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THE USE OF COAL IN MALAWI

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PREFACE

Traditionally, Malawi has always looked first at its important agricultural base. Today, even that rich agricultural base is affected by energy-related problems. The availability of land for increased production and the need for additional fertilizer are all part of the increasingly complex energy picture in Malawi. Coal, as a traditional fuel in this country, has a role to play in its agriculturally based economy.

In areas of the country where the growth of fuelwood is competing with agricultural needs, there may be some coal use to replace the fuelwood. This can provide the additional agricultural lands needed for the increasing population growth. In addition, women released from hours of collecting fuelwood will have the opportunity of raising local crops to supplement their food supply. They will similarly have time to spend on better health care, and the educational, and nutritional needs of their children.

Any use of indigenous coal to replace imports will assist the foreign exchange problem, thus aiding the total population by strengthening the economy. There is also an opportunity to develop coal resources in such a manner as to encourage economic growth in new areas and develop new jobs in specifically selected labor-intensive industries. As economic growth is desired in the Central and Northern regions, there may be opportunities to also develop coal base-load thermal electric power to supplement and compliment the hydroelectric capacity.

Thus it can be seen that a continuing coal exploration program which includes the development of a coal testing laboratory can lead to coal exploitation in a manner highly consistent with Malawi's needs for increased agricultural production.

* * * * * *

This report, "The Use of Coal in Malawi," represents one half of a team effort by Frederick O. Simon of the U.S. Geological Survey and Marsha Gorden of Development Sciences Inc. covering the work assignment, Development of an Energy Laboratory for Coal Analysis. The accompanying report by Frederick O. Simon is available from its author and from U.S. AID.

This report, "The Use of Coal in Malawi" is designed to show past and present uses of coal and project possible future uses of coal in order to demonstrate the need for a coal testing laboratory. The laboratory, which is a necessary step in the development of indigenous resources, is described in the accompanying report, "The Development of a Coal Analysis Laboratory in Malawi" by Frederick O. Simon. Taken together, the two documents include discussions on the alternative uses for coal and a specific design for an appropriate coal testing laboratory. The need for an analytical facility is based upon the country's need for a continuing program of coal exploration.

These reports resulted from a trip to Malawi over the period September 18 through October 8, 1982. Information on the visit can be found in Exhibit A, "Trip Itinerary and Meeting Schedule." This author greatly appreciates the assistance of Dr. Richard L. Johnson, Chief Geologist and James C.

Chatupa, Assistant Chief Geologist of the Geological Survey Department (GSD) of the Ministry of Forestry and National Resources, Malawi; and David J. Garms, Acting Director of USAID, Lilongwe and Charles Bliss, Energy Office of Science and Technology, USAID, Washington. These four gentlemen developed the organization, maintenance and intellectual spirit necessary for accomplishment of the work order.

I. INTRODUCTION

A small landlocked country heavily dependent on imported energy sources must evaluate all energy-related development opportunities extremely carefully. Fortunately, Malawi has traditionally considered unique solutions appropriate to its location and characteristics since Independence. The development and continued use of coal in the country is another opportunity for a specifically Malawian approach. The purpose of this report is to illustrate the role of a coal testing laboratory in the overall exploration program and in the continuing use of coal in Malawi. It is designed to accompany a separate report on the preparation of the laboratory.

Coal importation and subsequent use in Malawi are quickly approaching a crossroads. Even though a negotiated contract for a year has been reached with the Tete Mine in Mozambique, the supply has been constantly interrupted by insurgency on both the rail and truck routes. The situation has reached the point where production in key industries has been frequently halted, exports are affected, energy efficiency is decreased, and valuable manpower and irreplaceable finances are lost. There is no easy solution in the short run, but if industrial expansion and growth are to continue, some steps must be taken.

Coal supplies are obviously not the only affected import, and similar problems with all petroleum products negate conversion to oil or diesel. All existing supply routes are being utilized as possible and, in the most severe times, petroleum products have been flown in at great outlay of foreign exchange.

There are some opportunities for industrial energy conservation and changes to fuelwood or solar energy in specific industries which are appropriate, but there are fuelwood short areas in the country as well. In addition, the

population growth rate approaching 3 percent and the urban growth rate approaching 8 percent will continue to press at the fuelwood supply, especially in the urban areas where many of the industries are located.

Thus the need for continued coal exploration in this country which has a strong coal infrastructure can be expected to remain a high priority, and the development of a coal testing laboratory is an important next step.

II. A BRIEF REVIEW OF ENERGY USE IN MALAWI

Historically, the predominant source of energy in Malawi has been fuelwood and at the present time it accounts for approximately 90 percent of the country's energy use. The remaining 10 percent is made up of agricultural residues such as bagasse, hydroelectricity, imported petroleum products and imported coal. As end-use efficiencies of these various fuels are considered, the ratio becomes approximately 70 percent fuelwood and 30 percent other. Figure 1, "Energy Supply by Source, 1980,"* presents a detailed breakdown of these fuel sources.

Figure 1

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

Diminishing supplies of fuelwood in the heavily populated areas and disruptions in the importation of petroleum products and coal are causing serious

*"Malawi: Issues and Options in the Energy Sector," Document of the World Bank and UNDP, Energy Department, May 1982, p 4.

economic consequences across the economy. All sectors are affected and the major purpose of continuing the examination of indigenous coal supplies is to evaluate potential solutions to these shortages. Figure 2, "Sectoral Energy Consumption Pattern, 1980,"* which is a rough estimate made from varying sources, indicates which sectors are most influenced by changes in specific fuel supplies.

The importance of energy for the industrial sector with its heavy use of both fuelwood and commercial energy is readily apparent. Industry in Malawi is primarily based upon agricultural processing; tobacco, tea, beverages, and textiles are major sources of employment. Industrial minerals are also important sources of employment and users of energy with brickmaking and cement as leading subsectors.

Industrial use of fuelwood is heaviest in tobacco and tea processing and brickmaking. The Tobacco Research Authority, a grower-supported advisory group, has begun energy efficiency evaluations of tobacco processing to determine opportunities for design changes and improvements for furnaces and barns. It appears that this work will be extremely useful in reducing the energy use per unit of tobacco in the future. The tea plantations similarly are struck by their energy source coal's high prices along with its frequent unavailability and are evaluating more efficient use of local fuelwood for their processing needs. As a group, they are tending towards fuelwood grown on their own plantations as a major energy source. It can be anticipated that the more rural locations of tea and tobacco with sufficient opportunity of using fuelwood will continue to do so and will utilize it in a more efficient manner. The more urban locations, especially in the fuelwood short Southern Region,

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*Ibid, p. 6.
(These estimates based on data supplied by ESCOM, OILCOM, GOM and other agencies.)

Figure 2

SECTORAL ENERGY CONSUMPTION PATTERN, 1980*
(thousand toe)

Source	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		21.9	276.3
(Percent)	(58.5	(29.2		(7.9)	(100.0)
Fuelwood	1527.0	-		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 90% 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: "Malawi: Issues and Options in the Energy Sector," Document of the World Bank and UNDP, Energy Department, May 1982, p 6.

however, will find it more difficult to use fuelwood and will probably continue with coal as long as it is available.

The small-scale brickmaking industry, based upon Malawi's extensive clay deposits, is well developed in most areas of the country. It depends completely upon fuelwood and in the urban areas is facing increasing shortages. At the present time no provisions have been made for specific fuelwood supplies for this industry and industrial expansions in urban areas where potential growth is greatest are therefore limited.

As can be seen by Figure 2, "Sectoral Energy Consumption Pattern, 1980," all sectors of the economy are obviously affected by the severe shortage of commercial energy and gradually decreasing supplies of fuelwood. It is, however, the urban-located industrial sector which supports the major agricultural and mineral products of the country which is presently suffering the most severely. Add to the energy shortages with similar fertilizer and other raw material import problems, and it becomes readily apparent that the industrial sector of this landlocked country cannot be expected to prosper and grow with this continuing pattern of supply interruptions.

III. THE HISTORICAL USE OF COAL

Imported coal has come into Malawi from neighboring Zimbabwe, Mozambique, Zambia and South Africa concurrently with the development of electricity and industry and the building of schools and hospitals.* The earliest industries were tea and tobacco processing, followed by cement in 1956 and then later additional food/beverage processing and diversified manufacturing including textiles.

Coal from the Wankie Mine in Zimbabwe was the most common source and many presently utilized industrial boilers were specifically designed for its use. It traditionally arrived by rail on a route through Mozambique (see Figure 3). The closing of the Rhodesia/Mozambique border in the mid 1970s first cut this supply and made the finding of alternative supplies imperative. At that time, mine sources in South Africa, Swaziland, and Mozambique were sought and coal use evaluated from both a chemical and economic basis. For several years, the major supplier was the Moatize Mine at Tete, Mozambique, and the others were used as necessary. In 1977, the second major disruption came with the closing of the Tete Mine causing extreme economic hardship on the coal using economy.

This action prompted His Excellency the Life President to meet with several members of the coal using community and charge them with the responsibility of finding and obtaining coal for all coal users in Malawi. The establishment of the Coal Users' Committee, begun as a temporary assignment in 1977, has continued to this date. It includes all the users in the country with the exception of the Portland Cement Company, which is the largest

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* It should be noted that it is believed that coal use in Malawi dates from the Iron Age at the Livingstonia outcrop in the Northern Region. It was also later used to support Mission activities at that site.

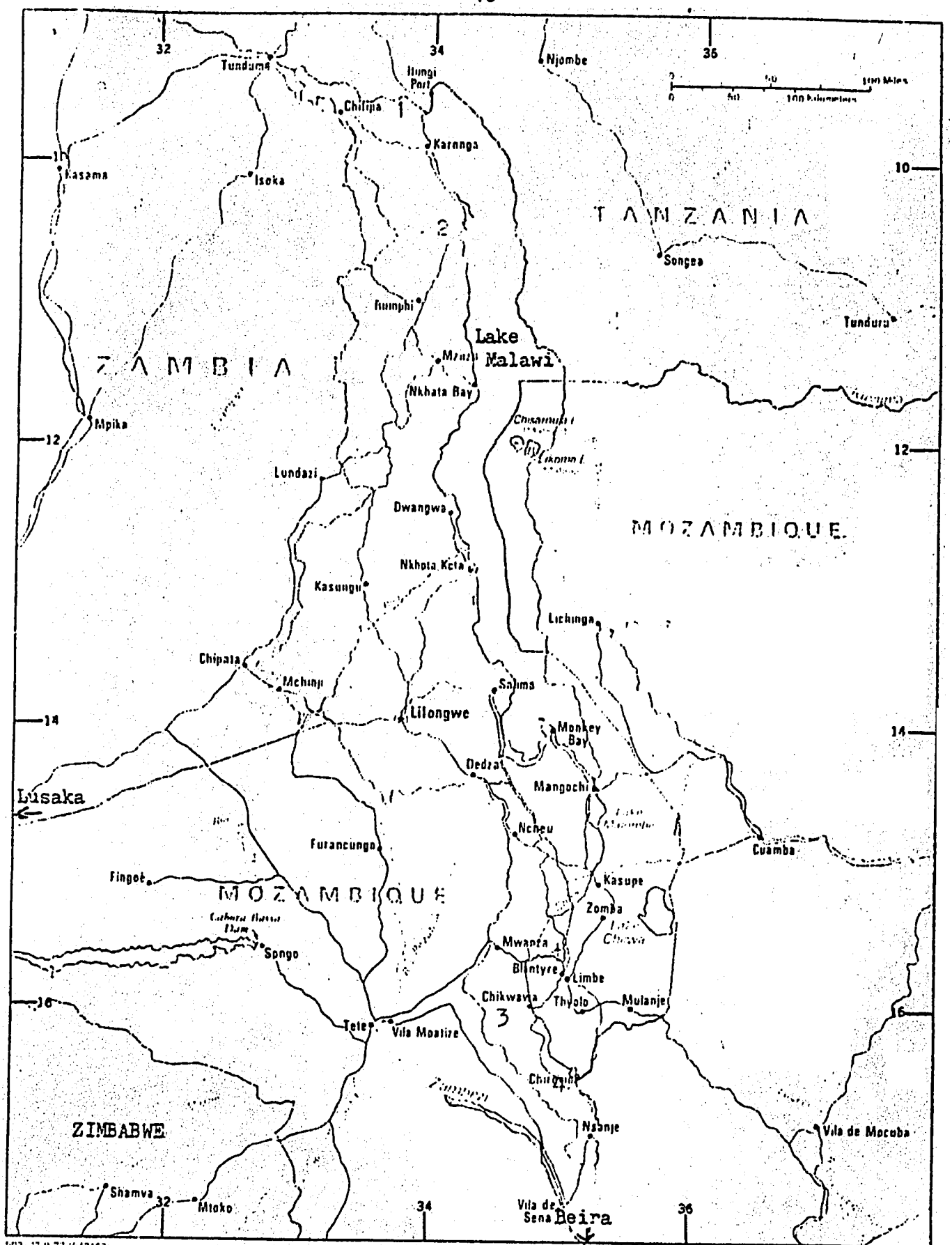


Figure 3
MALAWI AND ITS NEIGHBORING COUNTRIES

Coalfields: 1, Ngana; 2, Livingstonia; 3, Sumbu Nkombedzi; 4, Chiromo.

coal user and has continued to negotiate on its own behalf directly with the mines. The Committee has consistently sought coal sources from a number of mines, but the difficulty of local companies in raising capital to pay in advance for large quantities and the problems of varying quantities and qualities have continued to plague them. The coal testing laboratory will be able to assist the members of the Committee in the verification of quality levels.

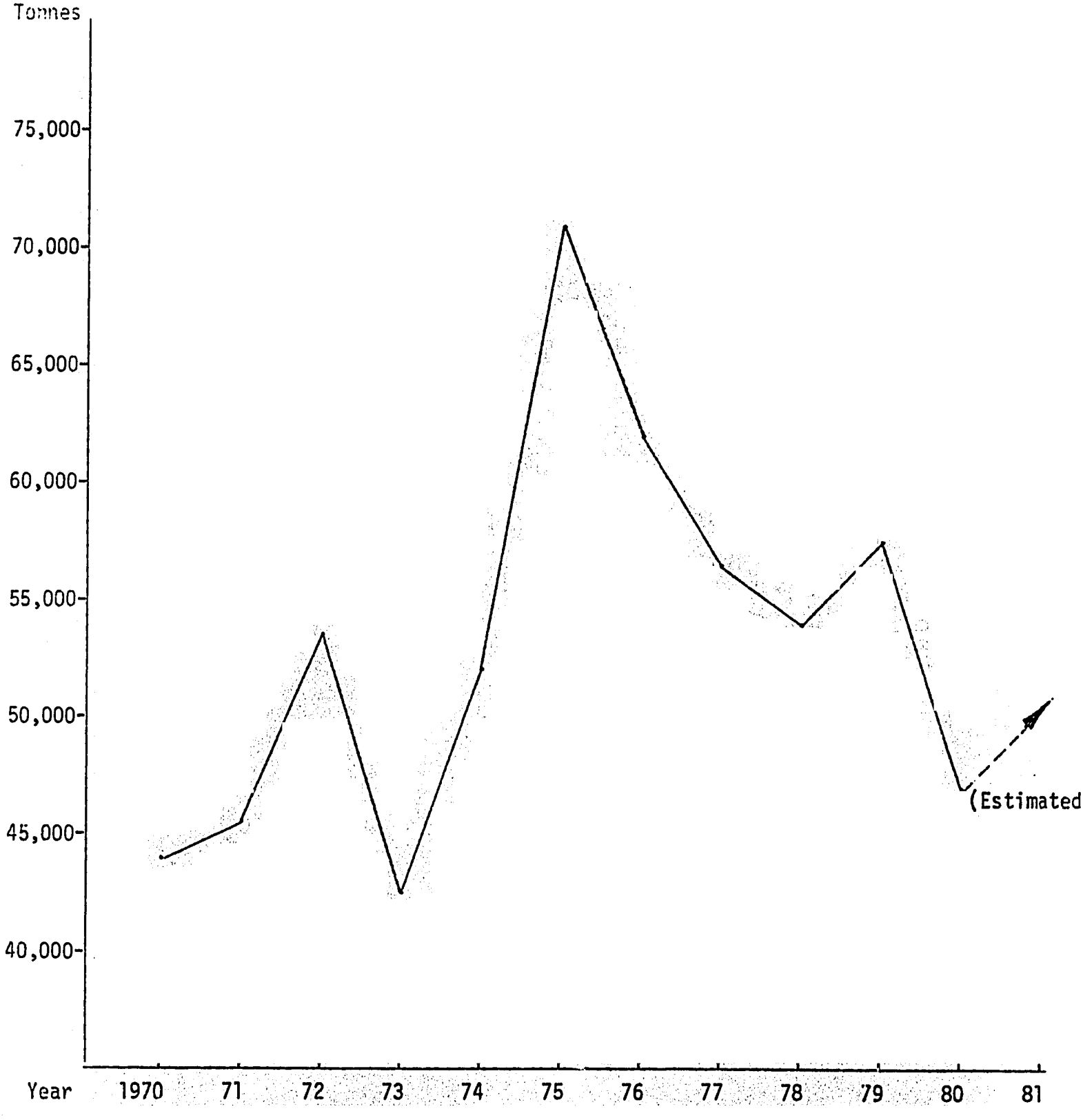
The Tete Mine has since reopened but continuing insurgency in Mozambique has periodically cut the railroad line resulting in frequent interruptions of supplies through Mozambique. The other railroad line serving Malawi from Macala, Mozambique, has proved inadequate in handling the required tonnage. Additional supplies have entered the country by truck over extremely poor quality roads directly from Tete to Blantyre. Also occasional supplies from Zambia have been transported by road from Lusaka to Lilongwe.

The Committee has served the coal users with coal from varying nations for several years now, even being approached by Tanzania to buy several hundred tonnes per month in 1978 from their nearby Ngana coal. There are, however, no other neighboring countries with supply routes suitable for coal importation at the present time.

These variations in dependability of supply have caused the coal consumption, as indicated in Figure 4, to vary greatly from year to year. It is difficult to estimate what use might have been made of coal if it were freely available over the decade, but it is know that the cement plant was closed at certain times over this period due to lack of coal. During those periods, cement was imported and 1000 jobs temporarily lost. Generally coal usage in the cement plant over normal years ranges from 30 to 35,000 tonnes per year. In addition, the energy efficiency of this largest energy user has been lowered due to non-continuous operation of the kilns in years of insecure

Figure 4

OAL CONSUMPTION IN MALAWI



Source: "Malawi: Issues and Options in the Energy Sector," Document of the World Bank, May 1982, p. 72.

coal supply. It is, of course, extremely difficult to estimate the economic impact of the coal shortages on the gross national product, but it has certainly been affected as the coal using industries are major producers for both local consumption and exportation.

In September, 1982, the Coal Users' Committee was reporting coal prices of $53/tonne (K56) by rail from Tete to Blantyre, $75 (K79) by convoy truck from Tete to Blantyre, and $100 (K105) from Wankie by rail through Mozambique to Blantyre and up to $210 (K220) for small quantities from Wankie through Lusaka to Blantyre. Coal users are estimating that prices may reach $123 (K129)/tonne in the near future. Coal prices from different sources should not be compared directly as coal from Tete is unwashed, contains fines, and has a heat content of 10-11,000 Btu/lb whereas coal from Wankie has approximately 14,000 Btu/lb. There are differences in ash content and size similarly controlling its use. Most of the coal users have boilers with chain grates and some have needs for high pressure steam which the Tete coal cannot meet. Figure 5, "Coal Requirements," shows the major coal users with their size and quantity needs for September, 1981. It should be noted that the cement plant is not included and also recognized that cement needs for a raw material supply are different from other industry needs for steam. A high ash content and small particle size are actually beneficial in cement production.

The Coal Users' Committee presently has an agreement for a year's supply of Tete coal. This agreement for a total of 80,000 tonnes appears to be linked to or include the one for 40,000 tonnes for the Portland Cement Company. There are, however, insufficient transport mechanisms to carry this quantity, even though the cement plant is presently using its own trucks. There is great hesistancy in utilizing the dangerous road from Tete, even in convoys, and no assurance that the railroad will continue to remain open; thus resulting

Figure 5

COAL REQUIREMENTS

INDUSTRY	USER	PER MONTH (M.T.)	SIZE (mm.)
TEXTILES	David Whitehead & Sons (M) Ltd		11-25
MANUFACTURING	Lever Brothers		11-25
TOBACCO	Lytton Tobacco Co (M) Ltd (Limbe)		11-25
	Limbe Leaf Tobacco Co Ltd (Lilongwe)		11-25
	Thondwe Tobacco Co Ltd		11-25
	Campbell Tobacco Co (M) Ltd		11-25
	Standard Tobacco Parkers (M) Ltd		11-25
	R W J Wallace Ltd		11-25
	E D Pyman		20-40
TEA	I Conforzi Ltd		11-25
	Malawi Tea Factory		11-25
	Chitakali Tea Estate		11-25
	Naming'omba Tea Estates Ltd		11-25
GOVT INSTITUTE	Queen Elizabeth Hospital	120	11-25
	Zomba Prison	40	20-40
	Zomba General Hospital	40	20-40
	Zomba Mental Hospital	40	20-40
BREWERY	Carlsberg (M) Ltd	35	11-25
	Chibuku Products	80	11-25
METAL	Encor Products Ltd	20	11-25
	Petroleum Services	40	11-25
FERTILIZER	Optichem (M) Ltd	270	11-25
TRANSPORT	Malawi Railways Ltd	31	20-40
MINERAL WATER	Southern Bottlers	19	11-25
EDUCATION	Designated Schools	10	20-40

Source: Coal Users' Committee Data for September, 1981. This list does not include the Portland Cement Company.

in no secure supply of coal at this time for Malawian needs. This is an extremely unstable industrial climate in which to operate, and certainly even a more difficult one in which to plan for increased economic growth.

IV. FUTURE POTENTIAL USE OF COAL

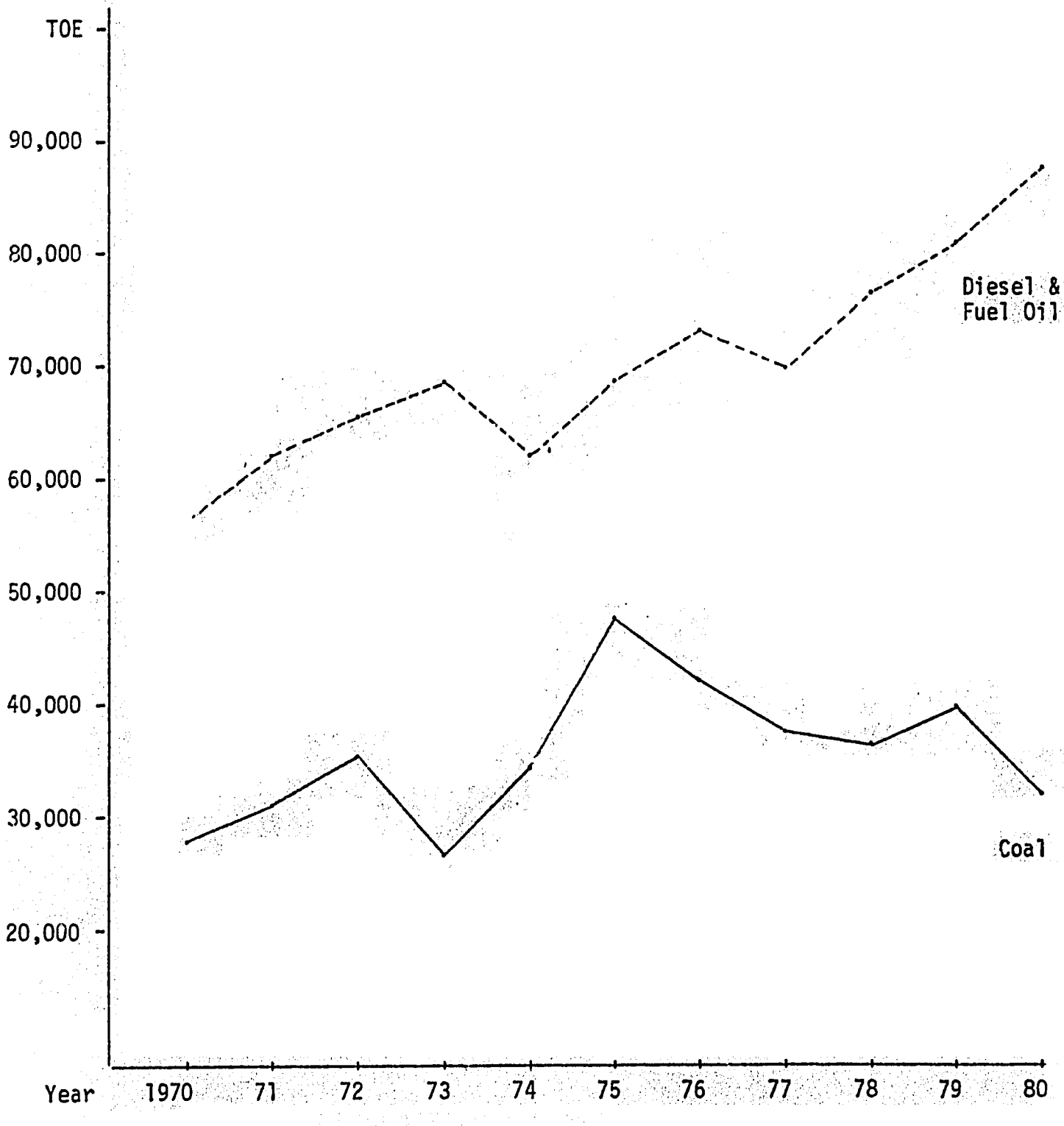
At the present time, as has been noted, the major use of imported coal is in industries for both steam needs in manufacturing and process needs in cement. There is an opportunity for increased industrial coal consumption in the future due to economic growth. Increased usage could occur both through existing plant expansions as well as new plant sites. Ongoing discussions for new cement capacity at Kasungu and other prospects such as new fertilizer production and other increased manufacturing capability could be serviced by coal. Increased agro-production in those urban areas without fuelwood availability could similarly be fueled by coal. Prospects for future coal imports or the developing of indigenous supplies are directly related to economic growth of those industries dependent upon coal's higher heat content or its use as a feedstock.

An additional opportunity for increased coal usage exists as a replacement for diesel and furnace oil. Over this past decade, diesel oil consumption has shown some drops but generally has been increasing from over 50,000 TOE to over 80,000 TOE. Furnace oil, on the other hand, had decreased from over 5,000 TOE in the early seventies to near 3,000 TOE by the end of the decade. It can be assumed that its use was replaced by diesel oil. The combined consumption values are shown in Figure 6, "Consumption of Diesel and Furnace Oil Compared to Coal Consumption (TOE)."

The opportunity for diesel and furnace oil replacement comes about through their use as a fuel for steam production both for industrial plants and electrical generation. Definitive data on diesel's use for these purposes aside from transport are not readily available, but it can be assumed that since over 40 percent of all petroleum products consumption is for industry, there are significant opportunities for replacement. Similarly, there is diesel

Figure 6

CONSUMPTION OF DIESEL AND FURNACE OIL
COMPARED TO COAL CONSUMPTION (TOE)



Source: "Malawi: Issues and Options in the Energy Sector," Document of the World Bank, May 1982, p. 73.

electrical generation in the four cities of Lilongwe, Kasungu, Mzuzu and Karonga totalling 8,355 kw with an additional number of small private diesel-fired generating plants (with capacity over 25 kw) totalling 22,826 kw. In the public sector, diesel generation makes up approximately 7 percent of the total installed capacity both interconnected and isolated. Continued diesel shortages with a change in the coal environment could provide an additional coal market.

Coal's position in the electrical generating capacity of the country is difficult to assess. There was early electrical generation from coal in Blantyre, but it has been replaced by a local gas turbine (15,000 kw) and an interconnected grid based primarily upon the less expensive hydro power. Plans for future expansion of electrical generation are based upon potential hydro power sites on the Middle Shire River to produce a national Interconnected System by 1983/84 with the exception of Karonga,* based almost entirely on hydro power. If there were available coal, it could be used to supply some base load power and also provide peaking relief in years of drought for a more balanced electrical generation system. Coal prices would have to compete with the less expensive hydro prices in order to even be considered for electrical generation. Additionally, any locations evaluated for possible coal thermal generation plants would require careful analysis of present and potential industrial and commercial needs to ensure replacement of existing diesel operations and provide for continued economic development, particularly in the Central and Northern Regions.

Specific areas in the Central and Northern Regions slated for economic growth where coal could provide feedstock inputs and steam/electrical supplies

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*"Malawi: Issues and Options in the Energy Sector," Document of the World Bank and UNDP, p. 80.

would be suitable opportunities for evaluation. New industrial plants such as cement, fertilizers, and other manufacturing enterprises could be well served by coal cogenerating plants, reserving hydro capacity for domestic and commercial use. Any consideration of coal for feedstock/fuel use in these areas must be carefully evaluated with plans for future industrial growth.

At the same time that increases in coal usage are considered, decreases in coal usage from conservation efforts and fuel substitution should also be evaluated. There has already been some discussion on fuelwood substitution as in the tea and tobacco industries, but solar energy is also a potential energy source for some industries.

A program of energy use audits for industry and commercial establishments will identify where conservation efforts are financially viable and also where fuel substitution is possible. Electrical use can be traced and heat lines evaluated, for example, to show possible solar replacement for low temperature water use. Conservation efforts and renewable resource substitution should always be a first step in any industrial/commercial energy plan.

There are other opportunities and purposes for expansion of coal besides its continued use in existing industries, its use as a feedstock and/or fuel for expanded or additional industrial sites, its use as a replacement for diesel and furnace oil in steam and electrical generating, and its use as a thermal baseload or peaking unit for a balanced electrical grid. These opportunities as a fuelwood replacement are based upon the increasing deforestation and subsequent fuelwood shortages of areas such as Blantyre, Zomba, the Lower Shire Valley in the Southern Region, and urbanized areas of Lilongwe, Dedza and Karonga in the Central and Northern Regions. The major uses of fuelwood in these areas are in homecooking and tobacco processing with a smaller amount consumed in brickmaking and other rural cottage industries.

A small amount of fuelwood, perhaps somewhat over 5,000 tonnes per year, is converted to charcoal for some of these purposes.

Replacement of either fuelwood or charcoal for these purposes by coal, probably in the form of smokeless briquettes, is a solution worth evaluating as part of a coal development plan in these more urbanized areas which are already fuelwood short or anticipated to become fuelwood short in the near future. It appears that the rural population at the present time does not believe that there is a fuelwood shortage* and has not changed patterns of lifestyle to reflect a shortage. In many developing countries, perception and adaptation occur too late to prevent widespread economic shortages and subsequent difficulties. Before these shortages become apparent it is important to consider both fuelwood conservation efforts including new stove designs as well as changes in supply patterns. These changes can include strong reforestation programs, introduction of fast growing tree species, and even new fuels where it appears the population, technology for use, and spirit of adaptation are available. Such a change could be towards the use of coal briquettes.

Coal briquettes can more easily replace existing charcoal uses rather than fuelwood uses since the heat contents, types of technology required, and experiences of the population are more similar. In Malawi, charcoal is presently utilized by the urban population for cooking, and by the rural population for cottage industries such as metal tool production in the villages. A survey on charcoal use is currently underway by the Ministry of Forestry and Natural Resources and more accurate information on charcoal demand and production will be extremely helpful in future energy resource planning for

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*Ibid., p. 11., and conversations as noted in Exhibit A, "Trip Itinerary and Meeting Schedule."

both charcoal use where appropriate and cost effective, as well as for potential coal briquette use.

Since any potential conversion of fuelwood into charcoal for domestic cooking and rural industries depends upon the quantities of available fuelwood, it is important to consider a supply and demand balance for fuelwood by Region. Figure 7, "A Fuelwood and Building Poles Demand and Supply Balance by Sector and Region for 1980," follows.* It shows the total balance to be negative with the greatest shortfalls in the Southern and Central Regions. Any additional conversion to charcoal, therefore, in those fuelwood-short areas could conceivably compete with the domestic fuelwood supply.

At the present time charcoal prices range from K2.75 to K4.50 per 30 kg bag depending upon location. These prices are based upon varying wood raw material costs developed for use in estimating the feasibility of charcoal production.** An increase in raw material cost, such as for plantation grown wood from K2.00 to K5.80 could raise the price of charcoal depending upon type of kiln, transport, etc., to approximately K4.47 per 30 kg bag or almost K150 per tonne.

Any potential use of coal briquettes in charcoal replacement for these purposes would be based upon a competitive price of coal with an adequate supply and distribution network appropriate to the fuelwood-short areas.

New markets of coal in the rural sector could come about in seriously depleted fuelwood areas through a combination of a readily available supply of low-cost coal briquettes and a development program based upon an extension service; perhaps through the efforts of the new Small-scale Enterprise Development

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*Ibid., p. 11.

**The K4.50 per 30 kg bag is at Lilongwe and Kawale Markets based upon a raw material cost of K2.00 per cubic meter. Source: Ret No 14/9/15 from R. A. Owen, the Senior Planning and Management Officer, Ministry of Forestry and Natural Resources, 4/8/82.

Figure 7

FUELWOOD AND BUILDING POLES DEMAND AND SUPPLY
BALANCE BY SECTOR AND REGION FOR 1980
(thousand cubic meters)

	Domestic	Tobacco	Institu.	Other Industry	Total Demand	Demand Poles	Total Demand	Sustained Supply	Balance
Southern	2479.3	1212.6	8.3	291.8	3992.0	795.1	2797.1	1380.8	(3406.0)
Central	1891.2	3246.3	10.2	6.6	5154.3	602.4	5756.7	2960.0	(2796.0)
Northern	569.2	44.1	13.6	86.9	713.8	464.1	1167.9	4606.4	3438.0
Total	4939.7	4503.0	32.1	385.3	9860.1	1851.6	11,711.7	8947.2	(2764.0)

Source: Fuelwood and Poles Project, Ministry of Agriculture and Natural Resources, 1978. Taken from: "Malawi: Issues and Options in the Energy Sector," Document of the World Bank and UNDP, May 1982, p. 11.

Organization of Malawi (SEDOM) as recently organized by the Ministry of Trade and Industry, along with efforts of other groups such as the Women's League and local industrial organizations including the Brickmakers Association. In these cases, coal briquettes would be replacing traditional fuelwood and thus require both new combustion technologies such as the metal stoves used in urban and some rural areas for cooking and new types of kilns for brickmaking. Extension services would play a key role in development and encouragement of this new fuel.

The potential market for coal briquettes in urban cooking is best estimated from the urban population's possible use of charcoal. This procedure considers the market for coal briquettes to be essentially charcoal replacement. The latest census in 1977 includes an urban total of 470,658 out of the country total of 5,532,298. Per capita consumption of wood* has been estimated at 0.85 m^3 per year for 1980 and at 0.65 m^3 in 2000. Using an assumption of 0.75 m^3 or 0.56 tonnes/year** for a proposed project date of 1990, one could estimate wood and then charcoal use for a group of urban dwellers.

One can select a target population of 10% of the urban area as an entry market for charcoal, and base its charcoal use on approximately one half the quantity of wood. Charcoal has approximately twice the heat value of wood.*** If this target group of 50,000 people uses 0.5 tonnes of wood or 0.25 tonnes of charcoal on a per capita basis, it would require 12,500 tonnes/year of charcoal to supply this 10% of the urban population with charcoal.

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*Ibid., p. 18.

** 1 m^3 of wood = approximately 0.75 tonne depending upon nature and type of wood.

*** With approximately 25 percent yield.

One can consider that coal briquettes would have roughly the same or a slightly higher heat content than the charcoal depending on both the quality of the raw material and the method of production of each to evaluate the amount of coal briquettes necessary to supply the target market of 10 percent of the urban population. If one assumes that the somewhat over 5,000 tonnes of charcoal consumed today is used for urban cooking then the target population of 10 percent coal briquettes users represents approximately a doubling of today's charcoal users.

One can similarly make an estimate of potential coal briquettes used for brickmaking. A recent survey* in 1978 estimated that over 15,000 people were employed in the industry producing over 53 million bricks with over 56,000 cubic yards of wood. Since at the present time cubic meters appear to be substituting for cubic yards, they can be approximated as equal and converted to 42,000 tonnes of wood or approximately 21,000 tonnes of charcoal. Again assuming a target market of 10 percent, somewhat over 2,000 tonnes per year of coal briquettes could be considered for early penetration of this market.

Thus it can be seen that small but reasonable penetrations of coal briquettes into both domestic cooking and brickmaking represent only a small use of coal. Charcoal replacement with coal briquettes, by itself, does not constitute a large enough market for development of Malawi's indigenous coal resources.

To summarize, future coal use can be based upon the existing industrial commercial use as represented by the members of the Coal User's Committee

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*Taken from "Development of Brickmaking Industry and Inventory of Industrial Ceramic Raw Materials," by William Buchanan. Prepared for the Government of the Republic of Malawi, the UNDP, and the UNIDO.

and the Portland Cement Company including conservation and changes to renewable sources with projections for increased economic growth. The projections for increased economic growth are difficult to determine because coal supply and use has been so unpredictable. Values for 1990 could range from 50,000 tonnes per year to 70,000 tonnes per year depending upon varying assumptions of economic growth and potential industrial conversion to wood. Replacement of diesel and furnace oil is the next potential use of coal, and possible coal conversions by industry would require capital costs for technology changes and coal infrastructure making many conversions unlikely. It can be assumed that the potential market here is only in the range of several thousand tonnes per year of coal, unless greater shortages of diesel and more availability of coal occur.

The use of coal for electricity generation is similar in that it again would mean a replacement of diesel. Readily available technologies generally lead to large sized plants, more than would be required or appropriate for Malawi. Additional investigation of coal requirements for small-sized generating plants is necessary.

New economic growth in the Central and Northern Regions where steam/raw material and electrical needs could be met by coal is again a possibility for investigation. Small cogeneration units could possibly compete with alternative fuels and hydropower depending upon the nature of the industry.

New uses of coal, based upon briquetting to produce an easily burned smokeless fuel, are interesting for domestic, brickmaking and small rural industrial uses where charcoal becomes noncompetitive due to costs. By themselves, however, these uses do not provide a basis for coal exploitation at this time. If and when coal development in Malawi begins on the basis of industrial coal consumption, then briquetting as a replacement for charcoal and/or fuelwood in fuelwood-short areas can be evaluated.

Finally, to conclude, there are two major types of consumption patterns for c al in Malawi. The first is basically a continuation of its present use recognizing industrial conservation and changes to renewable sources, with some possible new or expanded industrial clients and/or electrical generation stations to balance the grid. The second is a completely new approach based upon coal briquetting which could supply a replacement fuel for charcoal in the near future and wood in the more distant future. Since the second use is too small for a market by itself, it is reasonable to consider replacement of the existing industrial use as the primary market for indigenous coal. Coal use by industry at the present time must be accepted as a given. There are no quick and inexpensive alternatives after the opportunities for conservation and renewable fuel sources are evaluated. Malawi, therefore, needs to continue on the path of continued exploration leading to potential exploitation. The laboratory, with its use by both the public and private sectors, is an important next step.

V. ALTERNATIVE STRATEGIES FOR DEVELOPMENT

At the present time the coal exploration program of the Geological Survey is proceeding towards more complete mapping and further estimates of reserves in several coal fields. The development of the coal laboratory will increase this capability by providing ready access to analytical equipment which will provide quick and accurate quality data. The organization of a coal data base will greatly enhance the decision-making process on the potential development opportunities for coal in Malawi.

As has been previously described, there are basically two approaches to coal utilization in Malawi which affect the future plans for development of indigenous supplies. The first is based upon the existing usage including conservation and changes to renewable fuel sources with the possible expansion into new industries for raw material/fuel requirements or electrical generation. The second involves the development of a coal briquetting industry which supplies a smokeless fuel first to fuelwood-short urban households for cooking and rural industries for brickmaking or ironworking and then second to fuelwood-short rural households for cooking. The coal laboratory requirements of this second approach would be increased by the need for physical testing of the briquettes for breaking strength and abrasion properties. The laboratory has been planned to accommodate these functions. Other requirements such as heat content, smoke evolution, etc., are already covered in the accompanying design of a coal testing program.

Three major feasibility studies have been carried out on the exploitation of the Ngana coal field which to date is the most completely documented coal field in the country. The Chamber of Mines of South Africa, the Japan International Corporation Agency and Kier International Limited have each made

estimates of Ngana Coal Reserves, its quality, the coal recovery rate from beneficiation, mining methods and capital and operating expenses. Production estimates of washed coal with a calorific value of 24 MJ/kg have ranged from 70,000 t/yr to 200,000 t/yr. These studies completed over the years 1975 to 1978 have produced somewhat conflicting results over costs but generally concluded that exploitation with the goal of replacing imports was uneconomic.

It was not the purpose of this report to evaluate and compare these three feasibility studies on the exploitation of Ngana coal.* It should be noted, however, that they appear to be developed from the point of view of traditional large-scale mining projects based upon the use of heavy, automated where possible, equipment. Personnel estimates, for example, range from approximately 300 to under 470. For comparison purposes, the cement plant at Changalume with its associated limestone quarry produces up to 110,000 tonnes/year of clinker with a work load of over 1,000 employees. David Whitehead and Sons, Ltd., in Blantyre has a work force of 3,200 employees in its textile plant. A capital investment of the size necessary to exploit the coal should include as large a work force as possible. Previous evaluations from the concept of large-scale mining operations did not produce jobs.

The issue of market size is also important. Assuming that the use of coal in 1975 of over 70,000 tonnes/year is a base load to be expanded upon may not be a valid assumption. As previously shown, coal use since 1975 has declined, and there are opportunities for conservation and coal replacement by fuelwood and solar energy in some agro-industries where high pressure steam is not required. The market survey prepared for coal must carefully evaluate

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* Such a comparison has been produced by Press Holdings Ltd., Lilongwe, entitled "Ngana Coal Project," 10/9/82.

which existing industries can be converted to indigenous coal, where the market segments can reasonably be expected to increase and also where the segments can be anticipated to decrease. In this way, coal development can be seen as only one energy source in a group of other energy alternatives and therefore exploited and utilized in a manner most consistent with Malawi's economic goals and financial requirements.

As the geological and chemical data are collected, future decisions must be made. A mining feasibility study specifically designed for the labor-intensive, small-scale coal opportunity at Ngana and possibly other coal fields should be completed. Along with this study, a marketing survey covering both basic approaches to coal use is required. This economic study must project possible users and quantify their markets at varying delivered prices. Only in this way, can the true marketability of the coal be understood.

Similarly, the infrastructure designed to transport the coal to its markets must be carefully evaluated. It has been assumed that the coal will be trucked to the lake and then carried by lake steamer to Chipoka for rail transport to Blantyre and Lilongwe. It may be preferable to plan only for Ngana coal use in the Northern and Central Regions with shorter transport routes based upon coal as the transport fuel where possible. The availability of coal in these regions could lead to more northern industrial growth and subsequent population movement into these areas as presently envisioned by some growth plans.

The combination of the mining feasibility study and the segmented market survey should provide the data necessary for a decision on whether or not to exploit the coal. The mining study should confirm the proven mineable reserves, develop a labor-intensive mining technique(s) appropriate for a range of tonnages such as 15,000 to 75,000 per year, identify beneficiation

measures necessary to meet existing and proposed uses, and develop and cost an infrastructure suitable for delivering the coal to its most likely users. Certainly coordination of the feasibility and marketing efforts would result in the most efficient strategy for exploitation and utilization.

Any strategy for coal development must include a well thought out management plan. At the present time there are several disparate groups with much to offer. First of all, the Geological Survey in Malawi plays more than a minerals exploration role. They have ventured towards project development, for example, in their glass sands work and are striving to provide the same level of expertise in coal. With their small number of personnel and limited budget, they are hard pressed to play this coordinative role in project development, but are certainly well prepared to expand their informational role. The new coal laboratory will compliment and expand their present laboratory capability and strengthen their ties to the private sector.

The Coal User's Committee has developed a high level of expertise and they certainly should be encouraged to play an advisory, if not stronger, role. Their experience in negotiations with mining and transport companies in a half dozen different countries is invaluable and should not be lost in future efforts. Both they and the Geological Survey should continue in major roles.

Press Holdings Ltd. is presently playing a leadership role in evaluating and comparing the three major feasibility reports to date and in preparing the terms of reference for the next. Although they will not provide financing for a major coal undertaking, they are prepared to discuss alternative financing procedures with various banks and the private sector.

It would be anticipated that the leadership role in project development remain with the private sector and the role of market guaranteer remain with

the government. In addition, energy planning and coordination of events will continue as a government task with the Office of the President and Cabinet assuming a strong coordinative role.

Once this small-scale mining feasibility study and economic market survey are completed, and a management plan developed, there will be the opportunity of evaluating the two different strategies of coal development: capital-intensive, medium- to large-scale versus labor-intensive, small-scale. Only in this way will the most appropriate coal strategy for Malawi appear and be chosen.

This coal strategy must obviously fit with the overall energy plans of the entire economy. To do so requires an energy planning capability with authority to act. They must have a data handling system at some point in time to assist as the tradeoffs become more complicated.

Electricity, for example, may need to be examined in light of its possible use for ammonia fertilizer production through electrolysis (at 11 MWH/tonne NH_3) or its expanded use in rural electrification programs over the next 20 years. Similarly, transport costs for energy sources such as long distance movement of wood need to be evaluated. Any decision of this type requires a data base showing population growth, agricultural and industrial change and growth, and urban growth. The data base by sector and location should reflect the use of energy and the alternative energy forms with their characteristics including heat content in order to demonstrate where there are shortages and where there are surpluses. These data can be mapped to easily illustrate alternative solutions such as best sites for charcoal production. Over time a micro-computer can be utilized to assist the decision-making process.

In this way coal development alternatives, fuelwood utilization, electrical generation sources, and other economic growth scenarios can be evaluated and compared for Malawi's greatest benefit.

VI. CONCLUSIONS AND RECOMMENDATIONS

The coal testing laboratory is an important stage in the overall evaluation of coal resources in Malawi. As such it will serve the needs of the Geological Survey as well as the coal using community at large, and thus be an important energy analytical tool. By providing for expansion opportunities to cover future coal processing alternatives such as briquetting and oil exploration sampling, its use will be multiplied. Immediate consideration for the laboratory is strongly encouraged.

Evaluation of Ngana and other Malawian coal fields should follow a new strategy designed specifically for the country's unique situation. Feasibility studies should begin from a small-scale, labor-intensive point of view and relate to a segmented market study based on coal serving its most appropriate markets. Coal conservation efforts, fuelwood/solar substitution where applicable, and new coal uses based upon briquettes in fuelwood-short areas should be considered. It is recommended that any new feasibility studies for Ngana coal be structured to include this dual mining and marketing strategy.

Finally, coal use in Malawi should be viewed as part of an overall energy planning process which includes all sources of energy with their potential uses by sector relating to each form's characteristics including calorific value. In this way, each energy source can be considered on its own merits for its most appropriate use. Applicable energy source and use combinations should then be mapped to indicate locations of shortfalls and opportunities for change. Finally, energy-use projections for the future should be made on the basis of population growth, agricultural and industrial change and growth, and urban growth; and be similarly mapped. A small computer would be useful in the near future to demonstrate these mapped future energy requirements by energy form and thus permit energy-related decisions to be made in an

economically favorable manner. It is recommended that a group with overall energy planning responsibility be encouraged to seek assistance in developing such a data management program which provides information for these energy-related issues.

Exhibit A

TRIP ITINERARY AND MEETING SCHEDULE

September 18th	-	Arrive Chileka, Blantyre
	-	Check in at Mount Soche Hotel
September 19th	-	Orientation and Visit to Areas South of Blantyre
September 20th	-	0830 Hrs. Leave Blantyre. Check in at Government Hostel, Zomba
	-	1030 Hrs. Confirm Itinerary with Chief Geologist (CG) and Assistant Chief Geologist (ACG) Discuss Work Outline
	-	Start Examining other Coal Consultants Reports
	-	1330 Hrs. Discussions with CG and ACG Visit Geological Survey Division Laboratories (GSD)
September 21st	-	1000 Hrs. Visit Malawi Bureau of Standards (Mr. Chisala)
	-	1400 Hrs. Visit David Whitehead & Sons Ltd. (Mr. N. Rutherford, General Manager)
	-	1600 Hrs. Visit Lever Brothers (Mr. Mungwira, Technical Director)
September 22nd	-	0900 Hrs. Visit Changalume Cement Clinker Plant and Laboratory. (Mr. Ranawera, General Manager)
	-	1400 Hrs. Discussions with GSD and Studying Reports
September 23rd	-	0830 Hrs. Visit GSD Laboratories
	-	1330 Hrs. Visit Chancellor College (Lila E. Engberg, Assoc. Professor, Home Econ. Dept.)
	-	1500 Hrs. Visit SADZI Housing Project to Review Clay Stove Designs
September 24th	-	Begin Draft Report
September 25th	-	0900 Hrs. Meeting with Chairman of Coal Users Comm. (Bob Cormack, Chief Executive, Southern Bottlers, Ltd.)
September 26th	-	Drive to Lilongwe. Check in at Capital Hotel
September 27th	-	0830 Hrs. Meeting with R.J. Kott, Charge d'Affaires, American Embassy and David Garms, USAID
	-	1130 Hrs. Fly to Mzuzu from Lilongwe
	-	1430 Hrs. Depart by road for Karonga
	-	Check in at UTM Guest House
September 28th	-	0700 Hrs. Drive to Ngana Coalfield
	-	1400 Hrs. Visit Proposed Port Site at Kaporo

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September 29th
- 0700 Hrs. Visit to Lufira Coalfield
- 1300 Hrs. Drive to Mwesia to See Some Potential Targets for Coal Exploration

September 30th
- 0800 Hrs. Leave Karonga for Mzuzu
- 1000 Hrs. Visit Present Geological Survey Operations at Kaziwiziwi, Livingstonia Coalfield
- 1400 Hrs. Continue Journey to Mzuzu
  Check in at Mzuzu Hotel.

October 1st
- Morning Open
- 1315 Hrs. Depart Mzuzu by Plane to Lilongwe
  Check in at Capital Hotel
- 1515 Hrs. Visit Ministry of Forestry and Natural Resources. (Mr. David May, Chief Forestry Officer)
- 1600 Hrs. Telephone Call with Mr. David French, Energy Studies Unit, Ministry of Agriculture
- 1930 Hrs. Meet at Capital Hotel with Mr. B.W. Zingano, Architect with Ministry of Works and Supplies

October 2nd
- 1930 Hrs. Reception by David Garms, USAID
  Those Present:

Ministry of Forestry and Natural Resources

Mr. M. Mathotho, Deputy Secretary
Mr. P.J.S. Mpaso, Under Secretary
Mr. S.P. Kachipande, Principal Administrative Officer
Dr. R.L. Johnson, Chief Geologist
Mr. J.C. Chatupa, Assistant Chief Geologist

Ministry of Finance

Mr. W.J. Mabviko, Deputy Secretary
Mr. P.M.S. Kamtengeni, Administrative Officer
Mr. J.R. Phiri, Under Secretary

Office of the President and Cabinet

Mr. E.I. Chiwewe, Chief Development Division
Mr. J.D. Kalilangwe, Deputy Chief Development Division

Other Agencies

Mr. R. Borthwick, UNDP Representative

Exhibit A
TRIP ITINERARY AND MEETING SCHEDULE
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U.S. Mission

Mr. R.J. Kott, Charge d'Affaires, a.i.
Mr. D.J. Garms, Acting USAID Representative
Mr. J.E. Parsons, USAID Management Officer
Mr. J.T. Smith, Economic/Commercial Officer
Dr. F.O. Simon, USGS

October 3rd - Open

October 4th - 0800 Hrs. Roundup Meeting at Ministry of Forestry and Natural Resources
Present: Dr. W.K. Lipato, Principal Secretary
Mr. A.J. Nathotho, Deputy Secretary
Mr. P.J. Npaso, Undersecretary
Dr. R.L. Johnson, Chief Geologist
Mr. J.C. Chatupa, Assistant CG
Mr. Kachipande, Principal Admin. Officer
Mr. B.M.C.L. Phiri, Admin. Officer
Dr. F.O. Simon, U.S.G.S.

- 0930 Hrs. Roundup Meeting at Ministry of Finance
Present: Mr. J.R. Phiri, Undersec., Min. of Fin.
Mr. A. Mathoto, Deputy Secretary, MFNR
Mr. Chiwewe, Chief Devel. Officer, OPC
Mr. Mpaso, Undersecretary, MFNR
Mr. R.L. Johnson, Chief Geologist
Mr. J.C. Chatupa, Asst. Chief Geologist
Mr. Nthenda, Senior Economist, OPC
Mr. Kamtengeeni, Administrative Officer, Min. of Finance and USAID Desk Officer
Mr. B.M.C.L. Phiri, Admin. Officer, MFNR
Mr. David Garms, USAID
Dr. F.O. Simon, USGS

- 1200 Hrs. USAID Debriefing
Present: Mr. David Garms
Mr. Jay Smith
Mr. Jeremiah Parsons
Dr. F.O. Simon, USGS

- 1500 Hrs. Visit Ministry of Trade and Industry (Mr. Chunga, Deputy Secretary and Mr. Njolwa, Principal Economist for SEDOM)

- 1700 Hrs. Meeting at Capital Hotel with Press Holdings (Mr. Kamanga, Senior Economist)

October 5th - 0900 Hrs. Depart Lilongwe
Visit Port at Chipoka enroute to Zomba
Check in at Ku Chawe Inn

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October 6th	-	Complete Draft Report
October 7th	-	Complete Draft Report
October 8th	-	Complete Draft Report
	-	1640 Hrs. Depart Malawi

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10. "Ngana Coal Project," Press (Holdings) Limited, Projects Department, 10/9/82.

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14. "The Mines and Minerals Act, 1981 and Policy Guidelines," Ministry of Forestry and Natural Resources.

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