	1973	2 x 10,000	Hydro	
	1976	1976	1 x 10,000	Hydro	40,000
	1977	1977	1 x 10,000	Hydro	
Nkula Falls*	1966	1966	2 x 8,000	Hydro	
	1967	1967	1 x 8,000	Hydro	64,000
	1980	1980	2 x 20,000	Hydro	
Blantyre	1975	1975	1 x 15,000	Gas Turbine	15,000
Zomba	1953	1953	1 x 300	Hydro	600
	1954	1954	1 x 300	Hydro	
Lilongwe	1963	1963	1 x 700	Diesel	
	1956	1967	1 x 1,100	Diesel	
	1971	1972	1 x 3,000	Diesel	5,900
	1956	1978	1 x 1,100	Diesel	
Total Interconnected System					125,500
Isolated Undertakings					
Mzuzu	1959	1962	1 x 65	Diesel	
	1947	1971	1 x 85	Diesel	
	1950	1972	1 x 235	Diesel	1,225
	1951	1974	1 x 250	Diesel	
	1951	1975	1 x 150	Diesel	
	1967	1978	1 x 240	Diesel	
	1978	1978	1 x 200	Diesel	
Kasungu	1970	1971	1 x 30	Diesel	
	1951	1972	2 x 85	Diesel	
	1951	1974	1 x 85	Diesel	
	1959	1978	1 x 105	Diesel	390
Karonga	1978	1979	2 x 120	Diesel	240
Total Plant Capacity					127,355

* The third 20 MW machine was commissioned early 1981.

TABLE 14

PRIVATE GENERATING PLANT WITH CAPACITY OVER 25 KW 1/

LICENSEE	CAPACITY (KW)	TYPE
Lijeri Tea Estate	252	Hydro
Lijeri Tea Estate	220	Diesel
Lijeri Tea Estate	520	Hydro
Interprise Containers (Livingstonia)	130	Diesel
Christian Service Committee	145	Hydro
Chima Tea & Tung Estates	145	Hydro
Kachebere Seminary	65.45	Diesel
Salima Canners	75	Diesel
Sayama Tea Estate	161.50	Steam & Diesel
Sayama Tea Estate	65	Steam
Malamulo Hospital	37	Diesel
Chitakali Tea Estates	120	Diesel
NOIL - Karonga	200	Diesel
Lever Brothers	30	Diesel
Sucoma Sugar 2/	11000	Steam
Ministry of Works - Rumphi	46	Diesel
Ministry of Works - Makhanga	145	Diesel
Ministry of Works - State House	150	Diesel
Ministry of Works - Kasunga Hosp.	25	Diesel
Ministry of Works - Chkoko Bay	150	Diesel
Ministry of Works - Mikuyu Prison	40	Diesel
German Embassy - Lilongwe	27	Diesel
Malawi Army - Mvera	38	Diesel
Naming'omba Tea Estate	400	Diesel
NOIL - Chirumba	141	Diesel
Malawi Tea Factory - Mulanje	200	Diesel
Livingstonia Mission	33	Diesel
Diocese of Mzuzu	36	Diesel
Diocese of Katete	67	Diesel
Diocese of Rumphi	34	Diesel
Diocese of Chitipa	30	Diesel
M.B.C. - Ngumbe	325	Diesel
Posts & Telecom Kanjedza	64	Diesel
Cotton Ginners - Bangula	272	Diesel
Dwangwa Sugar Corporation	1500	Diesel
Dwangwa Sugar Corporation	7000	Steam
Mogamba Sawmill - Forestry Department	500	Diesel
Chikangawa - Forestry Department	150	Diesel

1/ Some of these installations are for standby only.

2/ Down rated to 5250 KW.

Source: ESCOM

TABLE 15

POTENTIAL HYDRO POWER SITES ON THE MIDDLE SHIRE RIVER

Sites	Mean Gross Head ft	Average Discharge cusec	Energy Potential MWh	Continuous Output MW	Reservoir Capacity Acre feet
Kholombidzo	225	6000	2184	91	3000
Nachembeya	70	6000	672	28	400
Nkula Falls	178	6000	1728	72	3000
Tedzani Falls	130	6000	1272	53	3700
Mpatamanga Gorge	210	6200+	2112	88	169000
Kapachira Falls	205	6000	1992	83	2700
		6200++	2064		
Totals	1018		9960	415	

\+ Extra discharge from flood waters stored at Mpatamanga.

++ Extra discharge if no water is abstracted for irrigation.

Source: ESCOM.

TABLE 16

ELECTRICITY SUPPLY COMMISSION OF MALAWI

ELECTRICITY TARIFFS

TYPE	DESCRIPTION	TARIFF SCHEDULE 1981	TARIFF SCHEDULE AS OF APRIL 1982	REMARKS
Tariff I Domestic (Low Density)	Minimum Charge Energy Charge (i) Energy Charge (ii)	6.00K per month (To include up to first 50 Kwh) 51-200 Kwh-6t/Kwh Over 200 Kwh - 4t/Kwh	5.00K per month 0-225 Kwh - 7.8t/Kwh Over 225Kwh- 5.7t/Kwh	
Tariff II Domestic (High Density)	Minimum Charge Energy Charge (i) Energy Charge (ii)	1.30K per month (To include up to first 20 Kwh) 21-200 Kwh-4t/Kwh Over 200 Kwh - 5t/Kwh	1.00K per month 0-150 Kwh - 5.0t/Kwh Over 150 Kwh - 7.5t/Kwh	The increasing Kwh rate is to discourage large high consumption premises from taking advantage of the high density rates to obtain cheaper electricity than low density consumers
Tariff III General & Commercial Up to 6600 Kwh per month	Minimum Charge/Fixed Charge Energy Charge (i) Energy Charge (ii)	3.50K per month 0-600 Kwh - 7t/Kwh Over 600 Kwh - 4t/Kwh	5.00K per month 0-600 Kwh - 9.3t/Kwh Over 600 Kwh - 5.7t/Kwh	
Tariff IV Power In excess of 6600 Kwh per month	Maximum Demand Charge Energy Charge Minimum monthly Demand Charge	10.00K per KW per month All Kwh at 1.5/Kwh 50% of maximum monthly demand charge in previous year	Fixed Charge 12.00K per KVA per month Capacity Charges First 60KVA at 12.0K per KVA per month	Tariffs IV and V are combined into one tariff and the new tariff is based on KVA instead of KW which automatically takes care of power factor penalty and eliminates the old complicated power factor penalty clause.
Tariff V Power optional over 500 KW M.D.	Maximum Demand Charge Energy Charge Minimum Annual Demand Charge	80.00K per KW per year All Kwh at 1.0t/Kwh 50% of previous years maximum demand charge	61-300KVA at 11.0 0K per KVA per month Over 301KVA at 8.7K per KVA per month All units at 1.4t/Kwh	

TABLE 17

ELECTRICITY SUPPLY COMMISSION OF MALAWI

FORECAST SALES OF ELECTRICITY 1981-1990

Year	Domestic Low Density	Domestic High Density	General and Commercial	Power Small	Power Large	Isolated Plants	Total	% Annual Growth
1981	51.68	11.05	37.06	92.61	162.18	15.52	370.10	5.4
1982	57.28	12.56	39.94	100.90	168.71	17.75	397.14	7.3
1983	63.33	14.19	42.96	109.49	177.71	19.88	427.56	7.6
1984	69.83	15.96	46.13	118.23	190.17	22.07	462.39	8.2
1985	74.82	17.86	49.42	126.94	198.14	24.25	491.43	6.3
1986	79.30	19.00	52.40	134.50	209.00	25.80	520.00	5.9
1987	84.10	20.10	55.50	142.50	221.60	27.20	551.00	6.0
1988	89.20	21.30	58.80	151.00	235.00	28.70	584.00	6.0
1989	94.60	22.60	62.30	160.00	249.00	30.50	619.00	6.0
1990	100.00	24.00	66.00	170.00	264.00	32.00	656.00	6.0

Note: 1. Isolated undertakings will all be connected to the Interconnected System by 1983/84 with exception of Karonga.

2. Forecast taken as 6% from 1986 through 1990 and rounded. This is conservative.

3. The proposed fertilizer project is not included in this forecast.

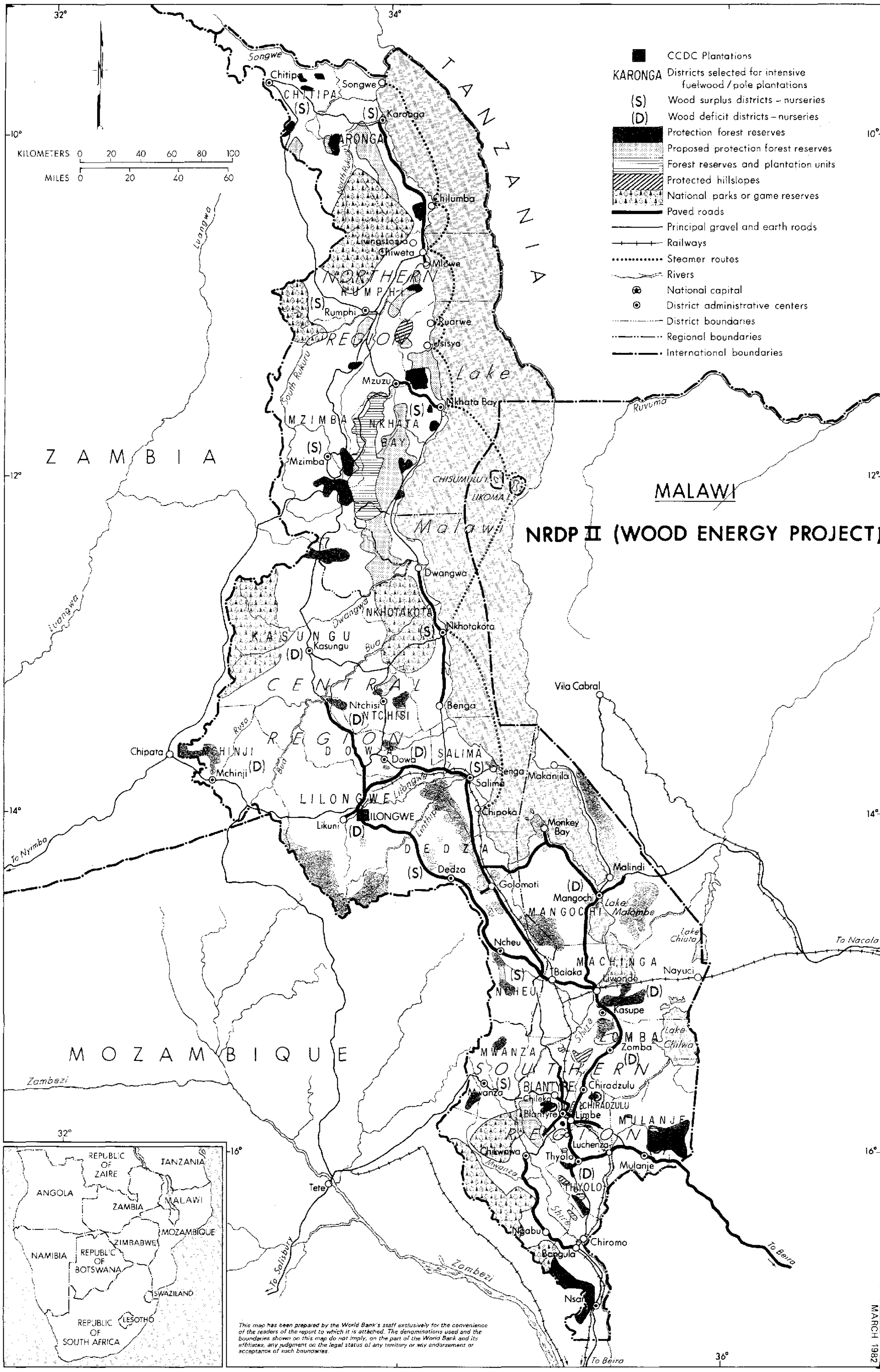
TABLE 18

FORECAST GENERATION, CAPACITY, AND MAXIMUM DEMAND

Year	Generation (GWh) Hydro	Thermal	Total	Installed Capacity (MW) Hydro	Thermal	Firm Capacity (MW) 1/	Maximum Demand (MW)
1981	412	1	413	124	20	94	72
1982	445	1	446	124	20	94	78
1983	484	1	485	124	20	94	85
1984	515	1	516	124	20	94	98
1985	545	1	546	144	20	114	111
1986	577	1	578	144	20	114	117
1987	612	1	613	164	20	124	122
1988	648	1	649	164	15	124	129
1989	687	1	688	194	15	144	135
1990	728	1	729	194	15	144	142

1/ Excludes thermal plant.

Source: ESCOM, Bank staff estimates.



MALAWI
NRDP II (WOOD ENERGY PROJECT)
CCDC Plantations
KARONGA Districts selected for intensive fuelwood / pole plantations
(S) Wood surplus districts – nurseries
(D) Wood deficit districts – nurseries
Protection forest reserves
Proposed protection forest reserves
Forest reserves and plantation units
Protected hillslopes
National parks or game reserves
Paved roads
Principal gravel and earth roads
Railways
Steamer routes
Rivers
National capital
District administrative centers
District boundaries
Regional boundaries
International boundaries
KILOMETERS 0 20 40 60 80 100
MILES 0 20 40 60
TANZANIA
ZAMBIA
MOZAMBIQUE
NORTHERN REGION
CENTRAL REGION
SOUTHERN REGION
Lake Malawi
CHITIPA
KARONGA
RUMPHI
MZIMBA
NKHATA BAY
NKHOTAKOTA
KASUNGU
NTCHISI
DOWA
SALIMA
MCHINJI
LILONGWE
DEDZA
MANGOCHI
MACHINGA
NTCHEU
ZOMBA
MWANZA
BLANTYRE
CHIRADZULU
MULANJE
THYOLO
Chitipa
Songwe
Karonga
Chilumba
Livingstonia
Chiweta
Mlowe
Rumphi
Ruarwe
Usisya
Mzuzu
Nkhata Bay
Mzimba
CHISUMULU I.
LIKOMA I.
Dwangwa
Nkhotakota
Kasungu
Ntchisi
Benga
Dowa
Senga
Salima
Makanjila
Chipoka
Monkey Bay
Chipata
Mchinji
Likuni
Dedza
Golomoti
Malindi
Mangochi
Lake Malombe
Lake Chiuta
Ncheu
Balaka
Liwonde
Nayuci
Kasupe
Lake Chilwa
Zomba
Mwanza
Chileka
Blantyre
Limbe
Chiradzulu
Luchenza
Chikwawa
Thyolo
Mulanje
Ngabu
Chiromo
Bangula
Nsanje
Tete
Vila Cabral
Songwe
Ruvuma
Luangwa
South Rukuru
North Rukuru
Dwangwa
Bua
Rusa
Lilongwe
Linthipe
Shire
Mwanza
Zambezi
To Nacala
To Beira
To Salisbury
To Nyimba
32°
34°
36°
10°
12°
14°
16°
REPUBLIC OF ZAIRE
TANZANIA
ANGOLA
ZAMBIA
MALAWI
MOZAMBIQUE
ZIMBABWE
NAMIBIA
REPUBLIC OF BOTSWANA
SWAZILAND
LESOTHO
REPUBLIC OF SOUTH AFRICA
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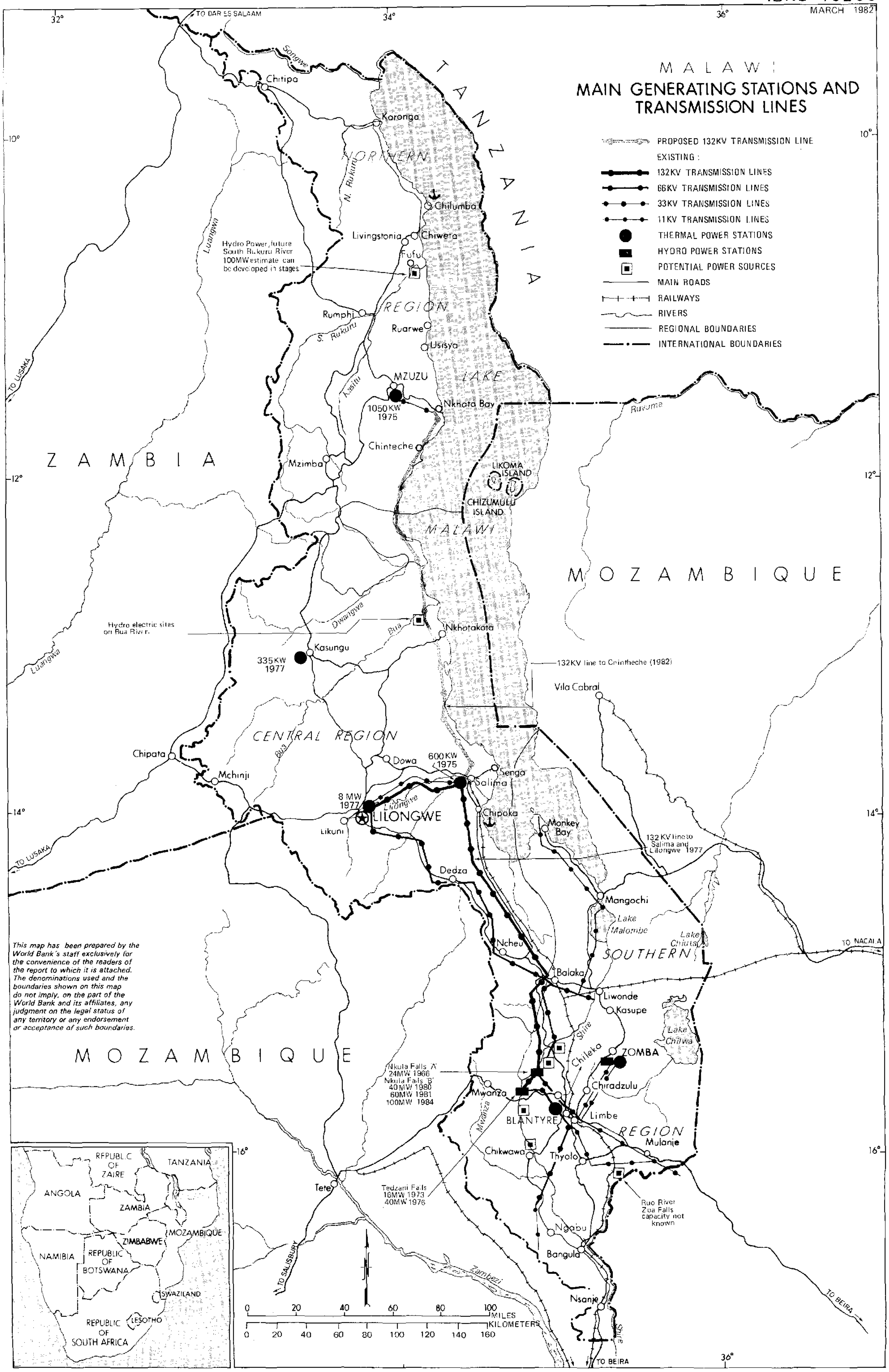
IBRD 14336R
MARCH 1982

IBRD 16266



MARCH 1982
MALAWI
MAIN GENERATING STATIONS AND TRANSMISSION LINES
PROPOSED 132KV TRANSMISSION LINE
EXISTING :
132KV TRANSMISSION LINES
66KV TRANSMISSION LINES
33KV TRANSMISSION LINES
11KV TRANSMISSION LINES
THERMAL POWER STATIONS
HYDRO POWER STATIONS
POTENTIAL POWER SOURCES
MAIN ROADS
RAILWAYS
RIVERS
REGIONAL BOUNDARIES
INTERNATIONAL BOUNDARIES
TO DAR ES SALAAM
32°
34°
36°
10°
12°
14°
16°
TANZANIA
ZAMBIA
MOZAMBIQUE
Chitipa
Karonga
NORTHERN REGION
N. Rukuru
Chilumba
Livingstonia
Chiweta
Fufu
Hydro Power, future South Rukuru River 100MW estimate can be developed in stages
Luangwa
Rumphi
S. Rukuru
Ruarwe
Usisya
TO LUSAKA
MZUZU
1050 KW 1975
Nkhata Bay
LAKE
Ruvuma
Chinteche
Mzimba
LIKOMA ISLAND
CHIZUMULU ISLAND
MALAWI
Dwangwa
Hydro electric sites on Bua River.
Nkhotakota
Bua
Kasungu
335 KW 1977
132KV line to Chintheche (1982)
Vila Cabral
CENTRAL REGION
Chipata
Mchinji
Dowa
600 KW 1975
Senga
Salima
8 MW 1977
Lilongwe
LILONGWE
Likuni
Chipoka
Monkey Bay
132 KV line to Salima and Lilongwe 1977
Dedza
Mangochi
Lake Malombe
Lake Chiuta
SOUTHERN REGION
TO NACALA
Ncheu
Balaka
Liwonde
Kasupe
Lake Chilwa
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Shire
Chileka
ZOMBA
Nkula Falls 'A' 24MW 1966
Nkula Falls 'B' 40MW 1980 60MW 1981 100MW 1984
Mwanza
Chiradzulu
BLANTYRE
Limbe
Mulanje
Chikwawa
Thyolo
REPUBLIC OF ZAIRE
TANZANIA
ANGOLA
ZAMBIA
MOZAMBIQUE
ZIMBABWE
NAMIBIA
REPUBLIC OF BOTSWANA
SWAZILAND
LESOTHO
REPUBLIC OF SOUTH AFRICA
Tete
Tedzani Falls 16MW 1973 40MW 1976
Ruo River Zoa Falls capacity not known
Ngabu
Bangula
TO SALISBURY
Zambezi
Nsanje
TO BEIRA
0 20 40 60 80 100 MILES
0 20 40 60 80 100 120 140 160 KILOMETERS