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Botswana: Issues and Options in the Energy Sector

September 1984

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REPORT NO. 4998-BT

BOTSWANA

ISSUES AND OPTIONS IN THE ENERGY SECTOR

SEPTEMBER 1984

This is one of a series of reports of the Joint UNDP/World Bank Energy Sector Assessment Program. Funding for this work has been provided, in part, under the supplementary "Small-Country Assessment Program" financed by the Swedish Government through the UNDP, and work has been carried out by the World Bank.

ABSTRACT

Botswana's energy problems present three broad challenges to energy planning: the first is sustaining an ongoing transition from the country's almost complete dependence on imported petroleum to increased reliance on local resources, particularly coal; the second is to devise and implement a strategy for exploring for and exploiting indigenous energy resources for export as well as domestic markets; and the third is overcoming institutional fragmentation in energy planning and sector management. The Government has made significant progress in outlining energy policy objectives which address some aspects of the above problems. This report reviews ongoing energy programs in Botswana and makes recommendations on: (a) the prospects for and economic viability of proposed projects to exploit huge coal deposits for exports; (b) the expansion and consolidation of the power system; (c) the scope for substituting diesel use for water pumping; and (d) the strategy for promoting exploration for oil and gas in the Kgalagadi desert area. The report also comments on Government initiatives concerning the supply and use of woodfuels, and efforts to apply renewable energy technologies to specific needs in the country.

ABBREVIATIONS AND ACRONYMS

AAC	Anglo-American Corporation of RSA
BCL	Bamangwato Concessions Ltd.
BDF	Botswana Defense Force
BHC	Botswana Housing Corporation
BMC	Botswana Meat Commission
BPC	Botswana Power Corporation
BRET	Botswana Renewable Energy Technology Project
BTC	Botswana Technology Centre
CAPC	Central Africa Power Company
CDF	Charbonages de France
CFTC	Commonwealth Fund for Technical Cooperation
CIDA	Swedish International Development Agency
DEE	Department of Electrical Engineering
DWA	Department of Water Affairs
EDF	European Development Fund
ESC	Electricity Supply Commission of Zimbabwe
ESCOM	Electricity Supply Commission of RSA
GOB	Government of Botswana
GPS	Gaborone Power Station
LDO	Light Diesel Oil
LPG	Liquified Petroleum Gas
LRMC	Long Run Marginal Cost
MCI	Ministry of Commerce and Industry
MFDP	Ministry of Finance and Development Planning
MMRWA	Ministry of Mineral Resources and Water Affairs
MOA	Ministry of Agriculture
MPS	Morupule Power Station
MWC	Ministry of Works and Communication
NDP	National Development Plan
NIR	National Institute of Development and Cultural Research
RIIC	Rural Industries Innovation Center
RSA	Republic of South Africa
SACU	South African Customs Union
SADCC	Southern Africa Development Coordination Conference
SIDA	Swedish International Development Agency
SPS	Selebi-Phikwe Power Station
TKR	Trans Kgalagadi Railway

CURRENCY EQUIVALENTS

1.00 Pula = US $0.87
1.00 Pula = 100 thebe
1.00 Pula = 1.06 Rand 1/

MEASUREMENTS

BTU (Btu)	British thermal unit	=	0.252 kilocalories
Bbl.	Barrel	=	159 liters
boe	Barrel of oil equivalent	=	6 million Btu.
m^3	cubic meter		
GWh	gigawatt hour	=	1,000,000 kilowatt hours
km	kilometer	=	1,000 meters
kV	kilovolt	=	1,000 volts
kVA	kilovolt ampere	=	1,000 volt amperes
kW	kilowatt	=	1,000 watts
kWh	kilowatt hours	=	1,000 watt hours
MW	megawatt	=	1,000 kilowatt
MWh	megawatt hour	=	1,000 kilowatt hours
MVA	megavolt ampere	=	1,000 kilovolt amperes
p.a.	per annum		
tonne	metric ton		
Tpa (tpa)	tonnes per annum		
hp	horsepower	=	0.746 kW

This report is based on the findings of an energy assessment mission which visited Botswana in August/September, 1983. The mission comprised Messrs. Amarquaye Armar (Mission Chief), Zia Mian (Senior Energy Planner), Paul Dyson (Senior Coal Specialist), John Stoddart (Senior Financial Analyst, Petroleum), Erdal Kabatepe (Consultant-Institutions), Daud Beg (Consultant-Power), and H. Waterland (Consultant-Petroleum Exploration). Mr. Masood Ahmed (Deputy Division Chief) joined the mission to take part in final meetings. Secretarial assistance for this report was provided by Mrs. Flavia Fernandes. The report was discussed with the Government of Botswana in Gaborone in June 1984.

1/ Until 1976, when Botswana established an independent Central Bank, the country's currency (Pula) was directly linked to the South African Rand. The value of the Pula (P) is now pegged to a basket of currencies consisting of Special Drawing Rights (SDRs) and the Rand. Exchange rates during March 1984 are indicated above.

ENERGY CONVERSION FACTORS

Fuel	Toe 1/ Per Physical Units
Liquid Fuel (Tonnes) 2/	
LPG	1.08
Avgas	1.04
Gascline	1.05
Kerosene/Turbo Fuel	1.03
Diesel Oil (LDO)	1.02
Electricity (MWh) 3/	0.25 and 0.09
Biomass Fuels (tonnes)	
Fuelwood	0.35
Coal (tonnes) 4/	0.56

1/ 1 TOE (toe) = 10 million kcal
= 6.61 boe
= 39.68 million Btu

2/
Avgas (Aviation Gasoline)	=	1413.6 liters/tonne
LPG (Liquified Petroleum Gas)	=	1729.1 "
Gasoline (Motor Spirit)	=	1,356.8 "
Kerosene/Turbo Fuel	=	1,229.1 "
Diesel (LDO)	=	1,186.5 "

3/ Converted at thermal power generation efficiency of 34% or 4 MWh per toe; and 12 MWh per toe at the level of consumption (end-use)

4/ Converted at calorific value of 5,636 million kcal per tonne

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I. SUMMARY AND RECOMMENDATIONS

The Energy Problem

1.1 Botswana's energy problems, although not as severe as those facing many other developing countries, present three broad challenges to energy planning: the first is sustaining an ongoing transition from the country's almost complete dependence on imported petroleum to increased reliance on local resources, particularly coal; the second is to devise and implement a strategy for exploring for and exploiting indigenous energy resources for exports as well as local markets; and the third is overcoming institutional fragmentation in energy planning and sector management.

1.2 With the exception of plans for establishing large export-oriented coal mines, the mission's recommendations are consistent with the Government's energy policy objectives for the Fifth National Development Plan (NDP-V). In the mission's view, the objectives are realistic, well conceived, and, for the most part, address the above problems.

Energy and the Economy

Country Economic Background

1.3 Botswana is a landlocked country which covers some 580,000 sq km in South Central Africa. Two thirds of the area is semi-arid and Kgalagadi (Kalahari) desert which is unsuitable for arable farming. Droughts occur regularly, often in successive years, and annual rainfall is unevenly distributed, varying from 250 mm in the southeast to 650 mm in the northern Chobe district. The country's population is about 941,000 (1981 Census estimate), but growing at about 3.3% a year. About 75% of the population has settled in the catchment area of the Limpopo River which is only 10% of the land area. Cattle rearing is the most important occupation. There were over 3 million head of cattle but persistent drought over the past three years has reduced the size of the herd considerably.

1.4 The country achieved a high economic growth rate during the 1970s (13% p.a. in real terms), but although the GNP per capita in 1980 was relatively high by African standards (US$910), wide income disparities remained. There are extremely weak linkages between the traditional agricultural based economy, which provides livelihood for 80% of the population, and the emerging modern sector which is based on capital-intensive mining operations. Agriculture's contribution to total GDP declined from 42% in 1966 to 11% in 1980. The mining sector produces diamonds (10 million carats annually), copper/nickel and coal, and altogether contributed 32% of GDP in 1980. The manufacturing base is

small, comprising two abattoirs of the Botswana Meat Commission (BMC), which produces for export, and some 100 small and medium-sized enterprises producing food products, textiles, chemicals and building materials. In 1980, the manufacturing sector contributed only 4% of GDP. Import/export trade activity amounted to over 65% of GDP.

1.5 The economy of Botswana is closely tied to that of the Republic of South Africa (RSA). Almost all the investment capital in the modern sector has been supplied by RSA-based companies. The RSA and the BLS countries (Botswana, Lesotho and Swaziland) are members of a customs union formed under the terms of the 1969 South African Customs Union (SACU) Agreement. Over 80% of Botswana's imports originate from the RSA, and all overseas commodity exports are made via outlets in the RSA. The currency, Pula (P), is pegged to a basket of currencies in which the South African Rand has a large weight. The Government of Botswana has been pragmatic in dealing with the RSA but also actively participates in the Southern Africa Development Coordination Conference (SADCC), which was created in 1979. SADCC currently is formulating strategies and programs which in the long run could help reduce Botswana's dependence on RSA.

External Influences on the Energy Sector

1.6 Botswana's ties to the RSA impinge on the energy sector in a number of ways. First, South African companies have large shareholdings in the two largest energy consuming entities in the country; the diamond mining operations of the DeBeers Botswana Mining Company (Debswana), and the copper/nickel smelting operations of the Bamangwato Concessions Ltd. (BCL). The only coal mine in the country is operated by the Morupule Colliery Ltd. which is a subsidiary of the RSA-based Anglo-American Corporation (AAC). Second, all petroleum imports are procured through the RSA under the SACU agreement, and 95% of coal imports (9% of total coal consumption) originate from the RSA. Third, the prospects for large export-oriented development of Botswana's coal reserves depend on transportation either through RSA to the port of Richards Bay on the Indian Ocean or through Namibia to Walvis Bay on the Atlantic.

1.7 The Government of Botswana is moving pragmatically to reduce the country's economic and energy dependence on RSA. Significant progress has been made towards: (a) substituting domestic coal for imported petroleum in electric power generation; (b) developing petroleum buffer stocks and contingency plans to minimize economic disruptions in the event of an interruption of supplies; and (c) developing alternative transportation links to overseas markets through Zimbabwe and Mozambique.

The Energy Import Bill

1.8 During 1980-82, Botswana's diamond export earnings fell sharply and the foreign trade deficit increased to P123 million (16% of GDP). The proportion of merchandise export earnings devoted to the energy import bill rose from 17% in 1980 to 23% in 1982. Over 95% of this is for oil,

which in 1982 cost Botswana about P105 million. In 1982, Botswana imported about 82 GWh of electricity from the RSA at a cost of about P3 million. The coal import bill amounted to about P1 million in the same year.

Table 1.1: PETROLEUM IMPORTS
(million Pula)

Year	1980	1982
Petroleum Bill	70	105
Total merchandise exports	423	474
Total imports (f.o.b.) a/	468	597

a/ excluding duties.
Source: MFDP and CSO Statistics Bulletin (Sept. 1983)

Indigenous Energy Resources

1.9 Coal is Botswana's largest known energy resource. There are some 17,000 million tonnes of reserves (equivalent to some 10,000 million toe). No hydroelectric or geothermal potential exists, and further geophysical investigations need to be made to determine if there are any petroleum deposits in three large sedimentary basins that have been identified in the Kgalagadi desert area. Although fuelwood is the major source of energy for rural areas, woodlands in areas surrounding the population centers in the southeastern part of the country are being depleted. Data on windspeed characteristics is still sketchy, but windmills are in use in some isolated parts of the country. The solar regime is good, and various solar energy technologies already are being used on a small scale.

Structure of Energy Demand

1.10 Reliable data on energy consumption by sector are not available, but the mission compiled available 1982 energy consumption data from different sources to prepare the energy balance shown in Table 1.2. Because of discrepancies in the orginal data, these estimates should be read with caution. Total annual energy use in Botswana is about 725,000 toe, giving a per capita average (0.8 toe) which is comparable to that of Zimbabwe (0.8 toe) and Zambia (0.7 toe) but much higher than Lesotho's (0.1 toe). The energy balance shows fuelwood to be the largest source of primary energy in the country, supplying 45% of the total; coal is second with 33% and petroleum is third with 19%. The remaining 3% is accounted for by electric power imported from the RSA. About 50% of domestic coal production is used for power generation and 25% of the gross energy supply is imported. Fuelwood is almost entirely used in households. In 1982, mining accounted for 57% of commercial energy consumed, transport 20%, and manufacturing/commerce 10%. Government services accounted for about 9% of commercial energy consumed.

1.11 Developments in the mining sector have strongly influenced energy demand. Between 1975 and 1980, a rapid expansion in the mining sector GDP (60% p.a. in nominal terms) was associated with a 15% p.a. growth of total commercial energy demand, a 14% p.a. growth in petroleum demand, and a 16% p.a. growth in power demand. The decline in the rate of mining sector growth between 1980 and 1982 resulted in a slowdown of demand growth for commercial energy. Petroleum demand increased by only 8%, and power demand, 4% p.a. during that period. The Government expected new mining ventures in coal, gold and soda ash to sustain longer run economic growth at 6.0% p.a. The mission has used a 4.5% p.a. economic growth rate for Botswana as the basis for projections. This reflects: (a) a slower rate of expansion in mining sector output due to uncertain world trade prospects for coal and diamonds; and (b) a slower rate of recovery of the economy, particularly agriculture, from the prolonged drought and water shortage. 1/ The mission projects that energy demand will increase at about 5.5% p.a. through 1990.

Table 1.2: BOTSWANA: ENERGY BALANCE FOR 1982 ('000 toe) a/

	Coal	Petroleum	Electricity	Total Commercial	Fuelwood	Total Energy
Primary Supplies						
Production	230.1	-	-	230.1	350.0	580.1
Imports	22.5	148.7	20.5	191.7	-	191.7
Total	252.6	148.7	20.5	421.8	350.0	771.8
Conversion						
BPC Power Generation	(142.2)	(0.6)	142.8	-	-	-
Conversion Losses	-	-	(43.0)	(43.0)	-	(43.0)
Distribution Losses	-	-	(4.2)	(4.2)		(4.2)
Net Supplies	110.4	148.1	116.1	374.6	350.0	724.6
Sectorial Consumption						
Mining	85.7	37.0	91.1	213.8	-	213.8
Transport	-	76.3	-	76.3	-	76.3
Government	1.0	7.4	3.7	12.1	-	12.1
Manufacturing/Commerce	18.2	5.0	14.2	37.4	-	37.4
Water Pumping	-	19.1	2.5	21.6	-	21.6
Residential	5.5	3.3	4.6	13.4	350.0	363.4
Total	110.4	148.1	116.1	374.6	350.0	724.6

a/ Negative flows indicated by parentheses.

Source: Mission estimates.

1/ During the June 1984 review of the draft report, the Mission was informed that the Government of Botswana had, on the basis of the mid-term review of NDP-V, revised downward its forecast for longer term economic growth from 6% p.a. to 4.5% p.a.

Table 1.3: ENERGY DEMAND PROJECTIONS
('000 toe)

Source	1982	1985	1990	Growth, 1982-90 (% p.a.)
Imports				
Petroleum	148.7	163.1	199.1	3.7
Coal	22.5	24.1	30.0	3.7
Electricity	20.5	45.0 a/	45.0 a/	-
Total	191.7	232.2	274.1	4.6
Indigenous				
Coal	230.1	303.5	504.8	10.3
(Electricity) b/	(143.0)	(222.0)	(310.0)	(10.2)
Fuelwood	350.0	385.0	410.0	2.0
Total	580.1	688.5	914.8	5.9
Gross Demand	771.8	920.7	1,188.9	5.5

a/ Assumes imports of power remain at the July 1983 level of about 15 GWh/month.
b/ Power generation by BPC coalfired stations.

Source: Mission Estimates.

Energy Sector Coordination and Planning

1.12 Although the Ministry of Mineral Resources and Water Affairs (MMRWA) has recently been given the mandate for energy, it continues to share significant parts of the energy portfolio with other ministries as follows: (a) the Ministry of Commerce and Industry (MCI) which is responsible for regulating the petroleum supply/distribution operations of the private oil companies; (b) the Ministry of Works and Communications (MWC), which, through the Central Transport Organization (CTO), controls various aspects of petroleum supply for the public sector; and (c) the Ministry of Agriculture (MOA) which is responsible for forestry and woodlots. MMRWA exclusively handles power, coal development and hydrocarbon exploration programs, and chairs a Renewable Energy Advisory Committee.

1.13 The Government recognizes that fragmentation in institutional responsibilities has hindered the planning and implementation of some energy programs, especially those that affect more than one subsector. The mission found that:

(a) energy sector plans that are drawn up as part of national development plans have not hitherto been as detailed as may be desirable;

(b) in spite of recent changes, the allocation of planning or operational responsibilities in the energy sector (between MMRWA and other agencies) is still not clear; and

(c) data on energy supply/demand are scattered and in many cases unreliable.

1.14 An Energy Unit (EU) 2/ recently was established within the MMRWA to handle the energy portfolio. The EU is not yet operational and hence energy functions are being handled by the Planning Unit of MMRWA. The immediate priority is to establish a nucleus staff for the EU within the manpower constraints of MMRWA. In the mission's view, the staff of EU should comprise persons with the following skills and backgrounds:

(a) Engineering - to assist in preparing and evaluating programs, projects or plans, and in monitoring BPC and other implementing entities under the Ministry. The specific areas would include power options, fuel substitution, renewable energy, and efficiency of energy use;

(b) Economics - to assist in economic and financial evaluation of energy programs, projects, or plans, including review of energy pricing policy options and so on;

(c) Statistics - to collect, evaluate, and collate energy statistics into an appropriate data base for planning purposes.

1.15 In cases where a position is filled by an expatriate, a Motswana should also be recruited and assigned as a counterpart. In the short-term, the nucleus EU could be established by:

(a) employing a power economist;

(b) redeploying an economist from the Planning Unit to work part-time until a full time economist is recruited and trained for the Unit; and

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2/ The EU staff currently comprised an Energy Advisor who is sonsored by the West German Aid Agency (GTZ), and a Senior Energy Officer who is a Motswana with engineering background.

(c) by seconding a statistician from the Central Statistics Office to assist in developing the energy data base.

1.16 Once this staff is in place, EU's capabilities should be developed through technical assistance and training: (a) to provide technical support to the Planning Unit for preparing energy sector plans and projects; and (b) to assist in monitoring energy parastatals and implementing agencies. The mission recommends technical assistance (a) to prepare a training course in project evaluation and energy planning methods for selected officials 3/; and (b) to assist the Energy Unit in its day-to-day operations, in particular, to supervise implementation of recommended pre-investment studies. 4/ The mission also recommends that the EU be given overall responsibility for collating and analyzing energy data. This would provide the basis for establishing a consistent data base for energy planning.

Coal Export Schemes

1.17 The Government hopes to accelerate the development of the country's largest mineral resource, coal, as a major foreign exchange earner and driving force for future economic growth. One scheme which is presently under consideration is known as the Kgaswe project and would mine 5-10 million tpa of coal from the Serowe coal field in the Greater Morupule Area. Future ventures could include projects which would mine some coal from the Mmamabula coalfield south of Serowe (see Map IBRD 17602). Shell Coal Botswana (Pty) Ltd. has completed pre-feasibility studies of the Kgaswe project which indicate that a capital investment of the order of P730 million (in 1980 prices) will initially be required for the mine. A total investment of the order of P1070 million (in 1980 prices) would be required over the lifetime of the mine. In July 1982, the Government concluded a joint venture agreement with Shell Coal Botswana (Pty) Ltd. to proceed with a detailed feasibility study of the Kgaswe Project. Under this agreement, Shell would do a detailed feasibility study on the coal mining operations and the Government would be responsible for studies on all the infrastructural requirements in support of the project. The study would include evaluations of the proposed Trans-Kgalagadi Railway (TKR) crossing Namibia to Walvis Bay and of the development/reinforcement of the eastern link to Richards Bay. The projected f.o.b. cost of exporting through Richards Bay would

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3/ Selected officials from the Ministries of Finance and Development Planning, Commerce and Industry, Works and Communications, and Agriculture; the Department of Electrical Engineering, and BPC would also be included.

4/ During the June 1984 review of the draft report, the mission was informed that the Government of Botswana had approached GTZ to expand its program of technical assistance for the Energy Unit.

probably be about US$60/tonne (in 1981 prices) while the corresponding cost via the proposed TKR would be higher. In any case, the prospects for developing a viable TKR depend very much on (a) political stability in Namibia and resolution of RSA's claim to sovereignty over Walvis Bay; and (b) large tonnages of coal exports being contracted at financially and economically viable prices. A final decision on whether or not to proceed further with the Kgaswe project will be taken by the Government and its partner, Shell, in mid-1985. The mission reviewed available information on the Kgaswe project in light of the international market situation for thermal coal. The Bank's long-term forecast is for the world market price for steam coal (in 1981 prices) to be in the range US$52-55/tonne (f.o.b. East Coast USA) by the mid-1990s, which implies that coal output from the Kgaswe project would not be competitive. The mission therefore doubts that the Kgaswe project would be viable without significant increases in the international price of steam coal (4.8-4.14). 5/

1.18 Investigations by BP, Charbonnages de France (CDF) and Amax at the Mmambabula Coalfield are still at the pre-feasibility stage, but the basic problems with the Kgaswe project would apply to these prospective projects as well (4.15).

Power Development Issues

1.19 The mission fully endorses the approach embodied in BPC's Power Development Program. Its basic goals are to completely eliminate petroleum use for power generation in the country's grid and to integrate the existing sub-grids that are currently operated separately by the Southern and Shashe Divisions. The capital expenditure for Phase 1 of the program (P458 million) already has been secured in the form of loans from external organizations (70%), contributions from local mining companies (10%), and BPC's internal cash generation (20%). The largest component of Phase 1 is the construction of the 99 MW coal based Morupule Power Station (MPS). When commissioned in 1986, the total firm capacity in BPC's combined grids would be 171.5 MW, and the remaining diesel powered units in the system would be retired and placed on standby.

Expansion of the MPS

1.20 BPC's least cost power development program is entirely based on the expansion of the MPS. BPC has decided to commission a fourth unit (33 MW) at the MPS by 1988. The mission revised BPC's load forecast to reflect the expectations that several major mining ventures in coal, gold, and copper may not be commissioned during the 1980s. The mission

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5/ During the review of the draft report the Government indicated that Shell had completed the feasibility study on the mine. Some details are presented in the text (footnote 27 on page 40).

concludes that a one or two year delay in commissioning a fourth unit at the MPS is sustainable and also that there is no longer the urgency to rapidly expand the MPS to the original design capacity by adding the fifth and sixth units. The mission therefore recommends that BPC should reformulate its least cost power development program to incorporate options such as firm power imports from ESCOM in the RSA and possibly, from Zimbabwe and other SADCC countries via the proposed high tension intertie (3.04 and 1.21).

Power Intertie with Zimbabwe

1.21 The Government is considering a proposal for a high tension intertie between Botswana and Zimbabwe which has been developed within the framework of SADCC. As currently formulated, a line would be installed between Selebi-Phikwe and Bulawayo at a cost roughly estimated at about P23 million. The mission considers that, on the basis of available information, the proposed intertie could be justified from Botswana's standpoint on the grounds that it would provide BPC's system with access to backup supplies/reserve capacity from SADCC member countries. The next step should be a detailed feasibility study to confirm this view. The mission understands that a study along these lines will be done under the joint supervision of the Governments of Botswana and Zimbabwe. The mission recommends that the alternative of a direct high tension link between Bulawayo and Morupule should also be included in the study, and that BPC should consider these intertie proposals in reformulating the least cost power development program for Botswana (3.5-3.6).

Electricity Sales Policy

1.22 BPC's consultants have recently completed an Electricity Pricing Study which establishes estimates of the marginal capacity and energy costs of supply to consumers at the high voltage (HV) and low voltage (LV) levels of distribution. The consultants have made a number of proposals which are being reviewed by BPC and the Government as a basis for establishing a new tariff structure (3.11). Due to the provisions of the Shashe agreement between BPC and BCL Ltd., the tariff charged to BCL Ltd. falls short of that required to meet BPC's financial objectives and requirements. The mission recommends that the Government considers providing an explicit subsidy in respect of BCL revenues forgone as a result of the Shashe agreement. The other option of distributing the burden on other consumers through a cross-subsidy should be avoided (3.12).

Electricity Service Connection Policy for Non-reticulated Areas

1.23 There is concern that BPC's connection charges are unnecessarily high in areas (both urban and rural) where reticulation is not presently available. Most potential consumers in such areas appear unable to afford the initial cost of connection on a lump sum basis. The Government has established a 'Revolving Fund' to assist in extending electricity supply from the existing grid in rural areas but there appears to be a number of problems with the use of this fund. There also

appears to be other constraints to the extension of electricity supply within some urban areas because guidelines that have been established by the Government for 'Self-Help' Housing Estates and for BHC sponsored Low Cost Housing Estates preclude reticulation. In order to improve access to electricity in these areas, the mission believes that it would be desirable to reduce the initial capital costs borne by individual consumers. One option would be to recover the initial costs for reticulation in such areas in the tariff, but a further evaluation of options is needed as a basis for any firm recommendations. The mission therefore endorses the Government's request for technical assistance to enable the MMRWA to do an independent and comprehensive review to identify measures that would lead to an improvement in the electricity sales policy for all residential consumers (3.14).

Energy Conservation and Electricity Supply to Isolated Institutions

1.24 The Department of Electrical Engineering (DEE), which is responsible interalia for operating small diesel power generators that supply electricity to public institutions in isolated areas, is unable to effect measures to conserve energy and/or substitute locally produced fuels for electricity. It appears that the incentive for the institutions to conserve electricity use has been eliminated as a result of the Government's decision in 1979 to phase out entirely the use of direct accounting at the institution level for services such as utilities. The mission understands that the rational for this change was the shortage of manpower within the public sector to maintain decentralized cost accounting systems. Nevertheless the mission strongly recommends that the centralized arrangement be reviewed from the viewpoint of controlling expenditure for diesel-based electricity supply to isolated institutions (3.17). The mission recommends also that DEE should begin selective energy audits to determine the patterns of energy use in such institutions. The information gathered could then be used to establish practical measures to conserve energy, and possibly to introduce substitute fuels in place of electricity. The mission recommends technical assistance to enable DEE to develop an in-house capability to conduct energy audits (3.18).

Reducing Dependency on Imported Energy

Coal Washing Plant

1.25 The mission strongly recommends that the Government give priority to the proposed Coal Market Survey over the proposed feasibility study on the Coal Washing Plant. The required size, scale of operation, and economic viability of any coal washing plant could not even be conceptualized in the absence of a Coal Market Study. The scope for substituting locally produced coal for imported clean coal depends on the existence of a large enough local market to support an economically sized plant. Information on the size of the existing market for clean coal is very poor. Furthermore, the potential for substituting LPG, kerosene and

fuelwood use has yet to be determined. The mission understands that both studies would be funded by West German bilateral aid (4.16-4.17).

Substituting Diesel Oil Use for Water Pumping

1.26 Although the Government has concentrated its effort on promoting windpumps and other nonconventional technologies to substitute for the use of diesel powered pumps, the mission believes that there is greater scope for doing so by retrofitting with electric pumps. On the basis of available information, the mission believes that it would be practical and cost effective to electrify pumps at some 500-1000 water wells located close to the BPC grid. The next step should be a detailed feasibility study to identify and rank existing pumping units by selected technical and economic criteria, including proximity to electricity distribution lines and annual operating characteristics. This study would also identify other potential loads such as isolated diesel generators, operated by DEE or private owners, which could also be linked to the BPC grid. This study should be done in close consultation with the Department of Water Affairs (DWA) which are currently involved in several projects under NDP-V to rehabilitate and expand waterwell services in the country (2.15-2.17).

Low Temperature Carbonization

1.27 The Government proposes to begin preliminary tests and analysis to ascertain the suitability of using LTC to convert local coals into coal derivatives such as coke, tar, fuel oils, creosote and pitch. The Government hopes that these products can substitute for some imported petroleum fuels. The Government has submitted a proposal to the European Development Fund (EDF) for funds to support the LTC program and is awaiting a response. The mission cautions that the economics of such specialized coal conversion processes is complicated and that because of the relatively small size of the local market for the products from LTC, it may not be possible to establish an economic sized plant in Botswana (4.17).

Petroleum Buffer Stocks and Contingency Plans

1.28 With the cooperation of the private oil companies, the Government has successfully implemented a major energy sector objective of NDP-IV to construct Strategic Storage Depots to hold both Government-owned and industry-owned buffer stocks. The Government has begun purchasing supplies to meet its quota for the combined strategic reserve, which would satisfy gasoline, diesel, and paraffin (kerosene) requirements for 56 days based on the average demand in the country during the preceeding year. The mission recommends that the Government expedite its plans to develop contingency plans by focusing on the following as priorities: (a) establishing a plan of action for emergency movement of products through alternative routes such as Zimbabwe; and (b) establishing a contingency product allocation plan based on improved and consistent data and clearly defined criteria. The main bottleneck for

moving emergency supplies through Zimbabwe would be the railways, and the mission suggests that Botswana and Zimbabwe consider a bilateral agreement to facilitate the movement of emergency petroleum supplies. The Government may require technical assistance to develop the contingency product allocation plan (2.11-2.14).

Oil and Gas Exploration

1.29 There have been no systematic efforts to explore for oil and gas in Botswana. Some companies have examined the geological data and have concluded that certain areas might be prospective for hydrocarbon, especially gas. This, together with the high costs of exploration surveys and exploration drilling, and the present market conditions of oversupply and declining real prices for petroleum has deterred oil companies from entering into formal contracts. Successful seismic surveys and geochemical studies may well enhance the prospectivity. The Government has submitted a proposal to the EDF for funding of geophysical surveys to acquire additional data to promote petroleum exploration. The mission endorses the general scope of the proposed program (2.19-2.21).

Woodfuel Options

1.30 Although wood is the traditional source of energy in the country, information on the supply and use of fuelwood in households is very sketchy. Afforestation schemes (using eucalyptus) appear to be a very expensive approach (over P1,000/ha) because of the harsh growing conditions in the country. In the mission's view, the Government should give priority to a proposed Rural Energy Survey in its ongoing review of woodfuel programs. This survey, to be funded by the UK bilateral aid program, should provide a basis for: (a) assessing quantities and patterns of fuelwood consumed in rural areas and/or 'exported' to urban markets; (b) assessing the fuelwood supply/demand situation in several localities that are in close proximity to major villages and towns along the eastern rail and road corridor; and (c) assessing the actual progress and economic viability of improving the fuelwood supply/demand balance in the eastern parts of Botswana through the existing approach (woodlot schemes). Without this information, it is not possible to make any firm recommendations on woodfuel programs (Chapter V).

Nonconventional Energy Applications

1.31 In the mission's view, the prospects are limited but good for using: (a) windpumps at cattle watering points; (b) solar water heaters to replace electric or LPG-fired water heaters in urban areas; and (c) solar photovoltaic power kits in isolated rural health posts and clinics. The mission supports the Government's decision to transfer the

responsibility for the management and supervision of the Botswana Renewable Energy Technology Project (BRET) from the Botswana Technology Center (BTC) to MMRWA. The mission recommends that future Government support for renewable energy technologies should give stronger emphasis to promoting their use where proven economic in feasibility studies.

Implications for External Assistance

1.32 The mission recommends that external assistance for energy development over the next 2-3 years should focus mainly on: (a) institution building, particularly of the Energy Unit of MMRWA; (b) specialized energy surveys to update information on energy supply/demand patterns and on fuel substitution opportunities; and (c) feasibility/pre-investment studies to clarify the scope and future level of investments in specific energy options. As indicated in Table 1.4, the source of external assistance for a number of these requirements already appear to have been identified. Overall, some US$2 million will be required over the next two to three years.

1.33 The mission also recommends that once the proposed energy surveys and feasibility/pre-investment studies are completed, the Government should establish a Special Committee on Energy to translate the findings and conclusions into programs, targets and projects consistent with objectives for the Sixth Plan (NDP-VI).

1.34 Most of the financing for the two major energy investments has been secured under NDP-V. This includes (a) Phase I of BPC's power development program which covers the construction of the MPS and associated transmission lines (P458 million); and (b) the Strategic Storage Depots and Petroleum Buffer Stocks (P15.5 million). In the mission's view, the current level of development expenditure for renewable energy (estimated P3.0 million until 1986) is adequate.

Table 1.4: SUMMARY OF TECHNICAL ASSISTANCE REQUIREMENTS

Type	Estimated Cost (US$'000)	Likely Source
Surveys		
Rural Energy Survey	300	UK ODA
Coal Utilization Survey	not determined	West German Aid
Nojane/Nosop Basin Seismic Survey	n.a.	EDF
Energy Audits of Public Institutions	n.a.	None identified
Pre-investment Studies		
Pump Electrification	100	none identified
Selebi-Phikwe/Bulawayo Intertie	not determined	SADCC/CIDA
Coal Washing Plant	not determined	West German Aid
LTC Study	280	EDF
Manpower/Institution Building		
Assistance to Energy Unit (MMRWA) a/	n.a	GTZ
Contingency Petroleum Products Allocation Plan	n.a.	None identified
Electricity Service Connection Policy Review	n.a.	None identified

a/ Includes establishment of a computerized energy data base.
Source: Mission Review and discussions with MMRWA.

II. PETROLEUM

2.1 Before 1970, Botswana relied almost exclusively on imports of petroleum products to meet its commercial energy needs. Although there still is no domestic oil production or refining activity, the Government has made significant progress in reducing the country's dependence on petroleum, particularly for power generation. The major issues in the subsector are:

(a) how to reduce the country's vulnerability to short-term supply interruptions;

(b) whether and to what extent it is economically worthwhile to further reduce the country's dependence on imports by substituting petroleum used for water pumping; and

(c) how to promote exploration for petroleum deposits in three sedimentary basins of the Kgalagadi desert.

Petroleum Supply

2.2 All of Botswana's petroleum product requirements are imported through the RSA. The imports are made under arrangements within the framework of the SACU Agreement. In 1982 the country imported about 144 thousand tonnes of petroleum products (about 3,000 bbl/day). The market is shared among five major oil companies: BP (41%), Caltex (17%), Mobil (26%), Shell (15%), and Total (1%). 6/ The companies transship almost all the refined products from the RSA by rail into storage depots at Gaborone, Lobatse, Mahalapye, Francistown and Selebi-Phikwe. The products are then distributed from the railfed depots by road. The companies have a total storage capacity of about 13,000 tonnes (16 million liters), which provides adequate cover for about 30 days at the 1982 consumption level. Retail stations and other large consumers in some western (Ghazi) and southwestern areas (Molopo Farms) receive road deliveries directly from the RSA or Namibia.

Petroleum Prices

2.3 Petroleum product prices are established in Botswana on an import parity basis. Price levels in 70 locations other than in Gaborone are set according to distances from the RSA border. The prices of gasoline, diesel oil and kerosene are controlled by the Government. All other products are priced independently by the industry but are kept in line with those in the RSA. For example, the price of LPG is determined from Cape Town in the RSA. The price structure is based on: (a) the average of Singapore postings for BP and Shell; (b) the cost of shipping;

6/ Total does not maintain an office in Botswana and operates directly from the RSA.

which is calculated according to the Worldscale rate escalated for AFRA as applicable to General Purpose (GP) vessels, and adjusted for a premium for clean cargo vessels; (c) insurance, at 0.1009% of the FOB price; (d) ocean losses, at 0.3% of CIF; (e) landing, wharfage and handling charges, applicable at the 'deemed' port of discharge and calculated at 1.8% of FOB; (f) railage from Durban to Gaborone, and (g) further adjustments based on an average exchange rate for a calendar month between the Pula (P), the US dollar, and the Rand. The per liter retail price of premium gasoline, gasoil and kerosene in January 1983 was 68.2 thebe, 65.5 thebe, and 50.9 thebe, respectively. LPG prices are not controlled and are currently P51.00 for a 48 kg bottle, and P21.00 for a 18 kg bottle. A detailed breakdown of the price structure for the major products is presented in Annex II.

2.4 The marketers' margins are determined by the Government and currently are 10% of c.i.f. at the Gaborone depot. Customs duty is levied in the RSA and collected from the companies to be paid into the Customs Union Pool. In addition, an equalization levy is imposed which is collected by the oil companies and then paid to the Ministry of Commerce and Industry (MCI). The MCI transfers this levy to the RSA for deposit in a separate oil equalization fund. The transport and handling costs are high and typically account for more than 25% of import parity costs. As compared to other landlocked countries in the sub-region (Malawi, Rwanda, Burundi, Zambia and Zimbabwe), the landed costs of petroleum imports are relatively low. The pricing system currently works smoothly.

2.5 The Government has little control over the pricing elements but waives taxes on some products to promote socioeconomic objectives. For example, although the import parity cost of kerosene is higher than petrol, its final price is kept low by means of tax exemption. Diesel oil sales are also tax exempt. All taxes and duties on aviation fuels also are waived. The Government has followed sound policy in passing on all costs to the consumers. Between 1975 and 1982, consumer prices increased: 16.6% p.a. for premium petrol; 17.1% p.a. for diesel oil; and 17.4% p.a. for kerosene. In August 1983, however, the consumer prices were lowered to reflect downward movements in international petroleum prices.

Petroleum Demand Patterns

2.6 No reliable data on petroleum consumption by sector is available from the Government. The mission therefore collected data on 1982 petroleum sales from BP and Shell (representing 56% of the domestic market) and used this information as the basis for analyzing sectoral consumption patterns. Similarly, the mission relied on petroleum import data obtained directly from the Custom Department's files to assess historical demand on a product-by-product basis. Although this raw data is more reliable than published figures, discussions with several large users to ascertain patterns of end-use indicate to the mission that discrepancies still exist.

2.7 The mining and transport sectors consume more than 76% of all the petroleum used in the country--25% and 52% respectively. The Government's direct purchases account for about 5%, and the balance is used by the residential, commercial and small industrial sectors. Details on consumption in these sectors are lacking. The breakdown of diesel consumption is diamond mining (36%), road transport (28%), water pumping (25%), and isolated electricity generation (6%). BPC and BCL together use less than 2% of the total. During 1978/79, when Debswana increased diamond output from 2.8 million carats to 4.4 million carats, diesel consumption increased by some 19,000 tonnes. Consumption for power generation at the Orapa diamond mine will drop by about 14,000 tonnes (17 million liters) in 1984 after the mine is connected to the BPC grid. Diesel use by BPC has declined from about 5,000 tonnes (6 million liters) in 1974/75 to 170 tonnes (0.2 million liters) in 1982/83, due mainly to the introduction of coal-based power generation units at Gaborone. Substituting electric pumps for diesel powered pumps at about 1,000 waterwells could reduce diesel oil consumption by 3,800 tonnes (4.5 million liters). Almost all the motor gasoline (31.6% of total products) used in 1982 went for road transport. The total number of cars increased by 16% p.a. between 1979 and 1982, 7/ but gasoline consumption increased only 11.3% p.a. during the same period. Kerosene (illuminating paraffin) is used for lighting in both urban and rural areas but no reliable data on consumption is available. Kerosene also is used to some degree for cooking, but the amounts involved relative to total kerosene use have not been determined.

2.8 LPG is widely used in urban areas, and 48 kg and 21 kg bottles are usually imported from filling points at Mafeking in the RSA. Shell operates a filling plant at Francistown, and Caltex is installing its own facilities in Gaborone. In 1982, the combined import bill for LPG and kerosene was about P5.5 million and the bill continues to increase.

Petroleum Demand Projections

2.9 Petroleum imports increased from 65,500 to 146,000 tonnes (about 14% p.a.) between 1975 and 1981. In 1982, the imports fell by 1.2%, mainly due to a drop in heavy fuel oil and kerosene/turbo fuel imports. The reasons for this decline were: (a) BPC's replacement of oil-based power units with coal-fired units; (b) electric power purchases via the 132-kV link with the RSA; and (c) a decline in aircraft traffic. Diesel oil and gasoline imports grew at 7.5% p.a. and 9% p.a. respectively, between 1979 and 1982. By 1982, diesel oil accounted for 64% of all petroleum imports, and gasoline 30%.

7/ The number of private cars registered in the country is about 9,700 (1982). New registrations have averaged about 2,500 vehicles a year (1979-82). The considerable traffic which moves across the border from the RSA also adds substantially to petroleum demand in Botswana.

2.10 The mission expects a considerable drop in demand growth from historical levels on the assumption that: (a) no major changes in transport modes will occur; (b) the mining sector will continue to buy the major proportion of its power needs from BPC; (c) the airlines will continue to lift fuel from airports outside Botswana; (d) the growth in petrol demand will be directly related to the growth in traffic as indicated in the National Transport Study 8/; and (e) about 500 diesel powered pumps will be replaced by electric ones. Between 1982 and 1985, total petroleum demand is expected to increase by 3.1% p.a. (from 148.7 thousand toe in 1982, to 163.1 thousand toe in 1985). Beyond 1985, total petroleum demand growth will be 4.1% p.a.

Table 2.1: BOTSWANA PETROLEUM DEMAND PROJECTIONS
('000 toe)

	Actual	Projections		Growth % p.a.
	1982	1985	1990	(1982-90)
LPG	2.8	3.8	6.0	10.0
Petrol	46.2	55.0	72.9	6.0
Kero/Turbo Fuel	4.9	5.3	5.5	1.5
Diesel oil	94.7	98.9	114.6	2.4
Fuel Oil	0.1	0.1	0.1	--
Total	148.7	163.1	199.1	3.7

Source: Mission estimates.

Reducing Vulnerability to Supply Disruptions

2.11 The objective of safeguarding Botswana against any interruptions in petroleum supply was one of the Government's priorities in the NDPIV (1976-81). The Government is concerned about the likelihood that petroleum sanctions would be imposed against the RSA. Because of the nature of SACU arrangements for petroleum supply to Botswana, this would lead to an interruption or severe restriction in supply, which in turn would have serious repercussions on the productive sectors of the economy. The Government embarked on a program to establish strategic petroleum stocks to mitigate the effects of such emergencies.

8/ The National Transport Study (May 1983) projects a drop in road traffic growth from 13.7% p.a. attained in the 1970s, to 8% p.a. during the 1980s.

2.12 Strategic Storage Facilities. Two strategic storage depots were built in 1979 at Francistown (capacity 15 million liters) and at Gaborone (capacity 24 million liters). The combined storage capacity in Government-owned and privately-owned facilities increased to about 50,000 tonnes (61 million liters), which is adequate for four months at the 1982 average consumption level. The Strategic Storage Depots have since been leased for an initial period of four years to private oil companies: BP Botswana (Pty) Ltd. manages the Gaborone depot; and Shell Botswana (Pty) Ltd. the Francistown Depot. Both companies have the option to purchase the strategic storage facilities during the term of the current agreements.

2.13 Management of Strategic Stocks. The Government began filling the strategic storage tanks in 1981. Under the terms of another agreement between the Government and the private oil companies, a Government-owned buffer stock is being created equal in volume to 8.33% of average demand during the preceeding calender year. The Government and the West German Kreditanstalt fur Weideraufbau (KfW) are financing the buffer stocks of three key products -- gasoline, diesel and kerosene. In addition, the private oil companies have agreed to maintain their combined stocks at not less than 56 days' requirements, based on average demand in Botswana during the preceeding calender year. These stocks include: (a) products owned by the private companies and held in either the two strategic depots or industry-owned bulk depots; and (b) usable stocks held in tanks owned by retail dealers, and other major industrial and commercial consumers. All stocks are monitored by the Ministry of Commerce and Industry (MCI), but the companies have the flexibility to run down their stocks to a minimum level of 42 days average demand. Any further liftings by the companies only can be done with the authority of the Government. Joint consultations also must be held to decide on the nature of any major supply bottleneck before the Government decides on mandatory rationing and/or other conservation measures. The Government, however, assumes full authority on the use of all supplies when stocks fall to the buffer level. The companies are required to pay the Government for the use of the buffer stocks based on a complex formula which incorporates interest payments at the prevailing commercial bank rate.

2.14 Contingency Planning. The Government has yet to establish contingency plans for petroleum supply through non-RSA routes and for demand management (as required by Article 9 of the Agreement). In the mission's view, the priorities should be:

(a) to establish alternative supply routes for emergency movement of products, one of such alternative routes would be through countries to the north. The main bottleneck for this alternative would be railway transportation. Since the Government is in the process of acquiring the facilities of the National Railways of Zimbabwe (within Botswana's borders), a bilateral agreement with Zimbabwe to facilitate the movement of emergency traffic must be considered as part of a contingency supply strategy; and

(b) to establish a contingency product allocation plan based on clearly defined criteria that will ensure essential supplies to important sectors of the economy at all times. A prerequisite for this is a consistent data base on petroleum supply/demand. At present some divisions of MCI and the MWC are responsible for collecting, evaluating and collating such data for routine statistical publications including the Transport Statistics Bulletin. However, data obtained by the mission from these bulletins are unreliable and appear to have been published without adequate evaluation to check for inconsistencies. Technical assistance may be required to prepare this contingency plan.

Substituting Diesel Use for Water Pumping

2.15 The Government is concerned about the increasing demand for diesel oil in pumping water and would like to substitute diesel use with other energy forms or technology. Most village communities and farms in Botswana rely on deep wells (50-100m dynamic water level) for their water supplies. The Department of Water Affairs (DWA) in MMRWA, which is responsible for these supplies, estimates that although there are a total of some 9,000 publicly and privately owned water wells in the country, 9/ only about 5,000 of them are in regular operation. Diesel-powered pumps 10/ (capacity 3-25 hp and consuming between 0.8-2.0 liters/hour of diesel oil) are used, and each pump consumes about 2,000 liters of LDO a year.

2.16 The mission believes that the distribution of water wells relative to the existing grid (see Maps 17601 and 17600) provides the basis for possible cost effective substitution of electric pumps for diesel powered pumps at about 500-1,000 water wells. The mission's preliminary analysis indicates that such a conversion could lead to annual savings of about 1.2-2.4 million liters of diesel oil valued at P0.8-1.5 million. Other factors such as the efficiency of energy conversion, the reliability of operation, and lower maintenance costs favor the switch to electric pumps (Table 2.2). The benefits of using electric pumps improve if economic costs are used (3.11). Also, the true costs of distributing diesel oil to existing boreholes would need to be estimated and used in the analysis. The costs of electrifying the pumping systems would in-

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9/ DWA has drilled over 4,300 wells, and is responsible for operating and maintaining pumps at the wells in the 17 major villages.

10/ Most of the well-fed water supply systems at isolated small villages are frequently out of operation because of the erractic supply of diesel oil. A joint review team of Swedish International Development Agency (SIDA) and the Government has recently recommended establishing of a formal schedule for making diesel oil deliveries to isolated village locations.

clude the cost of extending a 33-kV or 11-kV line as appropriate to waterwells and that of installing a transformer to match the size of the load. For example, DWA reports that the BPC estimate of the capital cost for extending the distribution line near Kanye by 5 km to electrify 5 boreholes and one pump booster station is P100,000. In practice, several wells in close proximity to a given transformer should together be considered in determining the load. Other potentially productive uses of electricity in the area surrounding each well also could be considered for connection. Replacement of isolated diesel power generators under DEE control would be included.

Table 2.2: COMPARISON OF DIESEL AND ELECTRIC PUMPS a/
(Pula p.a.)

	Diesel Pump	Electric Motor Pump
Fuel Consumption	1,243	1,370
Lubricants	45	-
Routine Maintenance	600	100
Engine Overhaul	300	-
Pump Operator Charges	1,300	300
Fixed Costs	570	295
Total	4,058	2,065

a/ Based on financial costs only; basis of estimates of component costs presented in Annex II.

Source: Mission estimates based on information from DWA.

2.17 In order to evaluate the economics of pump electrification and also identify the optimal criteria for such retrofits, the mission recommends a study to:

(a) classify water wells by proximity to the electricity grid;

(b) determine the size and annual operating characteristics of pumps as a basis for estimating the potential load, annual energy demand and recurrent expenditure after electrification;

(c) identify non-pumping loads in the vicinity of each water well;

(d) determine the capital requirements for electrification of pumps and nearby loads; and

(e) evaluate the economics of retrofitting existing diesel-powered pumps with electric pumps;

The study should focus only on pumps that could be converted practically. Also wherever possible, DEE operated isolated diesel power generators should be replaced by connection to the grid. The study could be completed with about 4 man-months total of consulting services, estimated at US$100,000.

Oil and Gas Exploration

2.18 During 1975 and 1976, CIDA funded an aeromagnetic survey of Botswana. The results of the survey indicated that there were two large sedimentary basins classified as intracratonic grabens. 11/ The prospective sub-basins are: (a) the Passarge Basin, which is located in the deepest part of the SW-NE graben trend; and (b) the Nosop and Nojane Basins that are along the N-S trend west of the Tshane region of Botswana (IBRD 17602). The aeromagnetic interpretation also indicated that the sedimentary section in each of these basins could be about 10,000 m thick. Very limited seismic work has been done in the country and no wells have been drilled. Although there are no oil seepages, a few scattered shows of oil and gas have been reported in water wells and shallow stratigraphic holes. Shell Botswana (Pty) Ltd. 12/ and Texaco 13/ have done a few geochemical studies which indicate that there is a greater likelihood of finding dry gas deposits than oil in Botswana. A team from the UN Department for Technical Cooperation for Development (UNDTCD) also reviewed available data (including data from shallow boreholes) 14/ and recommended further investigations consisting of (a) seismic surveys of the deep basins; and if necessary (b) some drilling and stratigraphic test wells to evaluate any structures identified by the seismic survey.

2.19 The Government has prepared a proposal and is currently seeking financing from the European Development Fund (EDF). The mission supports the general scope of the proposed program but recommends the following revisions of the proposal: (a) it is unrealistic to carry out on-the-spot

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11/ These are long trenches that were formed after the region's Precambrian shield rifted apart. The trenches have now been filled with marine and continental sediments.

12/ See report, "The Hydrocarbon Prospects of Botswana" by D.D. Clarke-Jones, and A.K. Yeats, Shell Botswana (Pty) Ltd., in 1977.

13/ Various reports prepared by Texaco in November 1980 are on file with the GSD.

14/ Project BOT/79/006: An Assessment of Energy Development Needs Related to the Petroleum Potential of the Republic of Botswana by R.M. Grivetti, UNDTCD, June 1980. This assessment was also based on an evaluation of data from shallow boreholes.

experiments to establish the optimum seismic acquisition parameters. Rather, advice should be sought from geophysical companies which have experience in modern technology in Kgalagadi-type conditions; (b) the relevant geophysical parameters therefore should be established by analogy rather than from on-the-spot experiments to determine whether explosive charges, vibroseis or another source should be used; and (c) if and when funds are secured for the program, competitive bids should be obtained from reputable geophysical contractors.

2.20 The mission supports the Government's main objective to promote oil and gas exploration by the private sector. The great thickness of the sediments in the identified basins has aroused the interest of some oil exploration companies who would prefer to explore Botswana under a "seismic option" with a pre-tax production split in the event of a commercial discovery, but with the option to surrender the concession before drilling. The prospects for concluding an exploration contract have diminished because of the current world oil situation. The withdrawal in March 1982 of ESSO from negotiations with the Government can, in part, be attributed to it. The mission believes that a major reason for the lack of interest in the industry lies in the scarcity of relevant exploration information, particularly seismic and geochemistry, and the very large size of the potentially prospective basins. Short of providing such additional geophysical and geochemical data which would allow a geological ranking of various segments of the geologicial basins, interest by oil companies will remain lukewarm. The mission fully supports, therefore, the Government's strategy for an ambitious exploration promotion project which would include, inter alia, (a) collation/interpretation of all geological/geophysical data; and acquisition of geophysical data, mainly seismic over selected areas; and (b) acquisition of additional geochemical data. The data so obtained should be packaged in a suitable form and be offered to industry. Nevertheless, the Government should proceed with negotiations whenever an interested party is willing to execute an exploration program. Drilling of one or two strategically located stratigraphic tests may be considered at a later stage.

2.21 The Government has prepared a prospectus for use in attracting private oil companies to the country. The prospectus is to be used together with the new Petroleum Code (the Petroleum Exploration and Production Law of 1981) which was prepared with assistance from the Commonwealth Fund for Technical Cooperation (CFTC). The code replaces the Mining Code for oil and gas activity in Botswana.

III. ELECTRIC POWER

3.1 The electric power subsector is the most dynamic in the country's energy sector. Substantial capital expenditures have been made to establish a viable power utility capable of providing a reliable supply of power that meet the rapidly increasing needs of the mining sector and to reduce the country's dependence on oil-fired power generation. The planned capital expenditure program is also very large (about P500 million through the mid-1990s), but necessarily so. The major subsector issues discussed in this chapter are:

(a) the timing of additional capacity once the 99 MW Morupule Power Station (MPS) is completed in 1986;

(b) the role of imported power from the RSA and possibly Zimbabwe in the formulation of BPC's least cost power development program;

(c) electricity sales policy for residential customers in areas without reticulation;

(d) the management of diesel-based electricity supply to promote energy conservation in isolated public institutions.

Supply/Demand

3.2 The interconnected power system of Botswana (IBRD Map 17600) is operated and maintained under two separate divisions of the Botswana Power Corporation (BPC): (a) the BPC Southern Division, which serves mainly Gaborone and surrounding towns; and (b) the BPC Northern or Shashe Division, which serves mainly Selebi-Phikwe, the copper mining and smelting operations of BCL, Francistown and nearby smaller towns. 15/ BPC's installed generation capacity comprises 15-MW coal-fired units and 9-MW diesel units at the Gaborone Power Station (GPS); and 80-MW coal-fired units and 2-MW diesel units at the Selebi-Phikwe Power Station (SPS). The combined firm power capability of BPC is 96.5 MW. A 99-MW coal-fired power plant, the Morupule Power Station (MPS), is being built near the Morupule Colliery. The MPS will be joined to the two sub-grids by two high tension links to Selebi-Phikwe (110 km) and to Segoditshane (262 km). The Southern Division can also draw up to 31 MW from the

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15/ Until recently, BPC supplied bulk power to the Francistown municipality who then distributed the power within the town. BPC is now responsible for supplying and distributing power to all consumers in Francistown. The residential townships associated with the mines at Orapa and Jwaneng are also supplied directly by BPC. BPC has an exclusive license to supply and distribute power throughout Botswana.

Electricity Supply Commission (ESCOM) of the RSA via a 132-kV transmission line which was commissioned in 1981. The grid recently has been extended via 33-kV lines to 15 major villages including Kanye, Mochudi and Molepolole under a SIDA-sponsored project.

3.3 During the mid 1970s, total generation grew by about 12% p.a.: 13.4% p.a. in the Southern Division, from a 1974/75 base of 28.5 GWh; and 11.7% p.a. in the Shashe Division, from a 1974/75 base of 152.7 GWh.16/ BPC's Southern Division has gradually reduced its dependence on petroleum based power generation from 72% of the total in 1974/75 to less than 4% in 1981/82. The present drought also has affected generation capability in the Southern Division. The water shortage in the Gaborone area reduced the availability of cooling and make-up water for the coal-fired units at GPS. Output from GPS initially was reduced to 5.4 GWh/month in January 1983, before being shutdown in March 1983. The station since then has been placed on standby (3.4). Electricity sales by sectoral categories up to 1981/82 are shown in Table 3.2. Total electricity sales by BPC grew by 16% p.a. during the mid-1970s.

Table 3.1: BPC POWER GENERATION STATISTICS (1982/83)
(GWh)

	Southern Division	Shashe Division	Combined Systems
Generation a/	63.3	336.0	399.3
Purchased Energy b/	101.0	-	101.0
System Losses	11.6	5.0	16.6
Sales	152.7	331.0	483.7

a/ on 'as sent out' basis excluding station's own use.
b/ purchases from ESCOM transmission link.

Source: BPC

16/ BCL's annual bulk purchases from BPC Shashe Division rose from 36.8 GWh in 1973/74 to 138.8 GWh in 1974/75 and has since increased to 302.1 GWh in 1981/82.

Table 3.2: ELECTRICITY SALES BY SECTOR
(GWh)

Category	1974/75	1978/79	1981/82	Average Growth Rate, 1974-82 (%)
Mining/Smelting				
Debswana	-	-	13.7	-
BCL	138.8	264.9	302.1	11.8
Commerce/Industry				
BMC	-	9.2	9.0	-
Other	9.1	18.6	33.0	20.2
Water Utilities/Pumping	5.7	7.8	10.2	8.7
Government/Municipalities a/	9.0	14.7	19.0	11.3
Residential	12.5	18.7	27.3	11.8
Total	175.1	333.9	414.3	13.1

a/ Includes sales to Francistown

Source: BPC.

Current Use of Supplies from ESCOM

3.4 BPC currently uses its full allocation of 31 MW from ESCOM because the average cost of supply from this source is substantially the same as the current incremental cost of generating power locally in the Southern Division (i.e., the GPS). BPC's interim strategy for utilizing power imports from ESCOM reflect the following considerations:

(a) by fully utilizing the capacity of the ESCOM link, water consumption for generation at the GPS has been reduced by approximately 500,000 gallons p.a.;

(b) the effect of the January 1983 increase in the ESCOM tariff 17/ appears to have been offset by the appreciation in the value of the Pula (P) relative to the Rand and the fact that the average cost per unit to BPC has decreased with the larger purchases.

17/ The agreement covers a minimum ten-year period, and the formula for establishing the bulk supply rate is similar to the regular ESCOM tariff for customers in the RSA with maximum demand greater than 25 kw. In January 1983, ESCOM increased the tariff to BPC by increasing the surcharge from 29% to 47.5% on the monthly charge, the energy charge, and the basic charge.

(c) the unit cost of water supplied to the GPS has more than doubled in the past year due to an increase in the water tariff to pay for the cost of raising the height of the Gaborone dam.

When the MPS is commissioned, the incremental cost of generation in the BPC system should be significantly reduced because the cost of generation at the MPS will be much lower than at the GPS. The mission recommends that the long-term strategy for using ESCOM supplies should be established in relation to the costs of generation using domestic coal at the MPS (3.10).

High Tension Link with Zimbabwe

3.5 A high tension intertie has been proposed within the context of the regional energy development program of SADCC. As currently formulated, the proposed intertie would consist of a 220 kV line which would link Selebi-Phikwe (Botswana) to Bulawayo (Zimbabwe). The intertie would cost about P23 million to install, and it is envisaged that it would be capable of transferring up to 50 MW of surplus power between the two countries. The mission expects that the proposed intertie could be justified from Botswana's standpoint on the grounds that it would provide the BPC grid with access to back up supplies/reserve capacity. However, the full justification for this investment must be based on having the intertie contribute directly to BPC's least cost power development program.

3.6 The mission understands that the SADCC sponsored study on this intertie will soon begin under the joint supervision of the Governments of Botswana and Zimbabwe. The Canadian International Development Agency (CIDA) has indicated its interest to provide technical assistance to implement the study which would include; a basic analysis of projected load flows and overall system stability given that the proposed intertie would put BPC's much smaller grid in parallel operation with two larger grids in the RSA and Zimbabwe; a preliminary survey of the route; and an estimate of the investment required for the intertie. The mission fully supports this study and recommends that the study also includes consideration of alternative intertie options with Zimbabwe such as between Bulawayo and Morupule. The mission recommends that these intertie proposals should be considered as part of updating the least cost plan for expanding BPC's system (3.10).

Low Tension Link with Zimbabwe/Zambia

3.7 A proposal to draw power via low tension links (33 kV) from Zambia or Zimbabwe to supply the towns of Kasungula and Kasane in the Chobe District of Northeastern Botswana is also to be sponsored under the SADCC energy program. Both towns are remote from BPC's grid (500 km from nearest substation at Francistown), and the use of diesel generators for the combined loads is not expected to be the least cost option. The nearest terminal stations on the Zimbabwe and Zambia sides of the border with Botswana are located at Victoria Falls and Livingstone respectively. SADCC proposes to investigate the feasibility of installing a low tension

link with either of the two points. CIDA has indicated an interest in providing technical assistance for the study.

BPC Power Development Program

Power Load Forecast

3.8 The latest load forecast for BPC's combined system 18/ is based on historical trends and incorporates step increases in load each time a new mining operation is commissioned. The mission reviewed this forecast in light of recent developments in the Botswana economy, particularly in relation to the timing of large export-oriented coal mining projects. The mission has revised the load forecast (up to 1990) to reflect the following:

(a) large scale export-oriented coal mining schemes (4.8 to 4.15) will not be implemented;

(b) new mining schemes at Nora and Matsitama may not be commissioned before 1990. About 13.0 MW in additional power load will be saved and the installation of 132 kV lines would be cancelled;

(c) the proposed Sua Pan Soda Ash Scheme, which will require 13.1 MW, will be commissioned on schedule by 1986 19/; and

(d) electrification of borehole pumps which could begin by mid-1980s would add some 2.24 MW of additional load each year.

3.9 The overall effect of these modifications are that the maximum demand would grow from 83 MW in 1982/83 to about 202 MW by 1992/93, and energy sales would increase from 503 GWh p.a. in 1982/83 to 1,130 GWh p.a. by 1992/93 (Annex III), or at an average annual rate of 8.4%.

Expansion of MPS

3.10 BPC's current least cost power development program is almost entirely based on the use of domestic coal (from the Morupule Colliery)

18/ BPC's Consultants, Kennedy and Donkin (UK) Ltd., carried out the load forecast study in association with two other consulting firms: Watermeyer, Legge, Piesold and Uhlmann Inc.; and Coopers and Lybrand Inc., also of the UK.

19/ BP Coal Ltd., plans to extract soda ash, potash and salt from deposits at Sua Pan (IBRD Map 17600). Operations are scheduled to begin in 1986 with soda ash production levels rising from 300,000 tonnes to over 600,000 tonnes by 1990.

at the MPS. BPC has decided to install and commission a fourth unit (33 MW) at the MPS by 1988. As indicated by the mission's revised load forecast (Table 3.3), a one or two year delay in this timetable should be sustainable. The revised load forecast also indicates that there is no longer the urgency to rapidly expand the MPS to the original design capacity of 6 x 33 MW. The mission believes that BPC now has an opportunity to re-formulate the least cost power development program. In the mission's view, BPC should base this new power development program on a ranking by economic cost of supply of:

(a) coal-based generation at MPS and/or SPS under the terms of the July 1983 coal pricing agreement between BPC and the Morupule Colliery. Coal prices to BPC continue to rise under the terms of that agreement (4.5);

(b) imports of power (up to 31 MW) from RSA under the terms of the agreement between BPC and ESCOM. This agreement cannot be terminated before ten years, but can be extended by mutual agreement between the two utilities (3.4); and

(c) imports of power via the proposed 220 kV link with Zimbabwe. The basis for assessing this option would be the results of the SADCC sponsored study (3.5).

The mission understands that BPC and the World Bank plan shortly to hold further discussions along these lines.

Electricity Sales Policy

Electricity Tariffs

3.11 BPC, under its Act of Incorporation, is required to operate commercially and to generate an adequate rate of return on its assets. 20/ BPC's present target for financial performance is to earn a minimum 8% annual rate of return on the average of its revalued assets, and to provide about 20% of its total capital expenditure from internal cash generation. To fulfil the above, BPC has frequently increased

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20/ BPC maintains its financial operations independently for Shashe and the Southern Divisions. During 1981/82, the Shashe Division accounted for 58.3% of revenues; the Southern Division accounted for the remaining 41.7%. The net surplus in the Shashe Division was P1.569 million yielding 9.91% return on average gross assets. The net surplus in the Southern Division increased from P.0153 million in 1980/81 to P0.982 million in 1981/82. Operating revenues increased from P22.078 million in 1981/82 to P31.241 million in 1982/83.

Table 3.3: CAPABILITY OF BPC INTERCONNECTED SYSTEM (1982-92)

Year	Energy Sent Out (GWh)	Max Demand a/ (%)	BPC Generation Capability (MW)	BPC Capacity Balance d/ (MW)	Capacity Balance with 31MW Firm Imports from ESCOM (MW)
1982/83	502.8	82.7	96.5	13.8	-
1983/84	536.6	90.2	96.5	6.3	37.3
1984/85	650.9	112.8	96.5	-16.3e/	14.7
1985/86	721.9	127.1	171.5	44.4	75.4
1986/87	854.8	150.0	171.5	21.5	52.5
1987/88	936.0	159.9	171.5	11.6	42.6
1988/89	975.95	167.1	204.5 b/ (171.5)	37.4 (4.4)	68.4 (35.4)
1989/90	1,005.1	174.4	204.5 (171.5)	30.1 (-2.9)	61.1 (28.1)
1990/91	1,041.6	182.2	204.5	22.3	53.3
1991/92	1,079.6	190.0	205.5	14.5	45.3
1992/93	1,129.14	201.6	204.59	2.6	33.9

a/ Simultaneous Max. demand based on 95% diversity factor (Table A3.12).

b/ Commissioning of fourth 33 MW Unitat MPS in 1988/89; Figures in brackets indicate capacity balance assuming installation of 4th unit at MPS delayed to 1990.

c/ BPC purchases from ESCOM (total allocation of 31 MW assumed).

d/ Without import of power.

e/ Deficit.

Source: Mission estimates.

tariffs: by 10%, 15% and 16% in April of 1979, 1982 and 1983, respectively. 21/ Different tariffs now apply in BPC's Southern and Shashe Divisions (Annex III). The municipality of Francistown and BCL Ltd. also have special tariff arrangements with BPC. BPC's consultants, Kennedy and Donkin, have recently submitted a final report on the tariff study which was done as part of the Power Project (IBRD Loan 2209-BT). Preliminary estimates of marginal capacity costs (per kW p.a.) for BPC's combined system are: (a) P73.9 for generation; 22/ (b) P95.0 for transmission at the 220 kV/132 kV busbars; (c) P124.7 for transmission at the 33 kV/11 kV busbars; and (d) P198.2 for low-voltage distribution. The estimated marginal energy costs (in thebe/kWh) for the integrated system would vary from 1.50 in 1984/85 to 0.81 by 1990/91. The mission understands that BPC is holding further discussions with the consultants to finalize these estimates of marginal energy costs and marginal capacity costs. The combined average Long Run Marginal Cost (LRMC) for supply at the low voltage distribution level could be about 8 thebe/kWh.

3.12 Power Tariff for BCL Ltd. The provisions of the Shashe agreement between BPC and BCL limits the BCL power tariff to a level that covers only BPC's expenses plus an 8% annual rate of return on historical investments. As such the BCL tariff level cannot be increased to cover projected financial requirements based on the criteria of rate of return on BPC's revalued assets. The consultant's study establishes that although the power tariff charged BCL is at about the same order of magnitude as the economic costs (LRMC) of supply to HV consumers, it falls far short (by P9.0 million p.a.) of the level required to cover BPC's financial requirements. This raises the issue of how to make up for this shortfall given that the BCL tariff cannot be raised. Rather than distributing this burden on other consumers (through a cross-subsidy), the mission recommends that the Government consider providing an explicit subsidy in respect to BCL revenues forgone as a result of the Shashe agreement.

Connections Fees for Residential Consumers

3.13 Urban Areas with Reticulation: BPC provides service connections at the following rates to residential consumers in areas where reticulation is available:

(a) P200 for a single phase serial connection (approximately 30 m distance) with a meter rated at 20/80 amps;

21/ Tariffs in BPC's Southern Division previously had been raised by more than 30% between 1976 and 1978.

22/ This estimate of the marginal capacity cost for generation could be increased following the ongoing review of the tariff study. The basis for estimating the shadow price of coal in the study needs to be updated to reflect the July 1983 agreement with Morupule Colliery (4.5).

(b) P675 for a three phase underground connection (over 30 m distance) with a meter rated at 50 amps; and

(c) P2900 for a three phase underground connection (over 50 m distance) with a meter rated at 100 amps.

Since BPC requires that the initial fee includes a deposit to cover about two months electricity consumption, total initial payment for service connections using specifications (a), (b), and (c) above are P300, P1100, and P5600 respectively. Although it is BPC policy to inform each prospective consumer of the availability of the cheapest form of connection which is the single phase aerial connection, some organizations such as the Botswana Housing Corporation (BHC) have insisted on underground connections. BPC also reports that over 90% of all residences in urban areas with reticulation have been connected.

3.14 Other Areas: There is concern that BPC's connection charges are unnecessarily high in areas (both urban and rural) where reticulation is not presently available. Most potential consumers in such areas appear unable to afford the initial cost of connection, which are in most cases considerably higher than indicated above (3.13), on a lump sum basis. The Government has established a `Revolving Fund' to assist in extending reticulation from the existing grid in rural areas but there appears to be a number of problems with the use of this fund. There appears to be other constraints to the extension of reticulation in some urban areas. It appears that guidelines that have been established by the Government for 'Self-Help' Housing Estates and for BHC sponsored Low Cost Housing Estates preclude reticulation. In order to promote the use of electricity in non-reticulated areas, the mission believes that it would be desirable to reduce the initial capital costs borne by individual consumers. One option would be to recover the amounts (costs for reticulation in such areas) in the tariff, but a further evaluation of options is needed as a basis for any firm recommendations. The mission therefore endorses the Government's request for technical assistance to enable the MMRWA to do an independent and comprehensive review to identify measures that would lead to an improvement in the electricity sales policy for consumers in non-reticulated areas.

BPC Manpower Development Program

3.15 BPC has a total staff of 910 which includes expatriates, local skilled and unskilled labor. The senior management of BPC, with the exception of the Secretary, is expatriate. BPC is however making significant progress in recruiting and training Batswana in various skills (generation, transmission, distribution and administration) required for the ongoing expansion program. The main objective for the short-term is to develop a total staff of about 190 for the MPS. BPC plans to re-deploy some experienced personnel from the GPS and SPS to the MPS. This nucleus staff for the MPS will be supplemented by new personnel to be recruited through BPC's training program. Since June 1982, BPC has

recruited Batswana for training: (a) in Mechanical, Electrical and Instrumentation skills; (b) to operate the System Control Center; and (c) for the operation, maintenance and testing of power plant equipment. Previous difficulties in attracting suitably qualified students (with passes in mathematics and science subjects) appear to have been overcome over the past two years.

3.16 BPC artisan trainees utilize the Botswana Polytechnic at Gaborone for theoretical studies, but rely on BPC's own workshops and electrical laboratories at Selebi-Phikwe and at Gaborone for practical training. BPC has recently decided to consolidate all workshop equipment at Gaborone, and hence equipment at Selebi-Phikwe is being used to upgrade the Gaborone workshop. Other on-the-job programs that have been organized by BPC for its technicians include: (a) an induction training program (minimum of 6 months) for all first appointees which covers basic engineering course work; and (b) remedial/refresher courses for artisans and operators (power plant personnel, distribution electricians, linesmen, cable jointers) which are held as appropriate for the needs of the various BPC departments.

Energy Conservation and Electricity Supplies to Isolated Institutions

3.17 The Department of Electrical Engineering is responsible inter-alia for operating and servicing some 190 small diesel generators (capacity 1.5 kVA to 250 kVA each) that are used by the Government to provide electricity to public institutions at isolated locations. The DEE is headed by an expatriate Chief Electrical Engineer who is supported by a permanent staff of nearly 100 (including 16 expatriates) and 400 part-time craftsmen. DEE estimates that some 5 million liters of diesel oil are consumed annually (cost P3.0 million) by these diesel generators and total annual electricity consumption by the institutions is of the order of 15 GWh.

3.18 Because an important objective of the Government's energy policy is to minimize consumption of imported petroleum products, the mission reviewed DEE's operations to ascertain what measures, if any, could be introduced to reduce diesel consumption for such services. The mission found that the following practices mitigate against the promotion of energy conservation:

(a) No records are kept of diesel fuel consumed by location. Although DEE is responsible for operating the generators, the diesel fuel is procured by the institutions from the Central Transport Organization (CTO) who do not keep separate records for the different categories of diesel oil used (for transportation, for diesel powered pumps, for heating and for power generation);

(b) No meter readings are taken of electricity supplied from these diesel generators to the institutions principally because such institutions are not accountable for the costs of supply.

Institutions therefore use electricity for a variety of needs (cooking, heating water, etc.) without any consideration of lower cost options such as domestic coal;

(c) In most cases, diesel generators are allocated to individual institutions rather than the DEE. This has led to sub-optimal use of generators and there appears to be considerable redundancy.

3.19 The mission was informed that DEE is unable to introduce effective measures to address issues (a) and (b) because of the Government's decision in 1979 to phase out entirely the use of decentralized (institution by institution) cost accounting systems for the provision of utilities such as diesel oil and electricity. The costs for such services are now met from a centralized fund under the control of the MFDP. The mission understands that the rational for this change was the lack of adequate manpower to maintain the decentralized system. Nevertheless, the mission strongly recommends that the arrangement be reviewed from the viewpoint of controlling recurrent expenditure for diesel-based electricity supply to isolated public institutions. As a matter of policy, all institutional consumers of energy should be directly accountable for the cost of energy supply.

3.20 In the mission's view, the objective for re-introducing accountability for energy use at the institutional level should be to promote energy conservation and rational fuel substitution. DEE has two options to effect conservation of diesel oil use in such isolated public institutions:

(a) eliminate inefficient use of diesel oil due to the current practice whereby small diesel generators are separately allocated to several institutions in a given locality. In this respect, the mission endorses DEE's current efforts to introduce in a number of localities some centralized diesel power generation stations in place of scattered units (including privately operated ones); 23/

(b) introduce selective audits to determine patterns of energy use in the respective institutions. On the basis of that information, DEE could evaluate what options, if any, could be introduced to conserve energy, and if possible to substitute alternative fuels for the use of electricity (coal-fired stoves and/or boilers in schools and hospitals).

The mission recommends technical assistance to enable DEE to develop an in-house capability to conduct energy audits along the lines discussed under (b).

23/ At such locations, DEE charges private consumers a tariff which represents the full cost of supply for the particular diesel power station.

IV. COAL

4.1 Coal is the only energy resource known to exist in Botswana in quantities large enough to have a major impact on the country's energy balance. Eventually coal may be a major export commodity for Botswana; meanwhile, it provides the basis for reducing the country's dependency on energy imports. The two main uncertainties facing the development of the coal sub-sector are:

(a) the prospects for and economic viability of proposed coal mining ventures; and

(b) the scope for further increasing the use of locally-produced coal in place of imported petroleum and coal.

Overview

Coal Resources

4.2 Coal deposits have been identified in ten areas of Botswana. The main coal fields are located in the Greater Morupule and in the Mmamabula areas of eastern Botswana (IBRD Map 17602). Total reserves are of the order of 17,000 million tonnes and, although the coal quality varies considerably from one area to another, the calorific value is low, ash content is high, and volatility medium to high. Three workable coal fields have been identified: (a) the Morupule coal field; (b) the Serowe coal field which is being explored by Shell International Co.; and (c) the Mmamabula coal field which is being explored by BP, and a consortium between Amax and Charbonnages de France (CDF).

Production

4.3 The Morupule Colliery which is owned and operated by the AAC of the RSA, currently exploits one seam in the Morupule coal field and provides about 90% of coal requirements in the country. The Morupule Colliery produced 371,000 tonnes of coal in 1980, 381,000 tonnes in 1981, and 415,000 tonnes in 1983. Further increases in production capacity are planned for the MPS. The first expansion is to bring production capacity at the Colliery to 600,000 tonnes p.a. by the time the MPS is commissioned. Additonal leases -- the so-called "provisional lease block" -- have been granted to AAC to ensure that adequate coal reserves are available to the colliery for planned expansions of the MPS. Coal from Morupule now is crushed and sent without further preparation by rail to

BPC's coal power stations at Gaborone and at Selebi-Phikwe, 24/ and to the BCL copper/nickel smelting plant at Selebi-Phikwe. Approximately 60% of the coal produced domestically is consumed by BPC. Most of the remainder is consumed for copper/nickel smelting by BCL.

Imports

4.4 Coal is imported from both the RSA and Zimbabwe for domestic consumers who require higher grade coal than presently can be supplied from the Morupule Colliery. This market for higher grade coal amounts to about 40,000 tonnes p.a. BPC had to import approximately 55,000 tonnes of coal from the RSA on an interim basis in 1981 because the coal-fired power generating units were installed at the GPS before the completion of the Morupule Colliery expansion scheme. BPC no longer needs to import coal. Coal is also imported from Zimbabwe for use in locomotives in the Selebi-Phikwe area, and for light industrial and commercial/residential requirements in the Francistown area.

Prices

4.5 The price of most coal produced by the Morupule Colliery is based on the Shashe agreement between AAC and BCL Ltd. This agreement established a complex formula for deriving the transfer price: AAC is guaranteed a fixed rate of return on capital after taxes; and the transfer price is kept in line with movements in the South African Wholesale Price Index (SAWPI). The current price for Morupule coal is just over US$13/tonne at the mine gate, compared to US$7.23/tonne in 1979. Transportation charges are added to establish the price charged to other customers. The selling price of Morupule coal in Gaborone, the principal market, is between US$20-22/tonne including transportation charges (US$7/tonne). A few public institutions purchase unwashed graded coal for P2.0/bag of 70 kg (US$29/tonne). BPC and AAC recently have agreed on a separate but similar transfer pricing formula to cover coal supplied to the MPS as a result of the mine expansion program (4.3). The wholesale price of imported washed coal (c.i.f. Gaborone) is US$25/tonne (P26/tonne in current prices), having dropped from US$40/tonne in 1980. The corresponding retail price for imported coal is currently P4.50/bag of 50 kg.

Demand

4.6 The total consumption of coal was about 450,000 tonnes in 1982 (Table 4.1). The largest consumers are BPC and BCL, accounting for 56% and 34% of total consumption, respectively. Information on coal consumption in the manufacturing, commercial and residential sectors is very sketchy and needs to be improved. These segments of the coal market use

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24/ The GPS has small steam turbines and consumes 1.1 kg of coal/kWh. The SPS is more efficient and consumes 0.6 kg of coal/kWh.

imported clean coal: BMC and the breweries account for about 30% of the market for clean coal; the extent of coal use in residences is not known but the main users appear to be expatriate households. The main commercial users include hospitals and other public institutions such as schools. The Government recognizes the importance of improving its knowledge of coal use in these smaller markets. The West German Government plans to assist the Government by funding and providing technical assistance for a survey (a) to determine current patterns of coal use in Botswana; (b) to assess the potential size of the residential market based on a number of scenarios as regards substitution of LPG, kerosene and fuelwood in the urban and the major villages; and (c) to assess the scope for substituting imported local coal in manufacturing/commercial enterprises. BMC and the Kgalagadi Breweries have tried unsuccessfully to use the unwashed, graded coal from Morupule in their furnaces. The major problem has been 'ash' in the coal which, upon burning, becomes 'fluid' and clogs grates in small and medium-sized furnaces.

Table 4.1: COAL CONSUMPTION, 1982

Consumers	'000 tonnes	Percent	Source of Coal
BPC	254	56.3	Morupule
BCL	153	33.9	Morupule
BMC	12	2.7	imports
Small Industries a/	12	2.7	Morupule/imports
Commerce/Residential b/	20	4.4	Morupule/imports
Total	451	100.0	

a/ Mainly the Breweries.
b/ Includes hotels, hospitals and other public institutions.

Source: Mission estimates; DOM and Morupule Colliery, Ltd.

4.7 Projections of coal demand in Botswana (Table 4.2) have been made under two categories: (a) demand by the large users, BCL and BPC; and (b) demand by other, smaller industrial, commercial and residential users. BPC's requirements are directly linked to developments at the MPS, and BCL's demand for coal is not expected to increase. BMC's demand for clean coal will increase slightly because of new processing plants at Maun and Lobatse. The coal requirements for processing when the Sua Pan Scheme begins operation after 1986 are also included. Any further increases in the demand for coal from other industries and the residential/commercial market would depend on the degree of acceptance of coal as either a direct or indirect replacement for LPG, fuelwood and kerosene. The mission's projections do not reflect this possibility and, hence, should be revised if the results of the proposed coal market survey provide any clearer indication of future needs in the residential and commercial sectors.

Table 4.2: COAL DEMAND PROJECTIONS
('000 tonnes)

	1982	1985	1990
Consumer			
BPC	254	396	553
BCL	153	140	140
BMC	12	14	18
Sua Pan Soda Ash Scheme	-	-	200
Small Industry	12	15	19
Commerce/Residential	20	20	25
Total	451	585	955

Source: Mission estimates.

Coal Export Schemes

The Kgaswe Coal Project

4.8 Background. In July 1982, the Government concluded a joint venture agreement with Shell Coal Botswana (Pty) Ltd. to develop the Kgaswe mine in the Serowe coal field. The agreement requires the Government to complete a detailed feasibility studies on all infrastructural requirements for the project, including the Trans-Kgalagadi Railway (TKR) by 1984. Shell is also required to complete a detailed feasibility study on the Kgaswe coal mining operations by 1984. A final decision on whether or not to proceed with the project is expected to be taken by the Government and its partners by mid-1985. 25/ Shell and its consultants have almost completed the mine feasibility study. Prior to this agreement, Shell's prefeasibility study had indicated that a total investment of P1,070 million (1980 prices) was required over the project lifetime, P730 million of which was directly attributed to the initial capital outlay for establishing the 10 million tpa coal mine. The mission reviewed available information on the project in light of the depressed international market situation for thermal coal.

4.9 Production Costs. The feasibility study has been prepared on the basis of specifications for clean coal prepared by Shell which required saleable coal of about 26.5 MJ/kg (11,400 Btu/lb) with an ash content of 12% or lower. The layout of the mine also has been revised from Shell's initial proposal for one long wall mine producing some 10 million

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25/ The Government has negotiated a 15% equity participation (without cash payment) in the project and an option to purchase an additional 10%. The feasibility study on the TKR has been delayed and will not be completed until January 1985.

tonnes of raw coal a year to two underground mines, each producing 5 million tonnes of raw coal p.a. by 'room and pillar' methods. The total output of washed coal from the two mines would be 5 million tpa. 26/

4.10 The preliminary feasibility study estimates of total mining costs were converted by the mission to production costs per tonne clean coal based on a projected output of 116 million tonnes of clean coal assuming a 25 year life for the mine. The initial capital costs were amortized over 25 years at an interest rate of 10% p.a. This roughly put the cost of clean coal of the order of US$32/tonne at the mine; the anticipated rail costs to Richards Bay, which is 1,300 km to the east of Serowe, was estimated to be of the order of US$24/tonne; and the cost of loading at the port was another US$4/tonne. The mission's estimate of total costs f.o.b. Richards Bay therefore was about US$60/tonne (in 1981 prices) tonne. The costs per tonne f.o.b. Walvis Bay, which is 2,900 km west of Serowe, would be higher.

4.11 Export Markets for Botswana Coal. The international market for thermal coal at present is severely depressed. The Bank's forecast is that the long term world market price for thermal coal (per tonne f.o.b. East Coast USA, and in 1981 prices) would rise first to US$52 by 1990, and then to US$55 by 1995. At these world market prices, Botswana coal would not be competitive. One additional factor is that while the annual volume of trade in thermal coal may double by 1990, there will be competion due to increased production in the US, RSA, Australia, Canada and Colombia.

4.12 Transportation Requirements. As indicated above, the prospects for developing the large scale export-oriented coal mines depends on major infrastructural investments, particularly the proposed Trans Kgalagadi Railroad (TKR) from Gaborane to Gobabis in Namibia, and the expansion of coal handling facilities at the Walvis Bay port. The capital cost for this "Western Link," that is for the railway line, the rolling stock and the coal terminal, is estimated (in 1980 prices) to be P1,000 million. The development of TKR is very much dependent on: (a) political developments and stability in Namibia; and (b) large tonnages being contracted at financially and economically viable prices despite the above uncertainties in the world markets. The Government and Shell are therefore considering eastern ports of Richards Bay (RSA) and Maputo (Mozambique) as short-term export outlets for the coal. A relatively short rail link (about 130 km in length) would be required between the Serowe junction in Botswana to Elisras in the RSA. The mission was informed that this link would cost about P150 million (in 1983 prices) and provide access via existing track of the South African Railways either to Richards Bay (1,200 km), or to Maputo (1,100 km). The Richards Bay coal terminal has the capacity to load up to 8,000 tonnes/hour of coal, but is fully occupied. Shell and BP have allotments for the export

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26/ The yield of clean exportable coal from washing is estimated at about 50% of raw coal.

of RSA coal but not presently for Botswana coal. The current allocations of the port are inadequate for RSA coal exporters and hence a further expansion to accomodate RSA needs is already in the planning stage. The Matola coal terminal at Maputo would need major rehabilitation and expansion to handle large amounts of Botswana coal. Currently, the capacity of the Matola terminal is under 1,000 tonnes/hour. The existing transportation infrastructure therefore requires expansion to handle the large tonnages of coal from the Kagswe project.

4.13 Availability of Water for Coal Treatment. The main options for water supply to wash the coal prior to export are: (a) from the Shashe Dam; (b) from groundwater reservoirs in the Serowe area. The latter option appears at this stage to be the most likely choice, although its feasibility cannot be realistically evaluated in detail until an ongoing assessment of groundwater resources has been completed.

4.14 Summary. The projected cost of exporting coal through Richards Bay would be about US$60/tonne (in 1981 prices), while the equivalent cost via the proposed TKR would be higher. The Bank's long-term forecast is for the world market price (in 1981 prices) for steam coal to be in the range of US$52-55/tonne (f.o.b. East Coast USA) by the mid-1990s, which implies that the coal output from the Kgaswe project would not be competitive. The mission therefore doubts that the proposed Kgaswe project would be viable without significant increases in the international price of steam coal. 27/

27/ During the review of the draft report in June 1984, the Government indicated that Shell had completed the feasibility study on the Kgaswe Project. On the basis of preliminary reports on the results of this feasibility study, the mission has estimated that the cost of clean coal (f.o.b. Richards Bay) would be greater than P60/tonne at 1983 prices. On the other hand, the results of the Bank's latest biennial review of "Price Prospects for Major Primary Commodities" projects that the mid-1990s price of steam coal (fob East Coast USA) would fall in the range of US$42-45/tonne (in 1983 prices). The previously quoted Bank price forecast for steam coal has been revised downwards both in real terms and also to reflect the appreciation in value of the US dollar in relation to other currencies.

The Mmamabula Project

4.15 The above transportation constraints for the Kgaswe Project would apply equally to proposed coal mining projects on the Mmamabula field. Prospecting licenses for the Mmamabula field were granted to BP; Amax and Charbonnages de France (CDF) in 1981. 28/ BP has proved large coal deposits in this field that are of a similar order of magnitude to that in the Kgaswe field. BP is proceeding with a feasibility study to develop a 5 million tonnes p.a. underground coal mine. Other large coal reserves have also been proved by CDF and Amax who have formed a joint venture to exploit the deposits. CDF, the operator in the joint venture, is presently carrying out preliminary feasibility studies for two possible coal production scenarios: a 0.5 million tonne p.a. underground pilot mine; or a 5 million tonne p.a. open pit mine.

Coal Washing Plant

4.16 The scope for the substitution of imported coal in the manufacturing/commercial sectors depends on the establishment of a local coal washery since unwashed coal from Morupule is unsuitable for use in this market. The Government proposes a feasibility study to establish the viability of a local washery in terms of the competitiveness of its output of clean coal -- on a cost per tonne (c.i.f. Gaborone) basis -- in relation to imports. The mission fully supports this initiative which should be accorded high priority. The mission believes that the size, scale of operation, and ultimately the economic viability of a local washery should be assessed with cognizance of the following factors:

(a) in addition to the import substitution potential in the manufacturing and commercial sectors, there could be a substantial potential for substituting residential use of fuelwood, LPG and kerosene. Although coal is currently the cheapest of the cooking fuels available to urban households (Table 4.3), there has as yet been no significant movement by households towards coal use, which in turn, suggests that there may be other intangible factors that need evaluation in the context of the coal market survey; and

(b) the Government is also investigating other technical options such as briquetting and pelletization which would produce more convenient solid fuels for the residential market. Some modification of the feasibility study may be required to reflect these options.

28/ BP and CDF were granted some additional licenses in 1982 and 1983, respectively.

However, the results of the proposed coal market study must be ready before the final size of the washing plant feasibiliy study can be determined.

Low Temperature Carbonization of Coal

4.17 The Government is interested in the possibility of utilizing the products of coal conversion processes such as Low Temperature Carbonization (LTC) to substitute for imported petroleum fuels. In this respect, the Government recently submitted a proposal to the EDF to obtain funds to begin preliminary tests and analysis to ascertain the suitability of local coals for LTC. These tests will provide an indication of potential yields of coke, tar, and other derivatives (fuel oils, pitch, and creosote) from the application of LTC on local coals. The scope of addition work on LTC in the country will depend on the results of the proposed tests. Because of the complicated economics of specialized coal conversion process such as LTC, the mission cautions that the size of the local market for LTC products may not be large enough to justify an economic sized plant in Botswana.

Table 4.3: EQUIVALENT COSTS OF COOKING FUELS IN GABORONE HOUSEHOLDS

Fuel Type	Energy Content	Fuel Unit	Retail Price	Cooking Efficiency	Energy Cost
	(Units/GJ)		(thebe/unit)	(%)	(thebe/useful GJ)
Coal a/	40.0	kg	9	20	1,800
Fuelwood b/	68.0	kg	10	15	4,533
Kerosene	28.7	liter	51	30	4,876
LPG	21.6	kg	104	50	4,493
Electricity c/	280.0	kWh	14	70	5,600

a/ Based on imported clean coal.
b/ Based on Gaborone retail price of P5.00/bundle of 50 kg.
c/ Based on BPC residential tariff.

Source: Mission estimates.

V. WOODFUELS

5.1 Most Batswana live without oil and without electricity, but do need woodfuels to cook their daily meals. Supplies are increasingly scarce around the major population centers, and the country's harsh climate makes it extremely difficult and costly to replace depleted forest resources. The survey data needed to begin to put the problem in quantitative terms on a regional basis is only now beginning to be collected. In this chapter, the mission reviews available information and attempts to put projects and programs in the subsector, including both those aimed at afforestation and those directed toward stove efficiency improvement, into perspective.

Consumption

5.2 Wood is the main source of energy for rural households. The current indication is that a large proportion of the lower income households in the major population centers of Botswana also rely on wood for cooking and heating water. Because the fuelwood supply/demand situation varies from region to region within the country, there is as yet no reliable basis for estimating total fuelwood consumption in Botswana. Recent surveys have also had very limited coverage, and annual per capita fuelwood consumption levels derived from these surveys vary considerably. 29/ Nevertheless, the basis used by the Government for estimating the total annual fuelwood consumption is 1.5 tonnes wood per capita. This translates into a total annual fuelwood consumption on the order of 1 million tonnes or 0.35 million toe. This estimate needs to be refined as improved data become available.

Fuelwood Prices

5.3 Although merchants organize fuelwood supply to the major villages and urban centers along commercial lines, no standard or consistent measures appear to be in use. The larger fuelwood

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29/ The findings of some of these surveys have been evaluated in Working Papers and Research Notes of the National Institute of Development and Cultural Research of the University of Botswana in Gaborone. An energy survey of the villages of Ditshegwane and Shoshong was recently done under BRET. Daily per capita fuelwood consumption levels vary from 0.4 to 3.0 kg in areas surveyed by the NIR. The BRET surveys indicate seasonal variations in fuelwood consumption. In Ditshegwane, weekly fuelwood consumption was found to be 67 kg per household of 5-6 persons during the cold (winter) season, and 28 kg per household during the warm (summer) season.

retailers 30/ sell wood in bundles of 50 kg, while the other merchants sell in rough measures of headloads or cartloads. 31/ A 50 kg bundle of chopped fuelwood is available from the timber treatment yard in Gaborone for P5, or 10 thebe/kg. Elsewhere in Gaborone, prices (on the basis of cartloads) have increased from P12/cartload in 1981 to about P25/cartload in 1983 or from 4 thebe/kg to 9 thebe/kg. Fuelwood prices are generally lower in the rural areas and are between P10-P20/cartload in major villages such as Mochudi and Molepolole. Prices are under P10/cartload in the smaller and more remote villages. At current prices, fuelwood is not much cheaper than alternatives such as kerosene and LPG, but is clearly more expensive than imported washed coal.

Fuelwood Supply

5.4 Fuelwood supply deficits are reported in most of the areas surrounding Gaborone, Lobatse, and the major villages in eastern Botswana. The vegetation in this region is dry woodland savannah and tree growth is 'stunted' by recurring drought. The standing volume of trees varies from some 60 tonnes/ha in the Limpopo river catchment area to less than 20 tonnes/ha around Lobatse. The indigenous species are hardy acacias and combretums which are slow growing (mean annual increment 1 tonne/ha p.a.). The preferred species for fuel is the combretum imberbus (local name 'motswiri') which is rapidly being depleted due to commercial trade in fuelwood.

Afforestation

5.5 The Government's policy towards afforestation has been to provide technical support to small growers and development organization such as the Kweneng Rural Development Association (KRDA) that have taken up tree growing on small plantations and woodlots to supply local requirements for building poles, fence posts and firewood. Several Government sponsored tree nurseries have been established in recent years to feed the plantations and woodlots. The Forestry Unit of the Land Utilization Division of the Ministry of Agriculture has been responsible for the nurseries. The main problems facing afforestation in Botswana appears to be: (a) the apparent high costs of establishing woodlots and plantations using eucalyptus; (b) the relatively poor growth rate achieved so far with eucalyptus; and (c) the lack of effective support from the Forestry Unit, which is also preoccupied with commercial operations in the Forest Reserve. The KRDA's Forestry Unit spends over

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30/ Example is the Timber Treatment Company in Gaborone.

31/ One headload of loosely packed fuelwood weighs between 10-25 kg, and one cartload of fuelwood (two wheeler) weighs between 300-400 kg.

P1,000/ha to establish woodlots, and about P100/ha annually for maintenance. The Government needs to address the question of what priorities should be assigned to establishing woodlots and plantations for energy and non-energy uses given the high costs involved, and the apparent scarcity of land for cultivation.

Stove Development

5.6 The Government has supported the objective of using efficient woodburning stoves and ovens to reduce wastage of fuelwood. Funds have been provided to the RIIC to demonstrate various designs of mud stoves and ovens, and to conduct extension courses to promote their use in rural areas. Courses of that nature were held at several villages including Maokane and Makaleng during the past year. The Botswana Renewable Energy technology Project (BRET) which is funded, in part, by USAID, has developed three versions of efficient stoves and is proceeding with field tests at the villages of Shoshong and Ditshegwane. The existing prototypes are: (a) a portable sheet metal stove known locally as the Louga 32/; (b) a one pothole mudstove; and (c) a larger mudstove. Despite the relatively high cost of materials (P15/stove), BRET has observed that the metal Louga is preferred and is making plans to recruit and train local antisans to produce and directly market the stoves. Although the prospects for the above stove projects are good, the mission is concerned about the lack of coordination between the two efforts. The Energy Unit of MMRWA should increase its role in coordinating and supervising these projects.

Charcoal

5.7 There is no charcoal production in Botswana. Small amounts (20-30 tonnes p.a.) are imported from the RSA and sold to a few households in the urban and mining centers. The current price is about P0.5/kg. Some consideration is being given by the Land Utilisation Department of the Ministry of Agriculture to large scale domestic charcoal production. Recently, the ECA/FAO Regional Forest Industries Advisory Group surveyed the prospects for this in Botswana using raw material from forest reserves in the north, from woodlands in eastern Botswana, and from Eucalyptus plantations which could be established near the urban centers. The Group recommended Government support for a major charcoal program. Based on available information, the mission believes that it is highly unlikely that viable charcoal operations can be established using raw material from the eastern woodlands or eucalyptus plantations. Other factors limit the availability of raw material for carbonisation from the

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32/ This metal Louga stove is very similar in design to the Paola which is used in lesotho.

forest reserves. On the basis of the report 'Utilization of Forest Resources' by Government consultants, a logging concession has been granted for exploitation of the Chobe Forest Reserve. The total logging potential in this reserve is estimated at 250,000 m^3 or 15,000 m^3 p.a. Some 10,000 m^3 of wood residues would be produced which on carbonization could yield about 2,000 tonnes charcoal p.a. While this charcoal could be delivered to some urban centers at a price which is competitive with imported charcoal, it is again unlikely that charcoal from the northern forest reserves will be competitive in price with other fuels (Table 4.3). Transportation costs by road from Kasane to Francistown (550 km at P0.09/tonne km) would be of the order of P50/tonne charcoal. Gaborone is a further 620 km by road or rail from Francistown. The mission therefore does not believe that there is as yet adequate justification for a major effort to promote charcoal production and use in Botswana.

VI. NONCONVENTIONAL ENERGY APPLICATIONS

6.1 Since the beginning of the Fourth National Development Plan (NDP IV), the Government has supported several projects to introduce into Botswana non-conventional energy technologies, including solar water heaters and windpumps. Local organizations such as the Botswana Technology Center (BTC) and the Rural Industries Innovation Center (RIIC) have been actively involved in these projects. Recently, the Government transferred the responsibility for managing BRET from BTC to MMRWA. This change was made to facilitate the reassessment of objectives and priorities for non-conventional energy. This chapter reviews the status of specific applications with a view to assisting in the ongoing redefinition of programs and priorities in this field.

Solar Water Heaters

6.2 Over the past five years, at least four companies have began marketing solar water heaters in the Gaborone area. Three of the solar marketing companies are distributors of manufacturers in Australia, the USA and the RSA, and one company, Solar Power/Kgalagadi Resources (Pty) Ltd., manufactures the units locally in Gaborone. Solar water heaters are also being used in mining townships such as Jwaneng and Selebi-Phikwe in place of electric or gas-fired water heating systems. 33/

6.3 The Botswana Housing Corporation (BHC) currently installs a solar system in all higher-income rental units. The solar system comprises a 4 m^2 sized solar collector and a 250 liter capacity storage tank and is roof-mounted. The installed cost of the system is about P2,000. BHC continues to install electric water heating units in the medium-income rental units. Two types are used: a 135 liter capacity storage tank fitted with a 3-kW electric heating element; or a system comprising a 3-kW electric heating element and two 45-liter capacity tanks. The installed cost of these electric units is about P500. BHC could replace these electric units with an appropriately sized solar system because it would lead to savings in costs (Table 6.1). In the mission's view, one locally available solar system, a 150-liter capacity storage tank connected to a 2m^2 sized solar collector would be appropriate. For lower income rental units, with direct access to pipe borne water supply, BHC could install locally available low-cost solar 'push through' collectors to substitute for the use of fuelwood, LPG or kerosene for heating water.

33/ All the available commercial solar water heaters are installed with electrical backup systems.

Table 6.1: COMPARATIVE MONTHLY COSTS FOR HEATING WATER

	Solar Unit	Electric Geyser Unit
Annuitized monthly cost a/	28	11
Monthly electric bill b/	2	23
Total monthly cost c/	30	34

a/ All systems amortized over 5 years at interest rate of 10% annual rate. Installed costs are solar 150 liters (P1,300) and electric (P500).

b/ Basis is 135 liters water/day heated from 20°C to 60°C. Heat load (at 0.93 efficiency) is about 17,200 Btu/day or about 150 kWh/month. Solar backup electricity bill is estimated to be 10% of electric system requirements. The monthly electricity bill is estimated on the basis of the existing domestic tariff for the Southern Division (Table A3.13).

c/ based on financial costs only.

Source: Mission estimates.

Solar Photovoltaic (PV) Systems

6.4 Several of the solar marketing companies in Gaborone report a significant increase in the number of enquiries by private customers about the feasibility of using solar PV power systems for households needs. 34/ Currently the Botswana Defence Force (BDF) uses about 150 solar power radio sets, and the DWA uses solar power on all anemometers. The Botswana Technology Center (BTC) has also used solar PV systems in several recent projects including: (a) fence charging systems for a number of outposts for the Police Service and for the Vetinary Service 35/; (b) a small water pumping system at an agricultural cooperative in Mogonye; and as part of BRET; (c) to operate a vaccine refrigeration system and maintain essential lights at the health clinic at Lentsweletau. A few other health clinics are soon to be added to the BRET demonstration project.

34/ A household electrification system comprising a solar PV panel, a current control module, a storage battery, and the necessary wirings and fittings to accommodate three lights and some appliances is available from local solar marketing companies for P1,000 (installed with a five-year guarantee).

35/ Used at quarantine camps to control foot and mouth disease.

6.5 Since there is already substantial global experience in the use of solar PV power kits for such small needs, the mission recommends that more emphasis should be given by BRET to assessing:

(a) the requirements in terms of manpower and institutional arrangements to implement a program for all rural health posts and clinics; and

(b) the level of financing required to provide electricity using solar PV systems to the existing network of rural health posts and clinics. 36/

6.6 Other potential rural applications of solar PV systems should also be surveyed. 37/ The mission does not support BTC's proposal that the Government provide incentives for the use of solar PV lighting systems in low income households. This would produce high cost electricity which such households could not afford on any large scale. The problem of improving the access of low income households to electricity should be tackled by revising BPC sales policy and connection standards for residential customers (3.14).

Windpumps

6.7 The mission supports the Government's strategy for promoting the use of windpumps as an alternative to diesel powered pumps at isolated village waterwells, and at watering points along cattle trekking routes. 38/ These isolated locations are not likely to be connected to the BPC grid for several years hence an alternative to pump electrification would be preferred. The Government has sponsored the development of prototype windpumps with special power transmissions that are compatible

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36/ A typical rural health post may require electricity for refrigeration of special vaccines and drugs, for essential lights and for a radio telephone. There are currently some 100 health clinics and over 200 health posts in the rural areas of Botswana. A few of the clinics or posts have electricity.

37/ For example, solar PV power units could replace existing use of small (3.5 kVA) diesel generators at Meteorological outposts at Tsabong, Tshane, and Shakawe.

38/ Watering points are provided by the Ministry of Agriculture at regular intervals (about 30 km) along the main cattle trekking routes. Currently, each waterwell is equipped with a medium-sized diesel powered pump which is operated and maintained by the DWA. Some 20 small diesel pumps (each rated at 10 kVA) are currently deployed along the Shashe River from Ramoegwebana to the Tuli Circle.

with the rotary drives of mono-pumps in the country. The Serowe Windmill Technology Group has recently licensed a model for commercial production by the Momoso Engineering works at Kanye; and the RIIC are currently testing another model at a well at Mogojogejwe. The BRET project proposes to sponsor extensive tests on 6 windmills: 3 of the RIIC design; and 3 of the SWTG design.

6.8 The Government has also provided funds to the DWA for windspeed surveys and for a pilot program in which eight windpumps would be installed for monitoring purposes. DWA reports that the windpumps have not performed well and several ofthem have had to be dismantled and replaced with alternatives such as handpumps. Most could not deliver adequate supplies of water against the high pumping heads at the demonstration sites. Others, such as those installed by MOA at cattles posts could not deliver water at satisfactory rates with the result that diesel engines that had been retained as standby to the windpumps, are now being used on a full time basis. DWA also reports that a meteorologist is currently monitoring and collecting data on surface windspeeds and will eventually develop a wind map of Botswana. The map will present information on surface windspeed patterns and also seasonal wind regimes. DWA expects that windpumps may eventually have a role that is limited to small farms and cattle posts where an intermittent supply of water is all that is needed.

Animal Driven Pumps

6.9 The RIIC has produced a prototype which is currently being tested at a borehole near Manyana. The system has a centrifugal pumping mechanism, and is driven by three mules that are capable of maintaining 1.5 hp to pump about 3 m^3/hour of water from deep wells. The mission supports this initiative which could provide an additional option for substituting diesel pumps in isolated areas. Two additional animal driven pumps will be installed for testing under the BRET project.

Use of Biogas in Pumps

6.10 A pilot biogas plant ($74m^3$) has been installed by the Rural Industries Innovation Center as part of a Government sponsored Integrated Farming Project at Diphawana. The plant produces enough biogas to substitute for 80% of diesel consumed by the water pumping system at the project. RIIC reports that the system is functioning satisfactorily and should provide enough water for 30 households and livestock (1,000 cattle and 300 small stock) on the project. The BRET project is providing funds to install and test 2-3 additional biogas plants. One of these plants will be installed at the Botswana Agricultural College for use as a teaching aid to extension workers and the general public. Because of the integrated nature of this approach, the mission expects that the utility of this option will be limited to relatively large cooperatives and cattle posts.

Solar-Powered Pumping Systems

6.11 In addition to the BTC scheme at Mogonye (6.4), BRET proposes to install about 4 similar systems 39/ for extensive tests. In the mission's view, the main issue is whether solar powered pumps are competitive with any of the above options in the Botswana context. BTC recently completed an evaluation of various renewable energy technology options for pumping water and concluded that solar powered pumps were competitive and should be deployed in Botswana. Notwithstanding various discrepancies with the methodology used in BTC's analysis, the mission considers that the conclusions should be applied with great caution. The choice between diesel and solar pumping options for isolated waterwells cannot be made without reference to several site specific factors that are yet to be clearly determined in Botswana. The findings of UNDP sponsored tests 40/ on solar powered pumping systems indicate that, at the present state-of-the-art, solar powered systems can only be competitive with diesel powered sytems if used: (a) for supply water to small rural communities rather than for irrigation; (b) in places where recurrent costs for diesel were high; and (c) where the static lift was less than 30 m. The latter condition does not always hold in Botswana because most wells require over 30m static lift. 41/

Handpumps

6.12 Handpumps are also being evaluated as an alternative to diesel powered pumps. DWA has installed 16 handpumps for a pilot testing program and intends to procure an additional 25 handpumps (the Mk II from India) for the program.

39/ The system at Mogonye consists of a solar PV array linked to a submersible pump (50 m deep). The pumping rate is electronically controlled and daily water output is about 3.5 m^3.

40/ UNDP Project GLO/80/003: Small Scale Solar-Powered Pumping Systems. Final Reports in eight volumes, dated June 1983.

41/ DWA reports that the static life in wells are usually in the range 20-50m, and the dynamic water level is between 50-100m in most locations.

COAL RESOURCES OF BOTSWANA

1. Some 17,000 million tonnes of coal are known to be proven or indicated reserves. In addition, the Geological Survey Department estimates that Botswana has inferred reserves of some 40,000 million tonnes of coal. The major coalfields are found in the following areas:

(a) Greater Morupule Area: This area includes the coal seams in Morupule and stretches west to the Moijabana area. Two sizeable coalfields have been identified: (i) the Morupule Coalfield which is currently being mined by the Morupule Colliery Ltd. This coalfield comprises three major seams and is estimated to contain some 20 million tonnes of coal (in situ). A considerable proportion of this deposit is affected by faulting and by intrusions of dolerite. However, about 2,500 million tonnes of coal in this field occur in areas that have little or no structural disturbances, and about 1,500 million tonnes of this coal occur within the basal seam which has an average thickness of 7.4m; and (ii) the Serowe Coalfield, which is west, adjacent to the Morupule Coalfield, and is being explored by Shell. Shell's exploration program has covered an area of about 215 square kilometers out of which about 151 square kilometers are considered to have a good potential for mining. The coalfield comprises three main seams. The principal workable seam is the Morupule Main which is located at a depth of 150 m, has an average thickness of 7m, and a mineable reserve of 375 million tonnes. The second largest seam is the Serowe Bright, which has an average thickness of 1.5 m and a mineable reserve of 186 million tonnes. The third seam is the Lotsane, which has an average thickness of 1.8 m and a mineable reserve of 98 million tonnes. The Serowe Bright and the Lotsane seams are located at depths 100 m and 50 m above the Morupule Main, respectively. The volatility of coal in the Morupule Main is about 24.3%, and that of coal in the other two seams are much higher and range from 32% to 34%. Raw coal from the Morupule Main has a 16 to 18% ash content, a 1.0 to 2.5% sulphur content and a colorific value of between 25 to 26 MJ/kg (6,000 to 6,200 kcal/kg); and

(b) Mmamabula Area: The Mmamabula Coalfield is located 130 km south of Morupule. Initial reconnaissance activity was over some 500 square kilometers of this area, but follow-up prospecting activity was narrowed down to a small central block of about 50 square kilometers. Three mineable seams have been identified in the central block: the first seam which is the lowest, is located at a depth of 30-60 m throughout the block and has an average thickness of 2.4 m; a second seam is located about 18 m above the first seam extends over 32 square kilometers and has an average thickness of 5.4 m; and uppermost seam which is some 28 m above the lowest seam, extends over 15

square kilometers, and has an average thickness of 1.1 m. BP, CDF and Amax have been granted prospecting licences in areas adjacent to the Central Block.

Annex 2

NOTES ON ANALYSIS OF PUMPING COSTS 1/

A. Diesel Pump

1. Fuel consumption rate estimated at 0.27 liters/kWh. Diesel pump assumed at 4 hp requiring 0.8 l/h. Hence at 3000 hours operation per year fuel costs is P1243 p.a.

2. Lubricant costs per year estimated at 0.5% of fuel requirements assuming unit cost of lubricant at P2.50/liter. Hence lubricant cost is P45 p.a.

3. Routine maintenance for diesel pumps (i.e. replacement of moving parts in the pump the mono column) is estimated at P600 p.a.

4. Overhaul of diesel pump is done once every two years at a cost of P600. On an annual basis engine overhaul cost is therefore P300 p.a.

5. Operator Costs for a diesel pump is estimated on the basis of each operator (salary P2000/year) responsible for 1.5 pumps. Hence operator iss about P1300 p.a.

6. Capital cost of diesel pump is about P3500. Assuming depreciation at 10% p.a., the fixed costs for the pump is about P570 p.a.

B. Electric Motor Pump

1. Electricity costs estimated on basis of 3 kW pumps operating at 90% efficiency for 3000 hours p.a. and at tariff 13.7 thebe/kWh. Hence cost is P1370 p.a.

2. Cost for lubrication is negligible.

3. Routine maintenace cost for electric pump is estimated based on expenditure of about P500 once every fifth year. Hence annuitized cost is P100 p.a.

4. Operator costs for an electric pump is estimated on the basis of part time attendance, P300 p.a.

5. Capital cost of the electric pump is about P2000 and is depreciated at 10% p.a. Fixed costs are therefore P295 p.a.

1/ Source of information is the DWA.

SUPPLEMENTARY ENERGY DATA

Table A3.1: CAPACITY OF EXISTING CTO FUEL DEPOTS

Location	Storage Capacity ('000 liters)
Gaborone	138
Lobatse	46
Kanye	23
Molepolole	46
Maun	69
Mahalapye	46
Selebi-Phihwe	46
Ghanzi	46
Kasane	46
Francistown	69
Palapye	46
Werda	46
Tshabong	46
Phuduhudu	46
Masana	46
Total	805

Source: CTO

Table A3.2: BOTSWANA PETROLEUM PRODUCT PUMP PRICES, 1975-1983
(Botswana Thebe/Liter)

End Year	Premium Petrol	Gas Oil a/	Illuminating Paraffin
1975	22.70	20.98	17.00
1976	26.00	24.10	17.80
1977	29.50	27.30	19.30
1978	29.50	27.30	19.30
1979	50.90	49.20	41.10
1980	54.60	52.60	40.30
1981	60.20	58.70	46.00
1982	66.70	63.50	52.40
1983 (August)	61.70	59.00	47.00

a/ Prices to industry are lower by 8.9 thebe/liter and to the farmers by 9.9 thebe/liter.

Source: Ministry of Commerce and Industry.

Table A3.3: BOTSWANA PETROLEUM PRICES STRUCTURE, JANUARY 1983
(thebe/Liter)

Cost Items	Premium Petrol	Gas Oil	Illuminating Paraffin
FOB	24.992	25.031	27.452
Freight	1.834	2.082	1.958
Insurance a/	0.027	0.027	0.030
CIF	26.853	27.140	29.440
Ocean Losses b/	0.081	0.081	0.088
Landing and Wharfage c/	0.450	0.450	0.450
Coastal Storage	0.400	0.400	0.400
Railage: Durban-Gaborone	0.258	5.588	8.455
Import Parity Gaborone	36.042	33.660	38.877
Sales Tax	3.000	3.000	--
Custom Duty	10.340	10.340	--
Levy d/	9.510	9.030	3.200
Depot Storage/Handling	0.400	0.400	0.400
Road Delivery	0.700	0.700	0.700
Marketers' Margin e/	3.604	3.366	3.888
Dealers' Margin	3.700	3.300	2.800
Pump Price	68.20	65.50	50.90

a/ 0.1009% of FOB + Freight.
b/ 0.3% of CIF.
c/ 1.8% of FOB.
d/ Levy for safe fuel fund and price stabilization. This is collected by the oil companies and paid to the Government for deposit in the BLS pool.
e/ Marketers' margins are 10% of the import parity Gaborone.

Source: Ministry of Commerce and Industry.

Table A3.4: BOTSWANA PETROLEUM IMPORTS BY PRODUCT, 1975-82
('000 tonnes)

Year	LPG	Petrol a/	Kero/Turbo Fuel b/	Gas Oil	Fuel Oil	Total
1975	0.5	22.4	4.6	53.9	4.1	65.5
1976	1.2	23.2	4.2	53.8	1.2	83.6
1977	1.7	28.3	5.2	57.2	1.8	94.2
1978	2.1	31.5	6.3	55.8	0.7	96.3
1979	2.3	34.0	4.3	74.8	1.1	116.5
1980	2.3	36.1	4.6	80.0	1.0	124.0
1981	2.8	41.0	6.7	93.2	2.4	146.1
1982	2.6	44.0	4.8	92.8	0.1	144.3

a/ Includes aviation gasoline.
b/ Includes power paraffin.

Source: Custom and Excise records of the GOB.

Table A3.5: BOTSWANA PETROLEUM CONSUMPTION BY PRODUCT, 1977-82
('000 tonnes)

Year	LPG	Avgas	Petrol	Avtur	Paraffins	Gas Oil	Fuel Oil	Total
1977	0.4	0.9	26.4	1.7	3.5	56.7	1.7	91.3
1978	0.6	1.1	28.7	1.1	3.8	59.0	1.0	95.3
1979	0.6	1.5	31.8	1.3	3.5	74.1	1.0	113.8
1980	0.7	1.8	34.3	0.5	3.8	85.6	1.3	128.0
1981	0.2	1.7	39.5	0.5	4.1	78.5	0.3	124.8
1982 a/	1.1	1.7	45.9	0.8	4.2	87.0	0.4	141.1

a/ Estimate based on data from four oil marketing companies.

Source: Ministry of Works and Communications.

Table A3.6: EXISTING GENERATION FACILITIES OF BPC

Station Location	Year	No. & size of units	Installed capacity	Firm capacity	Cumulative total
		(MW)	(MW)	(MW)	
Gaborone a/	1965	1x2.5 (Coal)	2.5		
	1968/68	1x1.0 (Diesel)	1.0		
	1969/70	2x1.0 (Diesel)	2.0		
	1970/71	1x0.7 (Diesel)	0.7	24.0	24.0
	1971/72	1x2.3 (Diesel)	2.3		
	1973/74	2x2.3 (Diesel)	4.6		
	1976/77	2x3.2 (Coal)	6.0		
	1980/81	2x3.2 (Coal)	6.4		
Selebi-Phikwe	1973/74	4x15.0 (Coal)	60.0	52.0	76.0
	1972	2x0.9 (Diesel)	1.8	1.5	76.5
	1983	1x20.0 (Coal)	20.0	20.0	96.5

a/ The Gaborone Power Station will be retired and used as a standby when the new Morupule Power Station is commissioned in 1985/86.

Source: BPC

Table A3.7: MONTHLY ELECTRICITY CONSUMPTION STATISTICS, JUNE 1983

Category	Number of Consumers	Average Monthly Consumption	Average Price of Energy
		(MWh)	(thebe/KWh)
Mining	5	5870.0	4.27
Business/Industry	1,243	8.8	10.83
Government/Municipalities	369	4.5	14.74
Street Lighting	23	4.7	18.15
Water Utilities/Pumping	36	15.5	12.70
Residential	8,230	0.4	11.47
Total	9,906	4.7	6.87

Source: BPC

Table A3.8: GENERATION STATISTICS - SOUTHERN DIVISION
(MWh) a/

The System Maximum Demand was 36,400kW in 1982/83 against 27,200kW in the previous year. Total generation was 172,680MWh including transfer against 77,354MWh in 1981/82. The table gives comparative numbers for the last ten years.

Generation	1972/73	1973/74	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83
Coal	8,128	11,318	8,613	10,981	23,548	37,684	38,465	44,444	54,257	70,059	69,318
Dieseline	3,709	3,480	17,044	6,777	3,569	1,637	8,113	4,543	2,920	1,387	
Heavy Fuel Oil	10,997	13,185	5,543	21,201	22,007	10,900	14,471	19,324	19,360	5,908	2,366
	22,834	27,983	31,200	38,959	49,124	50,221	61,049	68,311	76,537	77,354	71,684
Less Station Use	2,593	3,115	2,699	3,154	6,322	7,087	6,804	7,797	8,051	8,716	8,430
Station Send-out	20,241	24,868	28,501	35,805	42,802	43,134	54,245	60,514	68,486	68,638	63,254
Purchased Energy	-	-	-	-	-	-	-	-		27,099	100,988
Less: System Losses	2,267	3,245	4,377	5,056	4,165	3,613	5,275	5,564	5,170	9,338	11,601
Sales	17,974	21,623	24,124	30,749	38,637	39,521	48,970	54,950	63,316	86,399	152,641
Station Use %	11.31	11.13	8.64	8.09	12.87	14.11	11.15	11.41	10.52	11.27	5.52
System Losses %	11.19	13.04	15.36	14.12	9.73	8.38	9.02	9.19	7.55	9.75	7.6

a/ 1 MWh = 1,000 kWh

Table A3.9: GENERATION STATISTICS - SHASHE DIVISION
(MWh) a/

The system maximum demand was 52,500 kW in 1982/83 against 49,700 kW in the previous year. Total generation was 360,507 MWh against 354,603 MWh in 1981/82. The table gives comparative numbers for the last eight years of operation.

Generation	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83
Coal	168,140	211,803	232,240	274,254	305,686	333,006	324,254	354,605	360,507
Less: Station Use	15,454	18,342	18,041	19,004	19,197	20,246	20,296	27,091	24,464
Station Send-out	152,686	193,461	214,199	255,250	286,489	312,760	303,958	332,514	336,043
Less: System Losses	852	528	1,180	750	1,580	1,266	4,005	4,575	4,962
Sales	151,834	192,933	213,019	254,500	284,909	311,494	299,953	327,939	331,081
of which BCL	138,781	177,527	196,013	236,276	264,908	287,800	277,691	302,073	305,000
Station Use %	9.19	8.66	7.76	6.93	6.28	6.08	6.26	6.23	7.38
System Loss %	0.56	0.27	0.55	0.29	0.55	0.40	1.32	1.38	1.49
Sales to BCL	91.40	92.01	92.02	92.84	92.83	92.08	92.58	92.11	92.14

a/ 1 MWh = 1,000 kWh

Table A3.10: BPC STAFF RESOURCES, 1983

	Local	Expatriates	Total
Job Category			
Professional Engineers	3	13	16
Technician Engineers	2	-	2
Charge Engineers	-	10	10
Professional Accountants	-	5	5
Semi Professional Accountants	4	-	4
Administrators	4	-	4
Technicians	73	37	110
Others	759	-	750
Total	845	65	910
By Division			
Southern	425	36	462
Shashe	355	24	379
Rural	47	2	49
Central Power Station	17	3	20
Total	845	65	910

Source: BPC

Table A3.11: BPC ELECTRICITY CONSUMPTION STATISTICS, 1980-83

Class of Consumers	1981 Number	1981 Average Consumption per consumer	1981 Average Sale Price Thebe per KWh	1982 Number	1982 Average Consumption per consumer	1982 Average Sale Price Thebe per KWh	1983 Number	1983 Average Consumption per consumer	1983 Average Sale Price Thebe per KWh
SOUTHERN DIVISION									
Domestic	4,151	283	10.65	4,429	356	10.03	5,736	478	11.38
Business	492	3,811	10.43	645	4,236	9.95	797	12,687	10.49
Water Pumping	26	12,867	10.91	23	18,517	10.60	24	22,260	12.60
Government/Municipal	208	3,403	13.30	197	3,924	12.89	232	5,637	14.47
Street Lights	2	8,606	51.84	2	12,060	36.96	1	100,852	19.48
Botswana Meat Commission	1	688,000	8.76	1 + 1 (Jweng)	3,607,200 (Total)	8.65	1	591,000	9.80
Total	4,880	982	10.85	5,297	1,726	9.80	6,791	2,266	11.09
NORTHERN DIVISION									
Domestic	1,967	364	8.30	2,082	376	9.44	2,494	353	11.77
Business	354	2,129	11.48	393	1,871	13.29	446	2,014	14.70
Water Pumping	11	2,538	12.31	11	3,971	10.94	12	1,921	14.69
Government/Municipal	104	1,075	12.05	118	968	13.23	137	2,448	15.81
Street Lights	18	4,287	14.64	19	4,005	16.29	22	4,890	16.91
B.C.L.	1	25,843,000	3.32	1	25,613,000	3.59	1	27,086,000	3.76
W.U.C	2	252,230	5.67	2	273,450	5.72	2	266,180	5.69
Orapa/Mmadinare	0	0	0	0	0	0	1	1,141,253	12.57
Total	2,457	11,409	3.78	2,626	10,629	4.14	3,115	10,040	4.8
TOTAL (BPC)									
Domestic	6,118	308	9.79	6,511	362	9.79	8,230	440	11.47
Business	846	3,107	10.73	1,038	3,340	10.64	1,243	8,857	10.83
Water Pumping	37	9,796	11.01	34	13,810	10.62	36	15,481	12.70
Government/Municipal	312	2,627	13.12	315	2,815	12.93	369	4,453	14.74
Street Lights	20	4,718	21.42	21	4,857	21.07	23	4,714	18.15
Others	4	6,758,865	3.50	4	7,367,500	4.20	5	5,870,000	4.27
Grand Total	7,337	4,474	4.81	7,923	4,676	5.53	9,906	4,710	6.87

Table A3.12: BPC: FORECAST MAXIMUM DEMANDS AND ENERGY ON 'SENT OUT' BASIS

	Actual 1982 - 83		1983 - 84		1984 - 85		1985 - 86		1986 - 87		Estimate 1987 - 88		1988 - 89		1989 - 90		1990 - 91		1991 - 92		1992 - 93	
	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh
Urban/Rural South	22.3	84.3	24.0	91.6	25.7	99.6	28.2	110.7	30.3	120.4	32.5	130.9	34.6	141.4	36.9	152.7	39.4	164.9	42.0	178.1	44.8	197.4
Jwaneng (incl: Township)	13.3	71.0	15.5	85.0	16.7	92.1	18.1	99.5	19.2	104.9	20.2	111.2	21.0	115.4	21.8	119.6	22.7	124.5	23.5	129.2	24.6	134.5
BMC Lobatse	1.8	8.9	1.8	8.9	1.8	8.9	1.8	8.9	4.9	16.1	4.9	16.1	4.9	16.1	4.9	16.1	4.9	16.1	4.9	16.1	4.9	16.1
Water Projects	-	-	(1.8)	3.3	1.8	13.2	3.6	27.0	3.6	27.0	3.6	27.0	3.6	27.0	3.6	27.0	3.6	27.0	3.6	27.0	3.6	27.0
Kgalagadi (Diamonds)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.4	11.2
Urban/Rural Phikwe	3.6	18.1	4.0	19.3	4.3	20.6	4.6	22.2	4.9	23.7	5.3	25.7	5.7	27.4	6.0	29.1	6.4	31.0	6.8	33.0	7.3	35.1
Urban Francistown	2.5	17.2	2.8	18.5	3.1	19.9	3.5	21.8	3.8	23.5	4.1	25.2	4.5	27.4	5.0	29.8	5.5	32.3	6.1	35.1	6.7	38.1
BMC Francistown	-	-	-	-	-	-	2.6	4.3	2.6	9.1	2.6	9.1	2.7	10.2	2.7	10.2	2.7	10.2	2.7	10.2	2.7	10.2
Hospital Francistown	-	-	-	-	-	-	-	-	0.7	1.2	0.7	1.8	0.8	2.1	0.9	2.4	1.0	2.4	1.1	2.5	1.1	2.5
Morupule Coal	-	-	-	-	-	-	1.0	2.0	1.0	4.0	1.1	4.3	1.2	4.6	1.3	5.0	1.4	5.0	1.4	5.0	1.3	5.0
BCL	43.5	303.3	45.0	310.0	45.0	310.0	45.0	310.0	45.8	314.7	45.8	314.7	45.8	314.7	45.8	314.7	45.8	314.7	45.8	314.7	45.8	314.7
Orapa (incl: Township) a/	-	-	(15.4)	44.4	(18.4)	79.9	20.9	102.3	23.2	133.1	25.5	146.4	26.8	159.1	28.1	161.4	29.6	169.7	31.1	178.2	32.6	187.1
Sua Pan	-	-	-	-	-	-	-	-	11.2	57.0	13.1	96.8	13.1	96.8	13.1	96.8	13.1	96.8	13.1	96.8	13.1	96.8
Total (no Diversity)	87.0	502.8	110.3	581.0	116.5	644.2	129.3	708.5	151.2	834.7	159.4	909.2	164.7	942.4	170.1	964.8	176.1	994.6	182.1	1,025.9	192.1	1,068.7
Simultaneous M.D. 95% Diversity Factor	82.7	-	104.8	-	110.67	-	122.8	-	143.6	-	151.4	-	156.4	-	161.6	-	167.3	-	172.9	-	182.5	-
System Load Factor	-	69.4%	-	74.9%	-	78.7%	-	63.9%	-	63.9%	-	65.6%	-	65.4%	-	64.6%	-	64.0%	-	62.9%	-	62.7%
Additional Urban/Rural b/	-	-	-	-	3.0	11.45	6.0	22.90	9.0	34.35	10.0	38.17	11.0	41.98	12.0	45.80	13.0	49.62	14.0	53.43	15.0	57.25
Borehole Electrification	-	-	-	-	2.24	6.71	4.48	13.42	6.72	20.13	8.96	26.84	11.2	33.55	13.44	40.26	15.68	46.97	17.92	53.68	20.16	60.39
Total (no Diversity)	87.0	502.8	110.3	581.0	121.74	662.36	139.78	744.82	166.92	889.2	178.36	974.2	186.9	1,017.93	195.54	1,050.86	204.78	1,091.2	214.02	1,133.02	227.26	1,186.34
Simultaneous M.D. 95% Diversity Factor	82.7	-	104.8	-	115.65	-	132.79	-	158.57	-	169.44	-	177.55	-	185.76	-	194.54	-	203.32	-	215.89	-
Average annual Growth Rate	-	16.8	26.7	15.55	10.3	14.0	14.82	12.44	19.4	19.38	6.85	9.55	4.78	2.92	4.62	3.30	4.72	5.33	4.91	3.83	6.18	4.7

a/ Orapa load in 1983/84 is supplied by isolated diesel generation. Thereafter, it is connected to BPC Grid.
b/ Based on 3,000 additional service connections from 1984/85 to 1986/87. Thereafter, additional service connections are limited to 1000 p.a.

Source: Mission estimates.

Table A3.13(a): BPC ELECTRICITY TARIFFS - SHASHE DIVISION (FRANCISTOWN)

	Rate effective April 1979	Rate effective April 1982 and percentage increase	Rate effective April 1983 and percentage increase
Domestic			
First 30 Kwh t/Kwh	15.07	16.5 (5%)	18.1 (9.5%)
Balance t/Kwh	12.00	12.6 (4.8%)	13.9 (10.3%)
Minimum charge (P/kW/month)	5.00	5.26	5.8
Business Commercial and Industrial			
First 200 Kwh t/Kwh	13.07	14.04 (5%)	17.0 (18.0%)
Balance t/Kwh	12.00	12.06 (4.8%)	14.9 (18.2%)
Minimum charge (P/kW/month)	11.00	11.57	13.0
Government/Municipal			
Kwh t/Kwh	12.5	13.01	17.0
Minimum charge (P/kW/month)	5.0	5.26 (4.6%)	5.8) (29%)
Water Pumping, Street Lighting			
kWh t/kWh	10.00	10.05 (4.8%)	13.7 (30.4%)

Table A3.13(b): ELECTRICITY TARIFFS - BPC NORTHERN (SHASHE) DIVISION

	Rates (thebe/kWh)		
	Effective April 1979	effective April 1982	Effective April 1983
Domestic I			
First 50 kWh	12.00	14.01 (11.9%)	16.06 (17.7%)
Next 150 kWh	9.05	10.00 (16.8%)	11.08 (18%)
Balance	5.08	6.08 (16.0%)	8.00 (17.6%)
Minimum demand charge (Pula/kW/month)	-	2.58	3.00
Domestic II			
kWh	6.04	7.05	8.09
Minimum demand charge	1.25	1.47 (15.4%)	1.75(18.6%)
(Pula/kW/month)	-	-	-
Business I			
First 100 kWh	12.00	14.01 (16.9%)	16.06 (17.7%)
Next 100 kWh	10.00	11.08 (17.2%)	13.09 (17.7%)
Balance	7.05	8.08 (16.4%)	10.04 (18.1)
Minimum demand charge (Pula/kW/month)	-	2.58	3.00
Business II			
Demand charge (Pula/kW)	8.14	9.56	11.28
kWh	4.04	5.02 (16.5%)	06.01 (17.9%
Minimum demand charge (Pula/month)	220.00	258.50	300.00
Government/Municipal/ Street Lighting			
kWh	9.06	11.03 (16.9%)	13.03(17.6%)

Source: BPC

Table A3.13(c): BPC ELECTRICITY TARIFFS -

SOUTHERN DIVISION

	Rate (thebe/kWh)		
	Effective April 1979 a/	Effective April 1982	Effective April 1983
Domestic I			
First 400 kWh	10.06	12.04	14.04
Balance t/kWh	7.02	8.05	9.08
Minimum demand charge (Pula/kW/month)	2.20	2.58	3.00
Business I			
First 400 Kwh	12.01	14.02	16.05
Balance	9.09	11.06	13.05
Mimimum demand charge (Pula/kW/month)	2.20	2.58	3.00
Business II			
Demand charge (Pula/kW)	10.60	12.45	14.45
kWh	5.07	6.07	7.08
Minimum demand charge (Pula/month)	220.00	258.50	300.00
Business III			
Demand charge (Pula/kW)	9.40	11.05	12.82
kWh	5.02	6.01	7.01
Minimum demand charge (Pula/month)	220.00	258.50	300.00
Government/Municipal/Street Lighting			
Kwh	12.04	14.06	16.09
Water Pumping			
kWh	10.00	11.08	13.07

a/ An approximate percentage increase of 10% was effected on April 1, 1979.

Source: BPC

Table A3.14: DISTRIBUTION OF ISOLATED DIESEL POWER GENERATORS

Location	Available Diesel Capacity No. of Sets	Capacity (kVa)	of which Standby Capacity No.of sets	Capacity (kVa)
Border Posts	26	670.0	-	-
Hospitals	8	1,423.0	8	1,423.0
Health Centers	11	580.0	2	90.0
Airports a/	9	184.5	4	19.0
BDF b/	6	1,189.0	6	1,189.0
Schools	18	1,549.0	2	187.0
Colleges	2	147.0	-	-
Police Stations	7	123.0	5	120.0
Prisons	3	57.5	1	7.5
Meteorological Stations	5	21.5	1	7.5
Vetinary Stations	4	71.0	-	-
Farm Service Centers	4	86.0	-	-
Livestock Watering Points c/	20	200.0	-	-
Special Applications	38	965.5	33	460.5
Mobile and Reserve Units	27	964.0	276	964.0
Totals	188	9,231.0	60	5,467.5

a/ includes one standby 9 kVA unit to provide emergency power to radio beacon at Gaborone Airport.

b/ Botswana Defence Force.

c/ Along the Shashe River from Ramolegwebana to the Tuli Circle.

Source: DEE

Table A3.15: LOCATION AND SIZE OF TREE NURSERIES AND WOODLOTS IN BOTSWANA
(ha)

Location	Nurseries	Woodlots a/
Maun	0.5	-
Francistown	2.0	25.0 b/
Kanye	2.0	138.0
Gaborone	2.0	40.0 b/
Selebi-Phikwe	0.5	-
Ramatlabama	0.5	-
Kachikau	0.5	-
Molepolole c/	n.a.	n.a.
Kang	0.5	-
Kasane	0.5	-
Serowe	n.a	n.a
Palapye	-	2.5
Takatokwane	-	6.0
Shoshong	-	25.0
Mochude	-	25.0
Mahalapye	-	1.0
Tutume	-	5.0
Tonota	-	5.0
Lobatse	-	24.4 b/
Matsheng	-	30.0
Jwaneng	-	50.0
Good Hope	-	21.2

a/ established to provide fuelwood, construction materials and poles.
b/ non-fuelwood purposes only.
c/ a nursery and woodlot is maintained by Forestry Unit of the KRDA at Molepolole.

Source: Land Utilization Dept.

Table A3.16: PRICES OF STOVES IN GABORONE, SEPTEMBER 1983.

Type of Fuel	Price (Pula)
Kerosene	
'Triangle' non-pressure stove	11.50
'Hipolito' pressure stove	57.00
LPG	
Single gas ring stove	28.00-30.00
Electricity	
Single hot plate a/	25.00
Coal	
n.a.	n.a.
Fuelwood	
metal louga b/	10.00

a/ a two-plate model rated at 2.2 kW and 9.6 amps is priced at P65.00

b/ sold by artisans "mazezurus" near Gaborone railway station.

Source: Mission survey.

Table A3.17: MARKETS FOR DOMESTIC COAL
(tonnes)

Year	BPC		BCL	Kgaladi Breweries	Other	Total
	Selebi-Phikwe	Gaborone				
April 1981-March 1982	173,903	46,140	153,034	2,111	1,939 b/	377,127
April 1982-March 1983	188,975	64,795	152,551	1,307	3,409	411,037
April 1983-July 1983	66,910	39 a/	51,113	643	502	119,207

a/ Plant closed due to water shortage.

b/ May include some coal sold to Kgaladi Breweries.

Source: Monthly Reports of the Morupule Collieries; and of the Department of Mines.

Table A3.18: BOTSWANA, COAL IMPORTS (1977-1981)
(tonnes)

Year a/	Orgin		Total
	South Africa	Zimbabwe	
1977/1978	16,939	232	17,171
1978/1979	19,049	460	19,509
1979/1980	28,952	976	29,928
1980/1981	72,599	2,906	75,505
1981/1982	38,014	1,970	39,984

a/ based on fiscal year April through March.

Source: Transport Statistics 1981; MFDP.

Table A3.19: PROJECTED COAL DEMAND FOR POWER GENERATION
('000 tonnes)

Station		Year						
		83-84	84-85	85-86	86-87	87-88	88-89	90-91
SPS/GPS		286	342	336	132	134	103	90
MPS	Stage 1	-	-	60	275	325	325	325
	Stage 2	-	-	-	-	-	72	138
Total		286	342	396	407	459	500	553

Source: BPC

Table A3.20: APPROVED EXPENDITURE FOR ENERGY DEVELOPMENT a/

Project Title/Code	Approved Expenditure NDPV	NDPVI	Total Estimate
MPS (BP01)	61.25	54.05	115.30
Oil Storage Depots (CI05)	15.33	-	15.33
Rural Power Supplies (ID10)	1.82	0.42	2.14
Coal Development Studies (MR04)	9.50	-	9.50
Alternative Energy Development (MR01)	1.84	1.66	3.50
Dept. of Electrical Engineering (ID09)	2.67	0.5	3.17
Electrical Installations & Equipment (ID26)	0.16	0.41	0.57
Windmill Development (WB06)	-	1.50	1.50
Rural Afforestation (AE15)	0.28	0.59	0.87
Total Energy Related Projects	92.85	59.13	151.88
Total Development Expenditure	1,005.87	436.95	1,442.83

a/ Energy related projects only.

Source: NDP Project Review, 1982, MFDP.

Table A3.21: MONTHLY ENERGY CONSUMPTION STATISTICS OF DEBSWANA

1981	Year 1982	1983 (est.) a/
Orapa/Lethakane		
Power (MWh)	6,482	6,954	7,069
Diesel (kiloliters) b/	2,379	2,611	2,606
Jwaneng		
Power (MWh)	-	4,608	5,396
Diesel (kiloliters)	-	329	330

a/ data for June 1983 only
b/ 72% of diesel used for power generation at Orapa (18 MW) station.

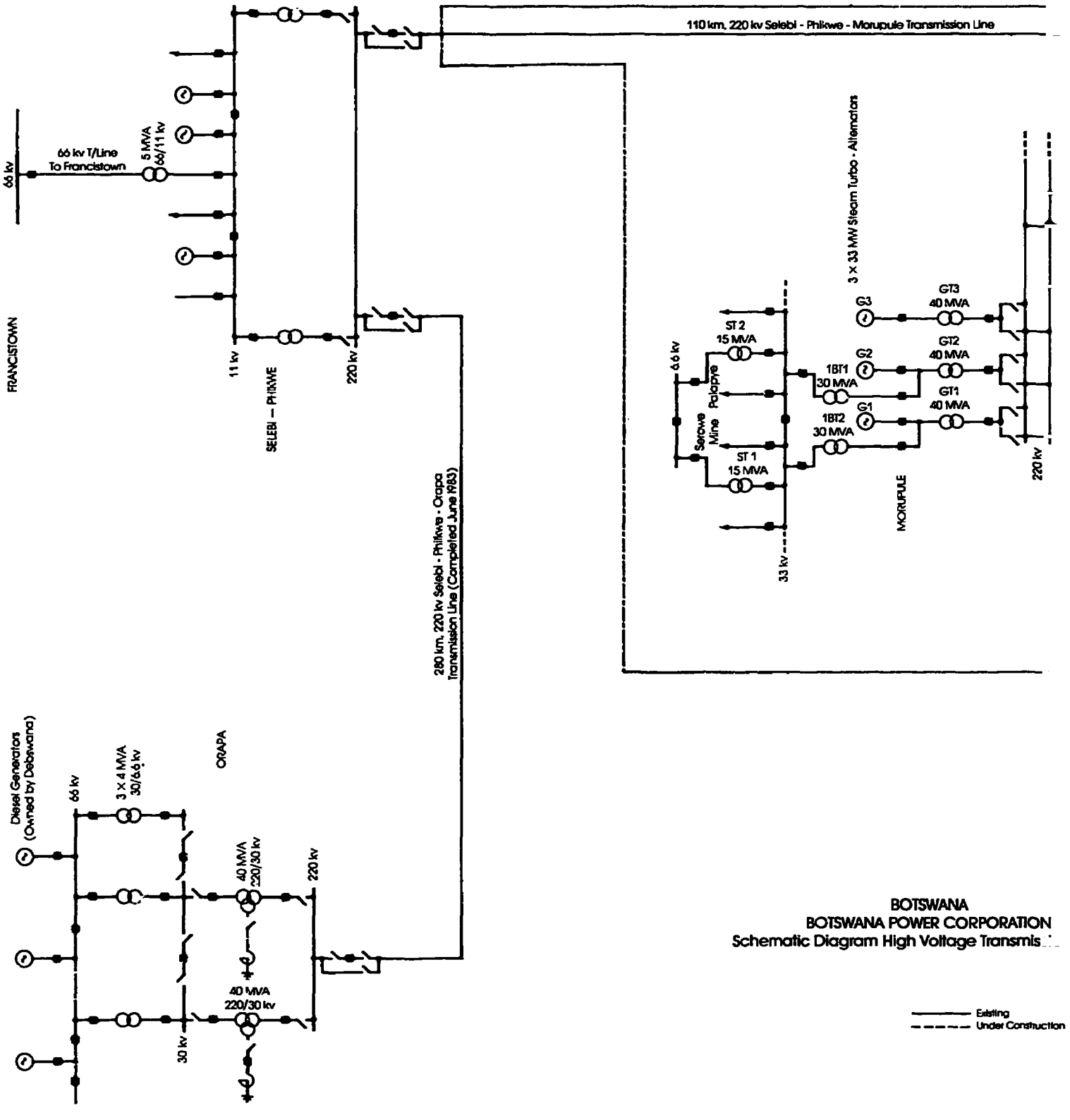
Source: Debswana.

Table A3.22: ANNUAL ENERGY CONSUMPTION STATISTICS FOR BCL LTD.

Type of Energy	1980	1981	1982	1983 (est.)
Petroleum ('000 tonnes)				
Fuel Oil	0.21	0.19	0.18	0.16
Diesel Oil a/	1.9	1.6	1.3	1.0
Coal ('000 tonnes) b/	179.0	162.7	149.7	142.5
Electricity				
Max. Demand (MW)	39.8	39.7	42.1	43.7
Energy Use (GWh)	274	299	299	317
Coal used/tonne ore mined	0.070	0.0065	0.060	0.051

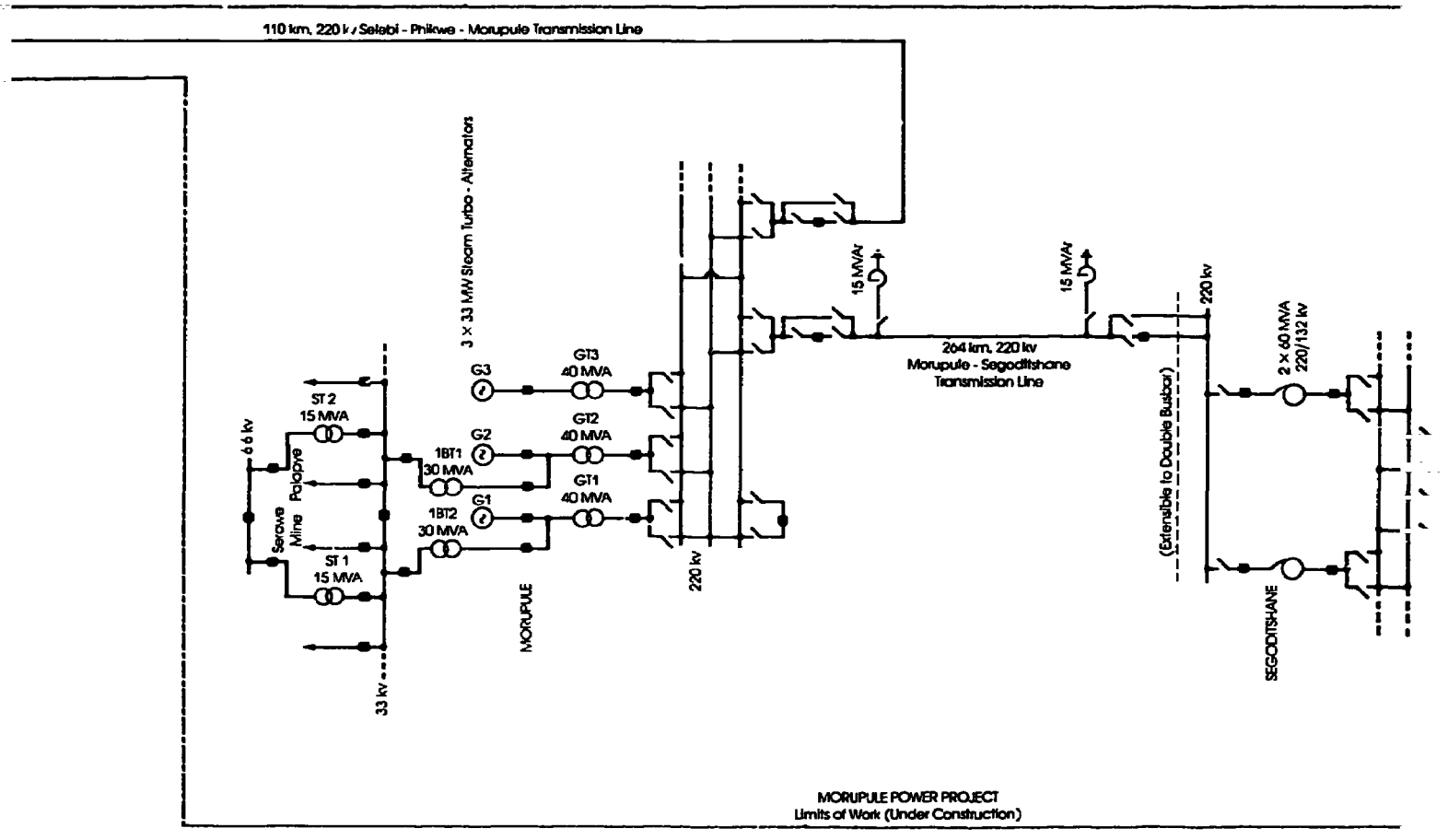
a/ about 40% for smelting operations.
b/ over 95% for smelting operations.

Source: BCL Ltd.



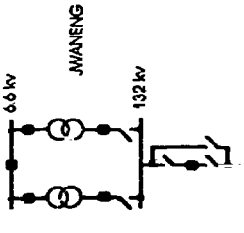
BOTSWANA
BOTSWANA POWER CORPORATION
Schematic Diagram High Voltage Transmis

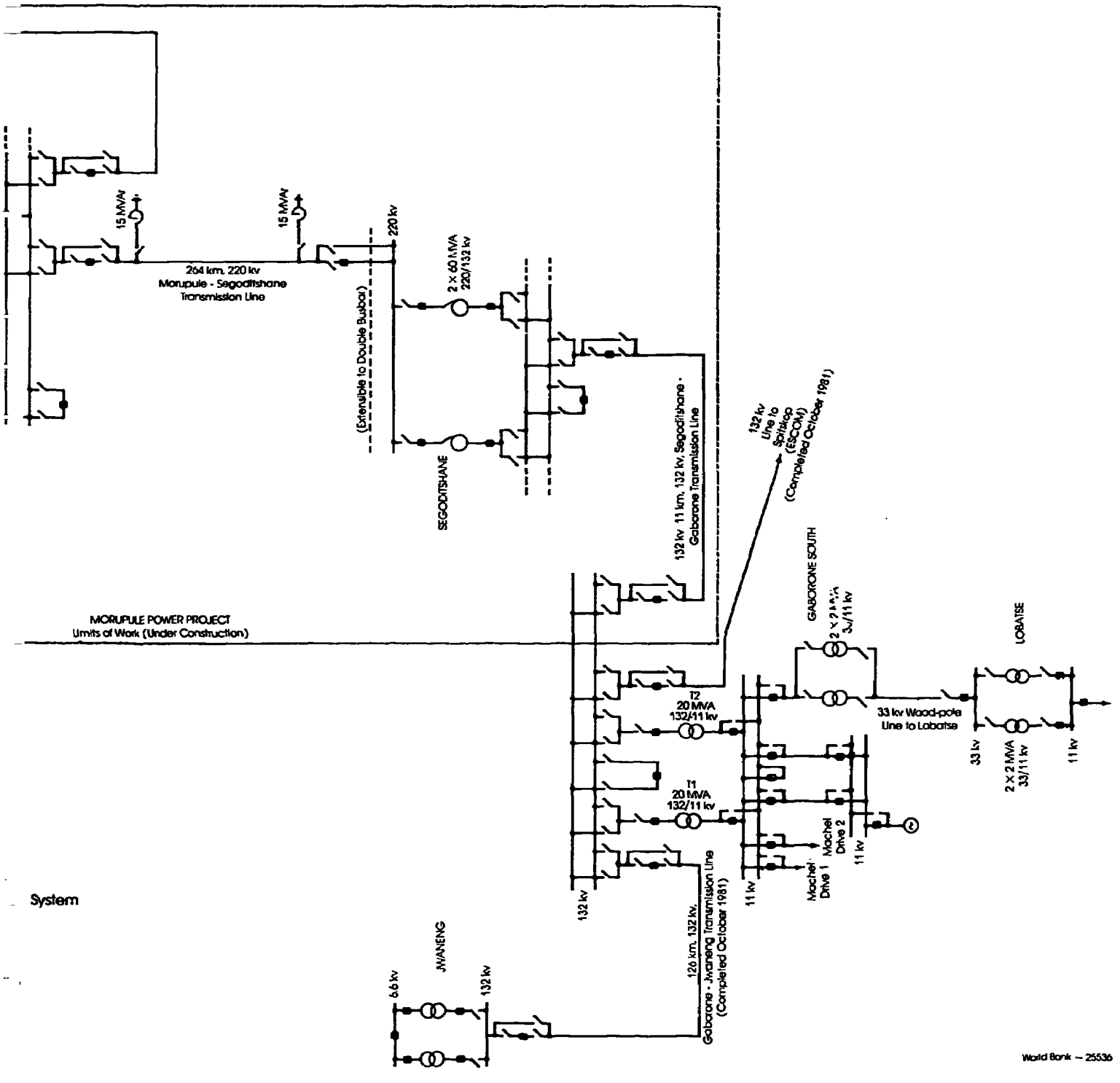
Existing
Under Construction

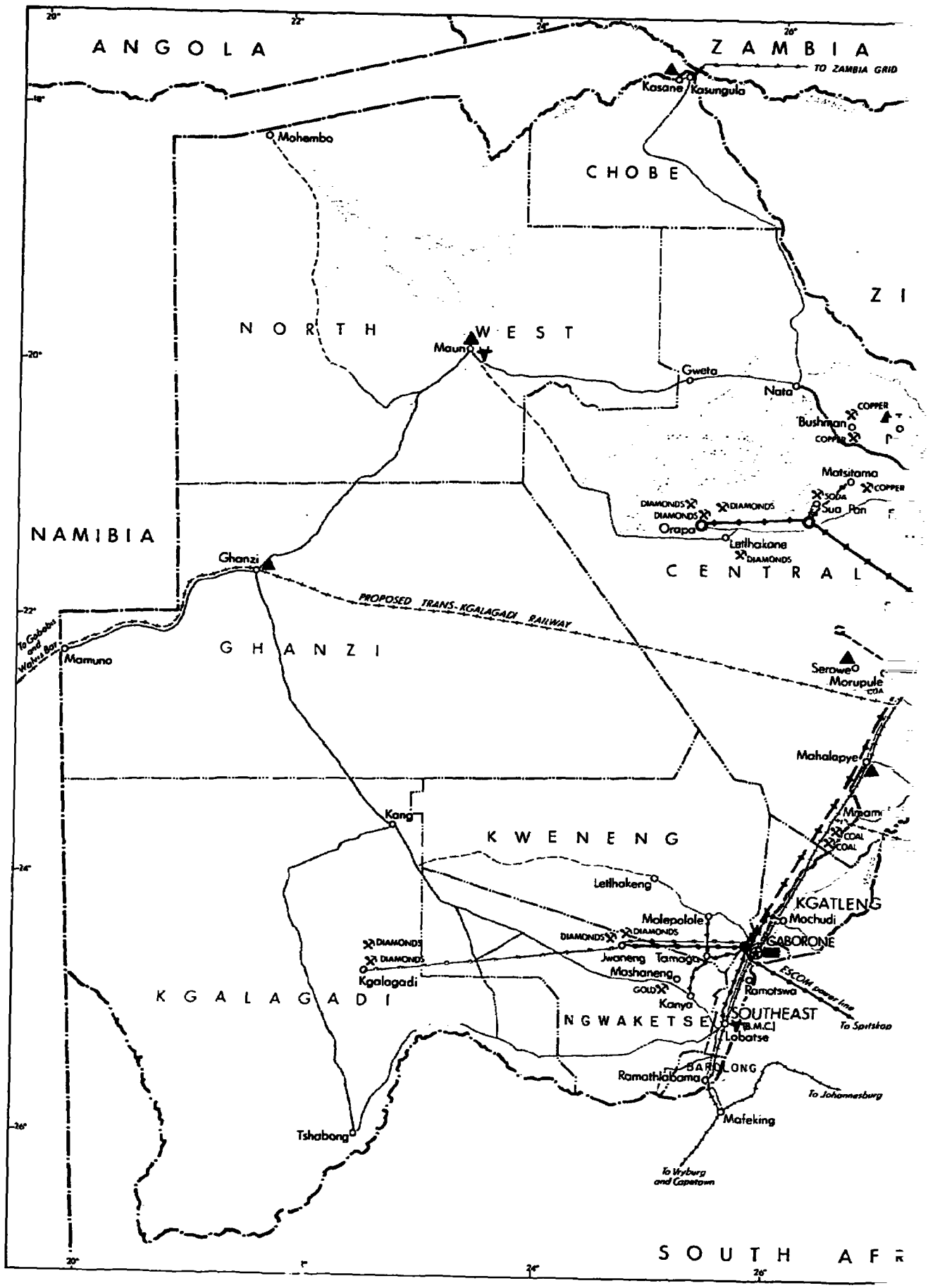


BOTSWANA
BOTSWANA POWER CORPORATION
Schematic Diagram High Voltage Transmission System

——— Existing
– – – – Under Construction



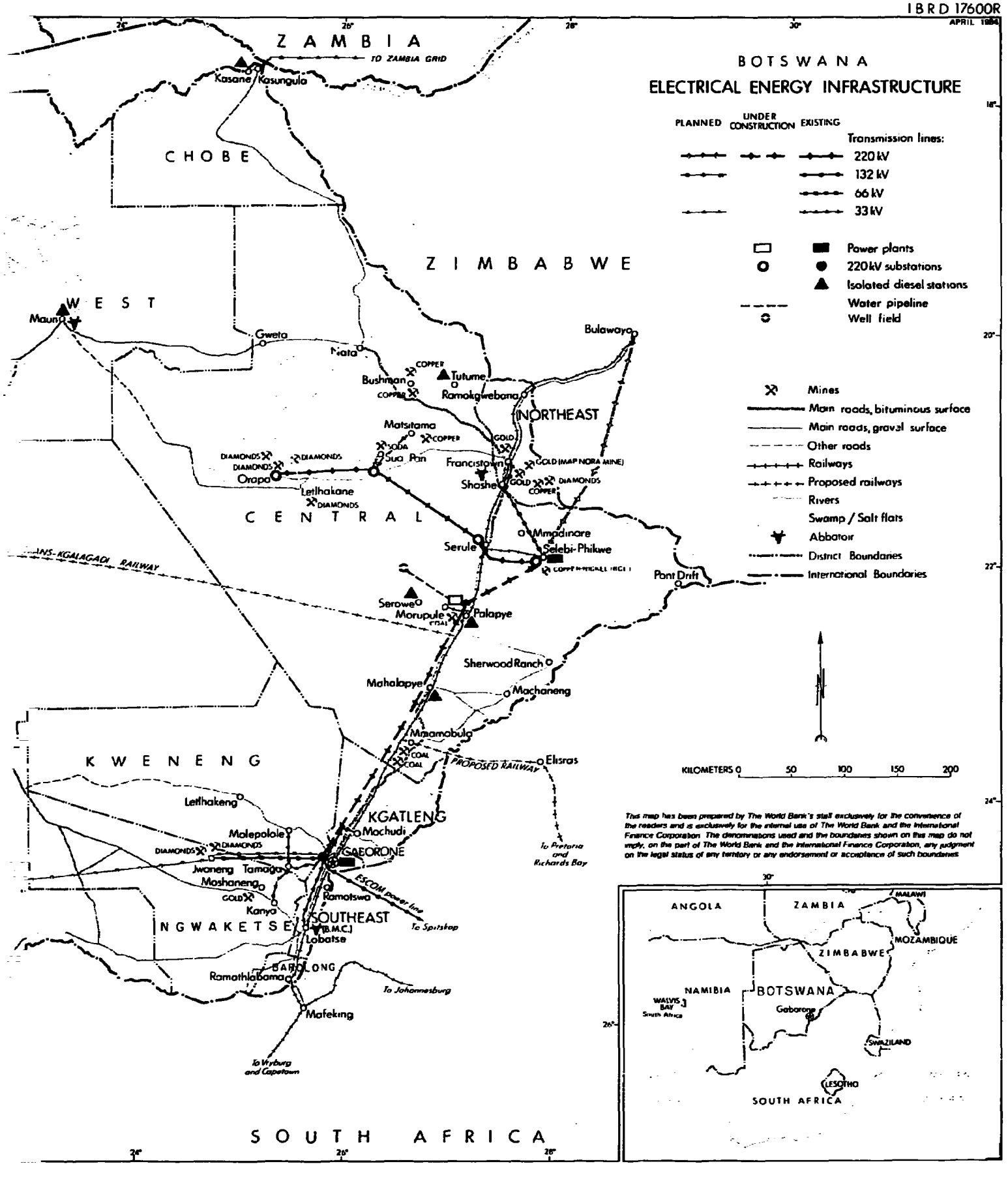

15 MVA
15 MVA
220 kv
264 km. 220 kv
Morupule - Segoditshane
Transmission Line
(Extendible to Double Busbar)
2 × 60 MVA
220/132 kv
SEGODITSHANE
132 kv 11 km. 132 kv. Segoditshane -
Gaborone Transmission Line
132 kv
Line to
Spitskop
(ESCOM)
(Completed October 1981)
MORUPULE POWER PROJECT
Limits of Work (Under Construction)
GABORONE SOUTH
2 × 2 MVA
33/11 kv
T2
20 MVA
132/11 kv
T1
20 MVA
132/11 kv
33 kv Wood-pole
Line to Lobatse
LOBATSE
33 kv
2 × 2 MVA
33/11 kv
11 kv
132 kv
11 kv
Machel
Drive 1
Machel
Drive 2
11 kv
126 km. 132 kv.
Gaborone - Jwaneng Transmission Line
(Completed October 1981)
JWANENG
6.6 kv
132 kv
System
World Bank – 25536

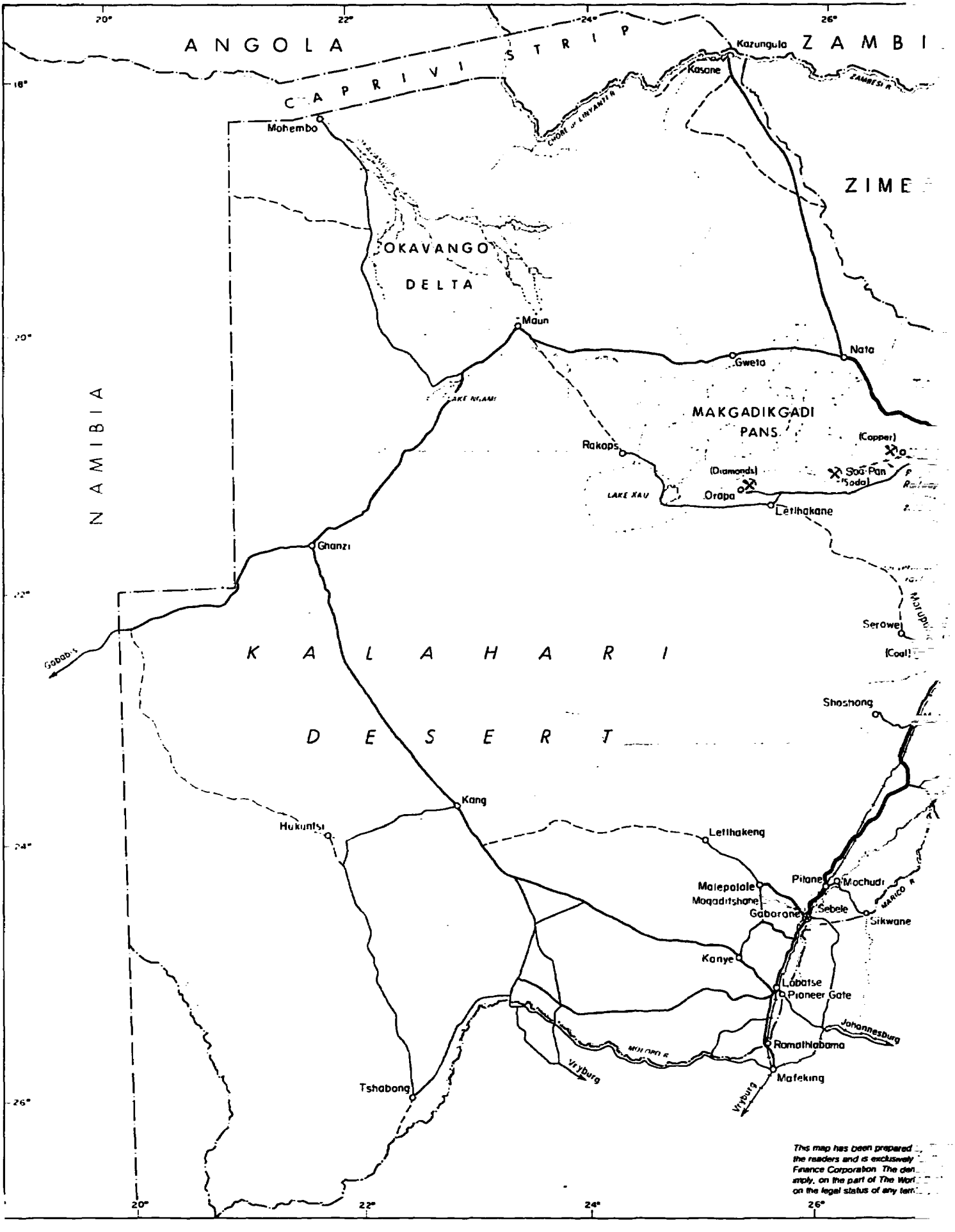

ANGOLA
ZAMBIA
TO ZAMBIA GRID
Kasane
Kasungula
Mohembo
CHOBE
NORTH WEST
Maun
Gweta
Nata
COPPER
Bushman
Matsitama
SODA
Sua Pan
DIAMONDS
Orapa
Letlhakane
NAMIBIA
Ghanzi
CENTRAL
PROPOSED TRANS-KGALAGADI RAILWAY
To Gaborone and Walvis Bay
Mamuno
GHANZI
Serowe
Morupule
COAL
Mahalapye
Kang
KWENENG
Letlhakeng
KGATLENG
Mochudi
Molepolole
GABORONE
Jwaneng
Tamaga
Mashaneng
Kgalagadi
GOLD
Kanye
Ramotswa
ESKOM power line
To Spitskop
KGALAGADI
NGWAKETSE
SOUTHEAST
(B.M.C.)
Lobatse
BAROLONG
Ramathlabama
To Johannesburg
Mafeking
Tshabong
To Vryburg and Capetown
SOUTH AF
20°
22°
24°
26°
18°

IBRD 17600R

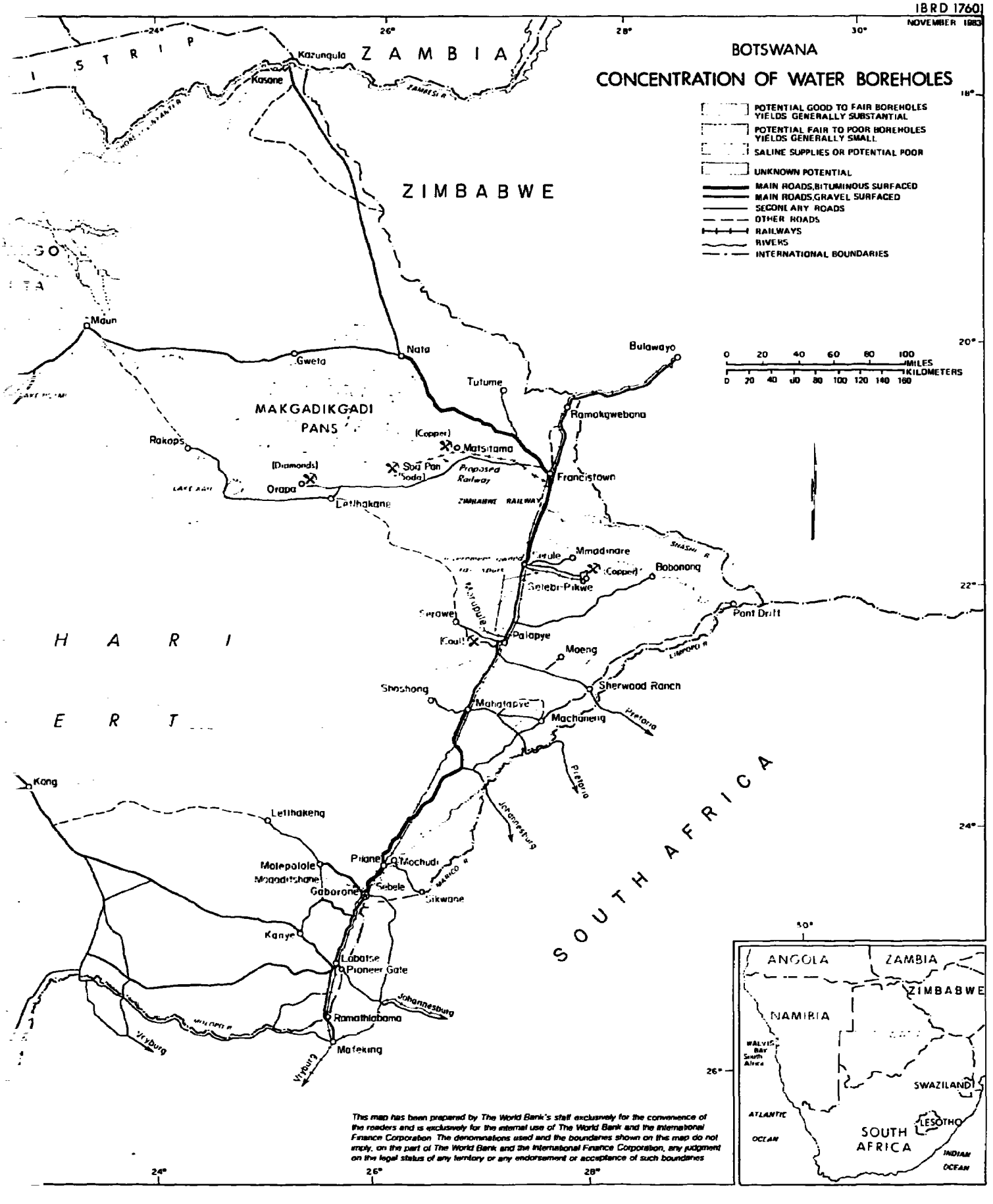
APRIL 1984

BOTSWANA
ELECTRICAL ENERGY INFRASTRUCTURE





IBRD 17601
NOVEMBER 1983



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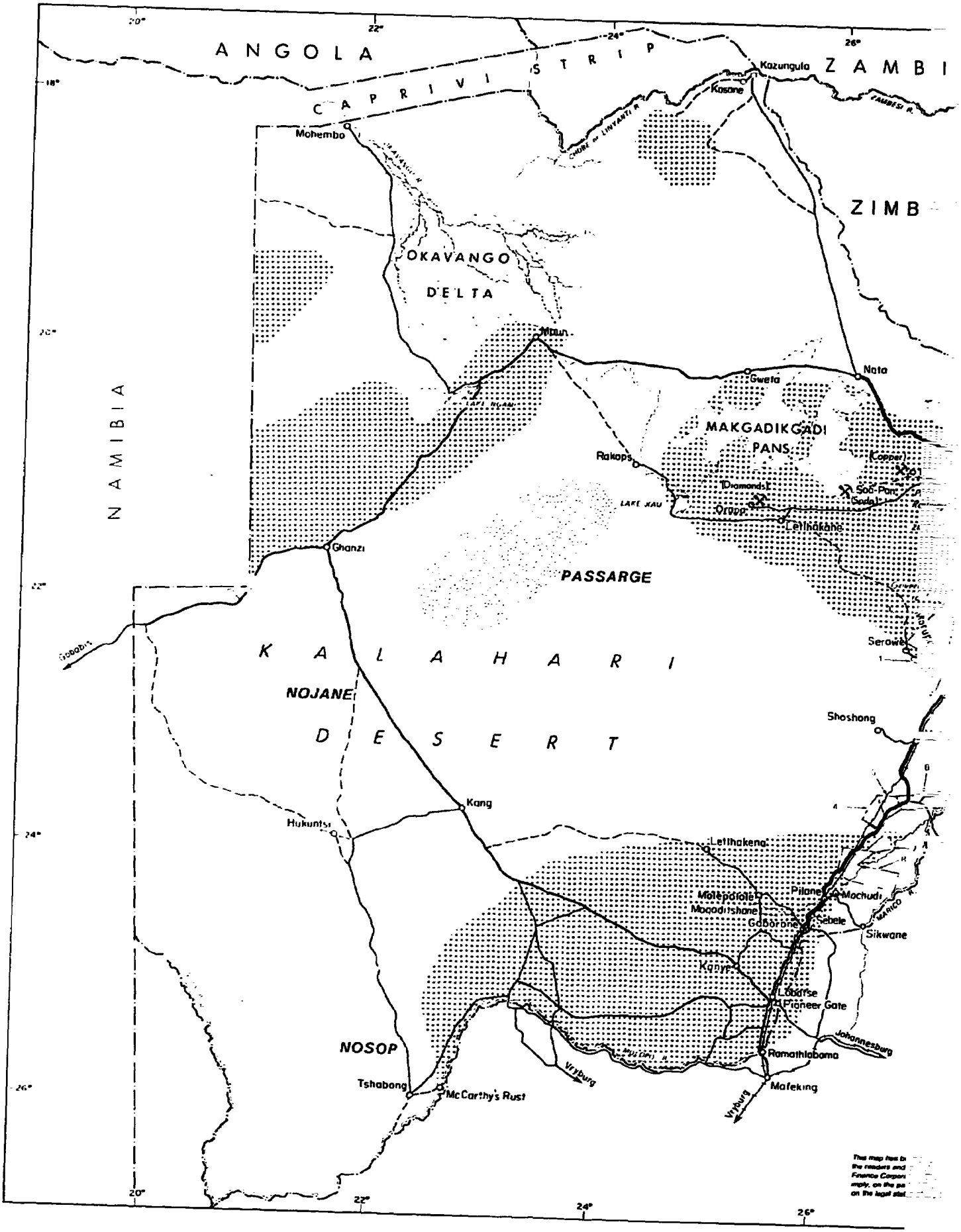
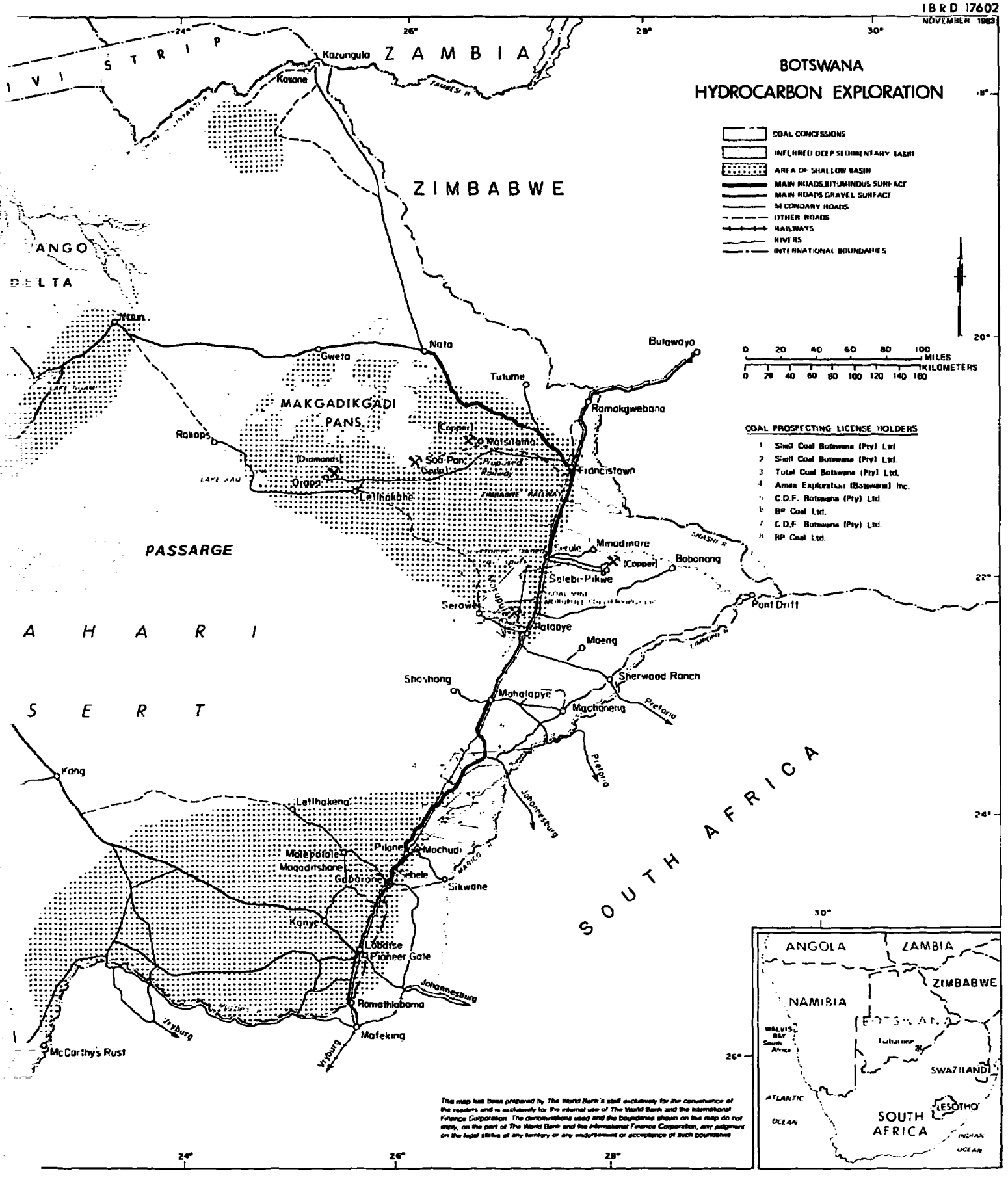

ANGOLA
CAPRIVI STRIP
Kazungula
ZAMBI
Kasane
ZAMBEZI R.
Mohembo
CHOBE or LINYANTI R.
ZIMB
OKAVANGO
DELTA
Maun
NAMIBIA
Gweta
Nata
MAKGADIKGADI
PANS
Rakops
Copper
Diamond
Soa-Pan
Soda
LAKE XAU
Orapa
Letlhakane
Ghanzi
PASSARGE
Serowe
Gobabis
K A L A H A R I
NOJANE
D E S E R T
Shoshong
Kang
Hukuntsi
Letlhakeng
Molepolole
Pilane
Mochudi
Mooditshane
Gaborone
Sebele
MARICO R.
Sikwane
Kanye
Lobatse
Pioneer Gate
Johannesburg
NOSOP
Ramathlabama
Vryburg
Tshabong
McCarthy's Rust
Mafeking
Vryburg
20°
22°
24°
26°
18°

IBRD 17602
NOVEMBER 1983



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