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ESMAP

Energy Sector Management Assistance Programme

Swaziland

Household Energy Strategy Study

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JOINT UNDP / WORLD BANK
ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

PURPOSE

The Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP) is a special global technical assistance program run by the World Bank's Industry and Energy Department. ESMAP provides advice to governments on sustainable energy development. Established with the support of UNDP and 15 bilateral official donors in 1983, it focuses on policy and institutional reforms designed to promote increased private investment in energy and supply and end-use energy efficiency; natural gas development; and renewable, rural, and household energy.

GOVERNANCE AND OPERATIONS

ESMAP is governed by a Consultative Group (ESMAP CG), composed of representatives of the UNDP and World Bank, the governments and other institutions providing financial support, and the recipients of ESMAP's assistance. The ESMAP CG is chaired by the World Bank's Vice President, Finance and Private Sector Development, and advised by a Technical Advisory Group (TAG) of independent energy experts that reviews the Programme's strategic agenda, its work program, and other issues. ESMAP is staffed by a cadre of engineers, energy planners, and economists from the Industry and Energy Department of the World Bank. The Director of this Department is also the Manager of ESMAP, responsible for administering the Programme.

FUNDING

ESMAP is a cooperative effort supported by the World Bank, UNDP and other United Nations agencies, the European Community, Organization of American States (OAS), Latin American Energy Organization (OLADE), and public and private donors from countries including Australia, Belgium, Canada, Denmark, Germany, Finland, France, Iceland, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Sweden, Switzerland, the United Kingdom, and the United States.

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SWAZILAND

HOUSEHOLD ENERGY STRATEGY STUDY

OCTOBER 1997

CONTENTS

PREFACE

This report is based on the findings of a mission of the joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP) to Swaziland from March 5 through March 20, 1996, to assist the Energy Unit of the Ministry of Natural Resources and Energy (MNRE) in formulating a comprehensive national household energy policy. The mission consisted of Messrs. Willem Floor (Task Manager) and Kevin Fitzgerald (Energy Economist). The mission worked directly and intensely with MNRE staff: Henry D. Shongwe, Senior Energy Officer; Peterson V. D. Dlamini, Energy Officer; Sibongile Precious Myeni, Energy Planning Officer; Walter Mbuso Hlophe, Assistant Statistician; Nico van der Linden, Energy Advisor and Petra Lasschuit (consultant), who conducted household energy surveys in 1993 and 1994.

ABBREVIATIONS AND ACRONYMS

CMA	Common Monetary Area
CSO	Central Statistics Office
DC	Direct Current
EPU	Energy Planning Unit
ESKOM	Electricity Supply Commission of South Africa
ESMAP	Energy Sector management Assistance Program
EU	Energy Unit
GTZ	Deutsche Gezellschaft für Technische Zusammenarbeit
IPP	Independant Power Producer
IVAM	Environmental Research, University of Amsterdam
LPG	Liquified Petroleum Gas
LRMC	Long Run Marginal Costs
MNRE	Ministry of Natural Resources and Energy
NGO	Non Governmental Organization
NPV	Net Present Value
Paraffin	Also known as kerosene
PV	Photovoltaic
RSA	Republic of South Africa
SACU	Southern Africa Customs Union
SADC	Southern African Development Community
SAPP	South Africa Power Pool
SEB	Swaziland Electricity Board
SEIS	Swaziland Energy Information System
TPA	Ton per annum

CURRENCY EQUIVALENTS

1 Lilangeni = 1 South African Rand = US$0.26

3.85 Emalangeni = US$ 1[a/]

UNITS OF MEASURE

Dung	12 MJ/kg
Crop residues	15 MJ/kg
Fuelwood	16 MJ/kg
Swazi anthracite coal	31 MJ/kg
RSA bituminous coal	26 MJ/kg
Paraffin	34.8 MJ/lt
LPG	49.5 MJ/kg
Electricity	3.6 MJ/kWh
Ton Wood Equivalent	16 GJ
Ton Oil Equivalent	41.87 GJ

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a/ March 1996.

EXECUTIVE SUMMARY

Background

1 In 1987 the Energy Sector Management Assistance Programme (ESMAP) conducted an Energy Assessment to assist Swaziland in identifying options for diversification of energy supply and import substitution. Since no previous analysis of household energy supply and demand patterns had been undertaken in Swaziland, the Energy Assessment mission recommended that the Government conduct a forest inventory and a national household energy consumption survey to identify areas of fuelwood stress. The studies, completed in 1990, showed that Swaziland's forest resources were being depleted rapidly. Almost 80% of the pressure on forest wood resources could be traced to the household-level demand for fire wood. Additional household demand surveys were carried out in 1994 to clarify and quantify the role of fuelwood use in forest resource depletion. The Government of Swaziland then requested ESMAP and the World Bank to provide assistance in developing a strategy for the household energy sector. The present report responds to that request.

Structure of the Report

2 *Chapter one* gives a broad overview of the energy sector. Almost 95% of Swaziland's commercial energy supply (coal, oil products, electricity, and charcoal) is imported from South Africa. The Swaziland Electricity Board (SEB) alone imported 87% of its electricity needs from South Africa's Electricity Supply Commission (ESKOM) in 1993, and this percentage is expected to grow with growth in demand. Accordingly, following the signature of a memorandum of understanding with Mozambique for an interconnector, Government, with the assistance of the Trade and Development Agency, is studying: (i) the feasibility of the interconnector; (ii) the economic viability of a coal fired power plant in Swaziland; and (iii) the possible role of cogeneration and energy conservation. Even though Swaziland is endowed with considerable reserves of high quality anthracite coal, almost all of the annual Swazi coal production is exported and Swazi industrial boilers burn imported South African bituminous coal. This is so for several reasons: (i) Swazi anthracite obtains its highest economic value as an exported industrial boiler fuel; (ii) Swazi boilers are designed for bituminous coal; and (iii) though it is a smokeless coal, Swazi anthracite is not used widely as a household fuel, because it is difficult to light.

3 *Chapter two* examines energy consumption patterns and trends in the household sector and highlights differences between rural and urban areas, and within the latter category between urban centers and company towns. The transition to modern fuels is evident in Swaziland's urban centers. In major urban areas and company towns, nearly

40% of households use electricity, which is low, given Swaziland's high GNP per capita (US$1,000). Electric cooking is uneconomic, but widespread in upper income urban homes. Tariffs are well below economic costs. Paraffin and LPG are used by 60% and 35% of non-rural households, respectively. Paraffin serves to bridge the transition from wood to LPG and electricity in urban areas and is used extensively as a cooking fuel by lower income urban households. While fuelwood is still used by one half of *urban* households, the practice of distributing free coal to employees in *company towns* has reduced the share of households using fuelwood to roughly one third. The practice naturally leads to high consumption of coal and, indeed, wasteful fuel use in company towns, a situation which could be corrected by paying employees in cash. In *rural* households, traditional fuels account for the bulk of cooking and heating end use services. About 20% of rural households purchase part of their fuelwood needs. Paraffin is used for cooking by more than 30% and LPG by roughly 10% of rural households. Paraffin consumption for cooking is higher in areas with fuelwood stress. Only 3% of rural households are electrified.

4 *Chapter three* discusses the issues and options for biomass fuels. This includes measures to increase supply and reduce fuelwood offtake through conservation and fuel substitution. Though the rural population is aware of the loss of forest cover, rural dwellers have generally adapted -- they use less wood, buy it, walk farther, or substitute wood -- rather than planting new trees or protecting and managing the existing ones. Moreover, wood is available for purchase throughout the country at very low resource cost; it appears that transport margins for woodfuels constitute over 75% of delivered prices. Hence, prices at the source do not give enough incentive to maintain the resource base. Moreover, because of land tenure characteristics, forest resources are treated as commonly owned, and access is relatively free. Control over local forests does not fully lie with local people. As a result, it is difficult to motivate them to undertake sustainable management practices. The fuelwood deficit is real in localized areas, but not as serious nationally as previously thought. Deforestation appears to be a land management and not an energy problem. Thus, the deforestation problem will not be solved by woodlots. Review of land tenure policy, provision of seedlings, and rationalization of fuelwood prices are needed. Government initiatives in this sense will contribute to: (i) reducing pressure on forest resources, thereby improving sustainability; and (ii) empowering private sector participation in the forestry sector. In addition, agglomerated briquettes from the wood industry might constitute a cost-effective fuelwood alternative, while energy efficient woodstoves could replace the ill-adapted coal stoves that are used in rural areas. More robust paraffin stoves show promise as a way to address fuel needs of the rural poor in fuelwood stressed areas.

5 *Chapter four* analyzes the problems of electrification in the household sector and explores how electrification might be increased. In urban areas, Government should ensure that SEB can recover costs and has an incentive to improve operations through a price cap mechanism. In rural areas, where as much as 50% of household cash

expenditure is spent on batteries, candles, and paraffin as well as on radios, television, and lighting, at least two options appear promising for increasing the number of connections serving households. The first would be to seek community participation in sharing SEB's connection fees. A substantial barrier to grid-based rural electrification could be removed by having communities which stand to benefit from electrification share the cost of line extensions. Schemes such as rural electric cooperatives (through which rural consumers construct, operate, and own rural lines) have a long and successful track record in other countries. Facilitating access to finance would also help rural electrification programs. In many countries, such programs have been financed by subsidies from general tax revenues or transfer payments from urban to rural consumers through tariff policy. However, even with these mechanisms, the economic cost of grid-based service will remain prohibitive for many households in remote areas. A second option, particularly for these households, may be solar photovoltaic (PV) home systems. A major obstacle for advanced penetration of PV as a rural electricity source is its high up-front cost. However, it would seem that credit programs and an appropriate variety of solar products would provide rural consumers with conditions and choices compatible with larger scale use of this technology. Given the pattern of rural settlements, i.e., dispersed homesteads rather than villages, photovoltaic systems appear to be well suited to Swazi conditions. The chief other alternative to grid-based electrification, namely diesel, is less attractive in Swaziland than in countries with village groupings.

6 *Chapter five* discusses some issues of energy planning. As a matter of industrial and commercial policy, Government should require the annual reporting of a consistent and non-repetitive set of information from all ministries, including MNRE, based on an annual census of manufactures. Given the extremely limited human and financial resources of Government, programs to address issues in the household energy area should follow a strict hierarchy of priorities. Any future Government activity in this field should be designed and budgeted in such a way as to permit monitoring and evaluation, as well as the drawing of conclusions regarding sustainability and replicability from financial, technical, and institutional perspectives. There is a need to concentrate on what is feasible and of high priority within the Swazi context, rather than on exotic subjects such as biogas.

Table 1: Key Issues and Recommendations

Sector/issue	*Key problem*	*Result*	*Key recommendations*	*Expected output(s)*
Supply & demand	Focus mainly on supply	Intervention often not the most economic choice	Pursue demand & supply options simultaneously, including energy efficiency (improved stoves, high efficient lighting, etc.) and substitution fuels	Higher economic growth through a more efficient energy sector
Woodfuels	No perceived long-term value of wood	No incentives for effective wood or land management, for woodlots or planting on homesteads	Review & implement measures to increase value of wood	Less wasteful wood management practices, and ultimately, sustainable supply of woodfuels
Electrification	Low electrification rates (both urban and rural)	Consumers incur high costs to satisfy basic services through non-electric alternatives	(Peri)Urban: pursue creative solutions such as through community, or cooperative cost-sharing, or private sector supply Rural: explore decentralized electricity supply (e.g. photovoltaics, diesel, hydro)	Larger percentage of population enjoys use of electricity Less pressure on SEB to electrify uneconomic clients/areas
Energy pricing	Electricity and woodfuels are not priced at economic costs Free energy provided (company towns, SEB)	Consumers do not receive the right signals to consume energy rationally Woodfuel producers have no incentive to plant more trees	Review and adjust electricity tariff and coal prices Woodfuel producers should receive higher returns	More rational use of energy Substitution options become more viable Consumers have more choices
Energy planning	No monitoring of energy activities Lack of capacity at MNRE	Lack of basic information Lack of coordination among energy sector actors	Focus on policy intervention Concentrate all MNRE activities on energy sector priorities Provide leadership and active role in coordination and monitoring of energy sector actors/activities	Synergy among energy sector actors resulting in more efficient energy sector

1

INTRODUCTION

1.1 The Kingdom of Swaziland is one of the smallest countries in Africa with an area of 17,364 km^2 and an estimated 1996 population of nearly 1 million. The country is landlocked, largely surrounded by the Republic of South Africa (RSA), but with a 100 km border with Mozambique. Despite its geographical limitations, Swaziland has been able to achieve a relatively high rate of economic growth for decades and now has a GNP over US$ 1,000 per capita,[1] one of the highest in Sub-Saharan Africa. A number of factors have led to this economic success, including: market-oriented policies with very little price and wage intervention; political stability;[2] fiscal prudence; and investment incentives. These conditions have resulted in an open economy concentrated in industries that process agricultural and forest-based products, resources in which Swaziland has a comparative advantage.

1.2 Swaziland's economy is closely tied to that of South Africa. It is a member of the Southern African Customs Union (SACU), through which customs receipts are pooled, and the Common Monetary Area (CMA). SACU receipts account for roughly half of Swaziland's fiscal revenues. South Africa is the source of 80% of merchandise imports and the destination of 30% of merchandise exports. Fifteen percent of GNP is in the form of remittances from Swazi nationals working in South African mines. Sanctions against RSA in the 1980s accelerated growth in Swaziland's economy to over 6% per year late in the decade. However, recent developments in RSA have made the investment climate there more attractive with adverse consequences for the economy of Swaziland. Given the close linkages between these economies, developments in South Africa can be expected to continue to play a determining role in Swaziland for a long time to come.

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[1] GNP per capita in 1992. See Swaziland Urban Development Project, Staff Appraisal Report, October 21, 1994.

[2] The importance of political stability as a factor in Swaziland's economic growth was illustrated in late January 1997 when nearly 75,000 of the country's 90,000 private-sector employees went out on strike for one week, which cost the economy over US$ 10 million.

1.3 The Energy Assessment for Swaziland which was prepared in 1986-1987 under the World Bank's ESMAP program paid particular attention to the country's energy security and identified a number of options for diversification of energy supply and import substitution (Table 1). Fully 95% of Swaziland's commercial energy supply (coal, oil products, electricity, and charcoal) is imported from South Africa. While oil import costs for many African countries fell in real terms after 1986, Swaziland's continued to rise due to declining terms of trade. The Swaziland Electricity Board (SEB) imported 87% of its total electricity needs from South Africa's Electricity Supply Commission (ESKOM) in fiscal 1993.[3] Recent increases in the price of ESKOM power resulted in SEB posting some of the largest losses of any government-owned company.[4] These losses led to the signing of a management contract between SEB and Government to improve the financial performance of the company through far-reaching financial and management restructuring. ESKOM price increases in 1994 and 1995 prompted Government to consider privatizing SEB and to announce plans to import power from Mozambique and possibly Zaire.[5]

1.4 The energy security issues identified in the Energy Assessment are still relevant today. In addition to looking into the diversification of power imports, various projects to exploit Swaziland's indigenous coal, hydro, and biomass energy resources have been considered. Most options for generating electricity using Swazi coal or hydro resources have been found to be more expensive than electricity imports from RSA. This situation is not expected to change in the medium term, even under increased ESKOM rates, since Swaziland's total connected load will remain well below the capacity of one medium-sized thermal plant for many years. Its larger neighbors can exploit economies of scale in power generation that are unavailable to Swaziland. However, options to diversify power sources should be monitored continuously. In this line, the planned study by the Trade and Development Agency (TDA) to determine the costs of power wheeling from Mozambique, Swazi anthracite coal fired power generation and cogeneration, and energy conservation options should proceed. The recently created South African Power Pool (SAPP) offers new possibilities that should be carefully studied, such as the option of operating a large, coal-fired power station in Swaziland which would export the bulk of the power, with SAPP facilitating the sale of electricity at a price allowing cost recovery and profit.

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3 SEB, Annual Report for year ended March 31, 1993.

4 Report of the Public Enterprises Unit, Ministry of Economic Development and Planning, March 1994.

5 "Minister planning to buy 'cheaper' electricity from Zaire," South African news agency SAPA, 31 August 1995 and "Agreement on power supply signed with Swaziland," Radio Mozambique, 15 October 1994.

1.5 Table 1.1 summarizes the latest available information on the level and composition of energy supply and demand. A striking feature of Swaziland's energy balance is the role played by biomass residues. Over 30% of national final energy consumption is used in agricultural and forest product industries in the form of biomass residues for process heat and captive-power generation. Two by-products of the sugar industry, bagasse-based power and molasses-based ethanol, were identified by the Energy Assessment as the most promising indigenous fuel sources. Although molasses from one sugar plant alone could replace as much as 20% of the petrol imports to the country, this is not further explored because there are no direct household energy implications. For the same reason, this report does not mention the utilization of bagasse.

Table 1.1: Swaziland Energy Balance, 1994

	Conventional			*Traditional*		
	Coal	*Petroleum*	*Electricity*	*Wood*	*Other biomass*	*Total*
Supply & transformation (TJ)						
Production	7,530		450	9,670	13,780	31,430
Import	5,220	7,460	1,910			14,590
Export	-7,150					-7,150
Primary supply	**5,600**	**7,460**	**2,360**	**9,670**	**13,780**	**38,870**
SEB power/self generation	-1,210	-10	814	-1,310	-1,210	-2,926
Transportation losses/self use	-380		-430			-810
Total supply after transformation	4,010	7,450	2,744	8,360	12,570	35,134
Final consumption (TJ)	**4,010**	**7,450**	**2,744**	**8,360**	**12,570**	**35,134**
Fuel shares (percent)	11.4	21.2	7.8	23.8	35.8	100.0
Sectoral shares (percent)						
Agriculture		6.8	9.5			2.2
Mining	1.7	0.1	7.3			0.8
Industry	67.6	14.8	58.5	5.9	96.6	51.4
Transport	1.0	72.0	0.7			15.4
Commercial & services		0.2	6.2		0.2	0.6
Household	29.7	6.1	17.9	94.1	3.3	29.6
Total	100.0	100.0	100.0	100.0	100.0	100.0

Wood includes wood waste and firewood. Biomass includes charcoal, agricultural residues, and dung.

Source: MNRE.

1.6 Commercial fuels account for over 40% of national final energy consumption, a much higher share than in most Sub-Saharan African countries. This figure, which is consistent with the structure of the economy and the observed relatively high per capita income, indicates that energy substitution is well underway in Swaziland (see below).

1.7 Nearly 30% of national final energy consumption is provided by fuelwood and crop residues used by households for cooking and heating. Although there was no overt fuelwood crisis at the time, the Energy Assessment mission estimated that fuelwood consumption exceeded the annual production increment and that the indigenous forest resource base was declining. Since no previous analysis of household energy supply and demand patterns had been undertaken in Swaziland, the mission recommended that Government conduct a forest inventory and a national household energy consumption survey to identify areas of fuelwood stress.

1.8 These studies were completed in 1990. They indicate that only 36% of Swaziland's total land area was under forest cover in 1990 and forest resources were indeed being depleted at an alarming rate.[6] Over 90% of fuelwood was consumed by rural households and household fuelwood use constituted almost 80% of total pressure on forest wood resources. Little is known about other activities which affect wood resources, such as agriculture, grazing, and logging.

1.9 Two further studies were carried out in 1993 and 1994 to generate insight into household fuel use patterns and sources of supply, but no new resource inventory was done.[7] Declining availability of fuelwood was perceived to be a major problem by rural dwellers in five out of six rural areas studied. While a diminishing biomass resource base is a legitimate problem in a number of localized areas in the mid-veld and low-veld, the more accurate estimates of fuel use in households provided by these studies indicate that the overall biomass resource deficit is not nearly as alarming as the previous estimates had implied. However, wood reserves in certain locations stand to decrease, and care is required when addressing fuelwood issues.

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[6] Gajo, M., "Energy Consumption and Demand in the Domestic Sector of Swaziland," Ministry of Natural Resources and Energy / Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Mbabane, Swaziland, 1989. Hess, P., H. Forster, and D. Gwaitta-Magumba, "National Forest Inventory of Swaziland" (5 volumes), Swazi-German Forest Inventory & Planning Project, Mbabane, Swaziland, 1990.

[7] P. E. Lasschuit, "Rural household energy strategies in Swaziland," IVAM Environmental Research, University of Amsterdam, Amsterdam, August, 1994. P. E. Lasschuit, "Urban household energy strategies in Swaziland," IVAM Environmental Research, University of Amsterdam, Amsterdam, January, 1995.

2

HOUSEHOLD FUEL USE: RURAL/URBAN DIFFERENCES

2.1 The transition to modern fuels mentioned in the previous chapter is evident in Swaziland's urban areas. (Total urban population – one-fourth of the national population - is about 206.000, of which 57% live in urban centers proper and 43% dwell in 14 so-called company towns.) In major urban areas and company towns, nearly 40% of households use electricity. Paraffin (as kerosene is known in southern Africa) and LPG are used by 60% and 35% of urban households, respectively. Paraffin serves to bridge the transition from wood to LPG and electricity in urban areas and is used extensively as a cooking fuel by lower income urban households. While some fuelwood is still used by half the households in urban centers, the practice of distributing free coal to employees in company towns has reduced the share of households using fuelwood to roughly one third in those jurisdictions. Largely stimulated by rural to urban migration, urbanization will continue to promote the shift to modern fuels in the residential sector.[8] Traditional fuels, on the other hand, are still dominant in cooking and heating end uses for rural households. Nonetheless, paraffin is used for cooking by more than 30% and LPG by roughly 10% of rural households. The broad patterns of household fuel choice are displayed in Table 2.1.

[8] Note that rural to urban migration is not occurring at the alarming rates witnessed elsewhere in the developing world. Mbabane and Manzini, home to half of Swaziland's urban population, are growing at an annual rate of 4.5% as compared with a rural population growth rate of 3%.

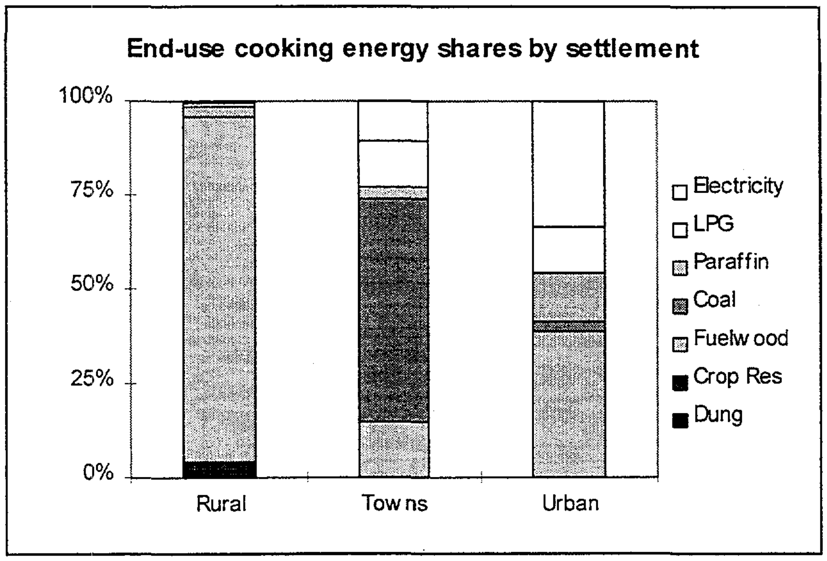
Table 2.1: Household Fuel Consumption in Swaziland, 1993

	Rural		*Company Towns*		*Urban*	
	Units/cap/yr	*% Users*	*Units/cap/yr*	*% Users*	*Units/cap/yr*	*% Users*
Dung (kg)	3.0	17.6	0.0	0.0	0.0	0.0
Crop Residues (kg)	26.6	72.3	0.4	5.0	0.5	7.0
Firewood (kg)	469.3	99.2	209.0	37.0	341.0	53.0
Coal (kg)	0.1	0.1	546.8	65.0	17.3	5.0
Paraffin (lt)	4.4	62.0	9.4	50.0	21.2	68.0
Cooking	2.1	31.3				
Lighting	2.0	61.1				
Refrigeration	0.4	1.3				
LPG (kg)	1.2	9.8	15.1	34.0	9.9	37.0
Cooking	0.5	9.8				
Lighting	0.1	2.3				
Refrigeration	0.5	2.5				
Electricity (kWh)	13.3	2.7	450.0	35.0	645.8	39.0

Source: Lasschuit, 1994 and 1995 (see footnote 7).

2.2 Cooking is the dominant energy using activity in the household sector. Thus, the shift to modern fuels appears even more pronounced when the share of cooking energy services provided by each fuel is examined. The share of end-use cooking services provided by each fuel was estimated using survey results from Table 2.1 and reasonable estimates for stove efficiencies and quantities of paraffin, LPG, and electricity used for cooking. The results are displayed in Figure 2.1 (details are presented in Annex 4). In urban centers, fully 60% of cooking services are provided by electricity, LPG, and paraffin. In company towns, these fuels meet 25% of cooking needs, while 60% of end-use cooking energy is provided by coal. The bulk of rural cooking energy needs are met by wood.

Figure 2.1: Cooking Energy by Settlement Type



Source: Lasschuit, 1994 and 1995 (see footnote 7) and mission estimates (see Annex 4).

2.3 The patterns of fuel choice displayed in Table 2.1 and Figure 2.1 highlight important policy issues. The 1993 urban household energy survey showed that LPG and electricity consumption increase with income, whereas the opposite holds true for coal and paraffin (Lasschuit, 1995, cited in footnote 7 of this report). Low income households in urban centers lack electricity connections and cook and heat largely with paraffin and wood, while higher income homes shift to electricity and to a lesser degree LPG. In economic terms, electricity is more costly as a cooking fuel than paraffin or LPG, and the domestic electricity tariff does not cover costs. A recent tariff study revealed that the marginal cost of electricity supply to domestic customers is 26% higher than the current tariff.[9] Higher income urban homes are therefore receiving a subsidy which can be said to be inducing uneconomic behavior. This is demonstrated by the high recorded electricity consumption of this group. Average monthly sales per urban residential connection were 399 kWh in 1995, a much higher level than commonly seen in the developing world. In July 1995, the coldest month of the year, sales reached 579 kWh per connection. Higher tariffs would mitigate the rate of growth of consumption.

2.4 By the same token, it is unlikely that employees in company towns would continue to use coal as a major cooking fuel if they did not receive it free from their employers, as noted. Given the already sizeable per capita usage rates of LPG, discontinuation of the practice of free distribution of coal would likely result in increased LPG and wood consumption. Paraffin, in turn, could represent a cost-effective option for

[9] "Costing and tariff study for SEB. First Phase." Kennedy and Donkin. 1996.

displacing fuelwood in fuelwood scarce rural areas. It is already widely distributed throughout Swaziland as a lighting fuel. Paraffin and other petroleum products are distributed in Swaziland by five international oil companies that operate roughly seventy service stations throughout the country. Pricing policies are broadly consistent with RSA policies which allow the prices of most petroleum products to be set by the market. Paraffin, together with gasoline and diesel, however, is subject to price regulation. Regulated prices are generally set to cover costs, but social objectives are also reflected in the relative margins allowed for each product. Paraffin was subsidized from 1990 to 1993 to provide an affordable cooking fuel for low income groups. Though the price is still controlled, the subsidy was largely removed when it became apparent that the industrial sector was the main beneficiary and some paraffin was being diverted to serve as a transport fuel.

2.5 The financial and economic costs of meeting the cooking energy needs of the average urban family (6 persons) are compared in Table 2.2.[10] Annual cooking costs amortize stove costs over expected lifetimes at different discount rates. A 10% financial discount rate represents the real time value of money while a 40% rate more closely models actual costs paid by households purchasing large quantities of energy using durables with retail outlet financing (a common practice in Swaziland). Economic costs as calculated here do not include externalities. Although a study conducted in South Africa shows damage estimates of R 1000/hh/year for in-house air pollution from cooking with firewood and R 90/hh/year for paraffin poisoning, these figures are not incorporated in the analysis.

[10] Fuel costs are compared on the basis of cooking services only. Since coal and wood stoves also provide heating services, which are not included in the cost comparison, the costs of using fuels in these stoves are overestimated relative to modern fuel stoves.

Table 2.2: Cooking Costs, Mbabane 1996

	Heating Value (MJ/unit) unit	*Stove Effic. (%) a/*	*Fuel Prices (E) b/ Financial (/unit)*	*Fuel Prices (E) b/ Economic (/unit)*	*Stove price (E) c/*	*Life (yrs)*	*Annual Cooking Cost (E) d/ Financial R=40%*	*Annual Cooking Cost (E) d/ Financial r=10%*	*Annual Cooking Cost (E) d/ Economic r=10%*
Wood									
Fireplace	16 kg	12	0.24	0.28	0	1	1,269	1,269	1,496
coal stove	16 kg	10	0.24	0.28	2,200	10	2,174	1,848	2,121
wood stove	16 kg	17	0.24	0.28	50	3	918	914	1,074
Coal									
basic coal stove	26 kg	12	0.35	0.35	2,200	10	1,790	1,464	1,464
deluxe coal stove	26 kg	12	0.35	0.35	3,500	10	2,174	1,656	1,656
Paraffin									
Wick	35.9 liter	31	1.25	0.95	18	2	1,151	1,149	876
Pressure	35.9 liter	39	1.25	0.95	57	3	932	927	710
LPG									
2 burner set	45.5 kg	55	3.00	2.72	295	5	1,320	1,288	1,175
range & oven	45.5 kg	55	3.00	2.72	1,135	10	1,553	1,385	1,272
Electricity									
2 burner set	3.6 kWh	70	0.25	0.51	145	5	1,052	1,036	2,093
range & oven	3.6 kWh	70	0.25	0.51	2,000	10	1,593	1,297	2,354

a/ Stove efficiencies from stove tests (Lasschuit, 1995 [see footnote 7] and mission estimates).

b/ Financial prices are Mbabane retail prices, March 1996. Economic cost of fuelwood includes Ecent 4.3/kg amortized woodlot costs (Lasschuit, private communication, based on data from Forestry Section). Import parity prices of coal are mission estimates. Companies pay E120 - E130/T for bulk coal delivered (MNRE 1994 industrial survey), less than 1/2 of market prices. 1995 import parity prices of paraffin and LPG from MNRE petroleum product price buildups. LRMC of domestic electricity is Ecents 35.7/kWh (1992 SEB tariff study) expressed in 1996 terms through projected GDP price deflator (Ministry of Economics and Planning, Budget Outlook Paper, October 1995).

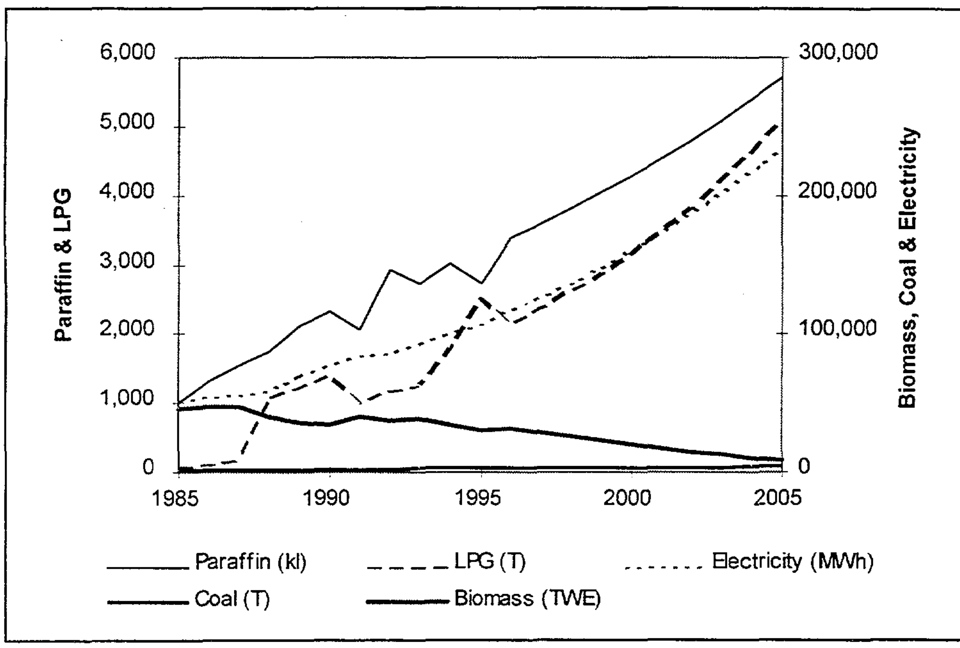
c/ 1996 Mbabane market prices. LPG stoves include E135 for a 3kg bottle. Lifetimes are mission estimates.

d/ Annual cooking costs based on an average of 10,150 utilized MJ/household (average hh size = 6 persons) (Lasschuit, 1995). Forty percent financial discount rate reflects tight cash constraints facing poorest households.

2.6 Paraffin and LPG are low cost cooking fuels in economic terms. Using the most recent estimate of LRMC (updated to 1996 using a general measure of price inflation), electricity appears to be very costly to the economy if used for cooking. However, under existing domestic tariffs, electricity compares favorably to the low cost paraffin and is substantially cheaper than LPG (using a simple two burner cook set). Households that cook with electricity are getting bargain rates, as noted. Rationalizing electricity tariffs should be a priority for Government in establishing its household energy policy.

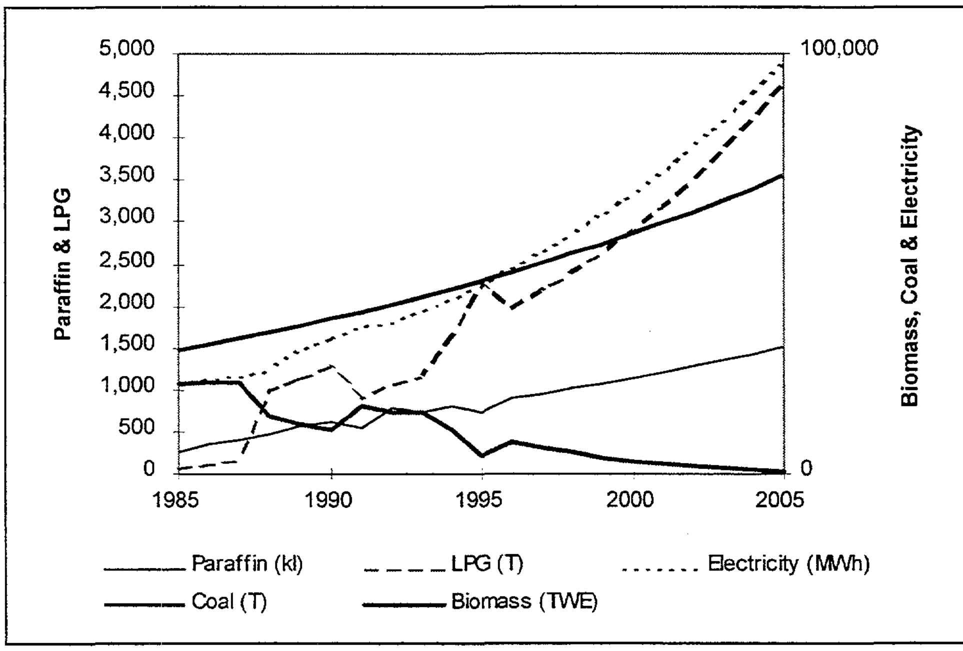
2.7 The effect of an adjustment of electricity tariffs on the consumption of wood in *urban centers* and hence on the pressure on forests is a question which deserves further analysis. A base case set of trends and forecasts for household fuel use in urban centers without changing relative prices is given in Figure 2.2. These data have been compiled on the basis of sales figures from petroleum distribution companies and SEB, as well as the 1993 energy use survey. Historical trends and demographic projections were used as a guide to construct the indicative forecasts (see Annex 4 for assumptions). While the accuracy of the trends and forecasts is limited by the need to make a number of assumptions to complete the data, the most notable conclusion from Figure 2.2 is that the potential for additional substitution of traditional fuels in urban centers as a means to reduce pressure on forests is limited. Fuelwood is a minor and declining household fuel in urban centers. Conversely, electricity, paraffin and LPG consumption is growing rapidly. Increased electricity connection rates in (peri-)urban areas could further accelerate the reduction in wood use, if tariffs were not adjusted. If they were adjusted to reflect the economic cost of supply, this impact would be much lower.

Figure 2.2: Swaziland Urban Household Fuel Consumption: Trends and Projections



2.8 The household fuel use patterns in *company towns* are significantly different from those in other urban areas and in rural areas. Household cooking needs are met chiefly by (free) coal, as stated. In higher income company town households, however, as much as 60% of cooking fuel requirements is met by LPG. Trends can be seen in Figure 2.3. LPG, paraffin, and fuelwood consumption on a per household basis are substantially higher than in other urban areas where people pay for all of their fuel, albeit at subsidized rates in the case of electricity. This indicates that there is a substantial waste of fuel in company towns. Using households in other urban areas as an indication, if residents of company towns were able to express their fuel preferences by purchasing them, they would purchase wood, paraffin, or LPG, and not coal. This indicates that if employees were paid in cash, rather than in kind, they would be better off. Since RSA bituminous coal is not a preferred household fuel, economic welfare may be increased if the practice of in-kind distribution were discontinued and wages increased by the amount that companies would have spent on coal for employees.

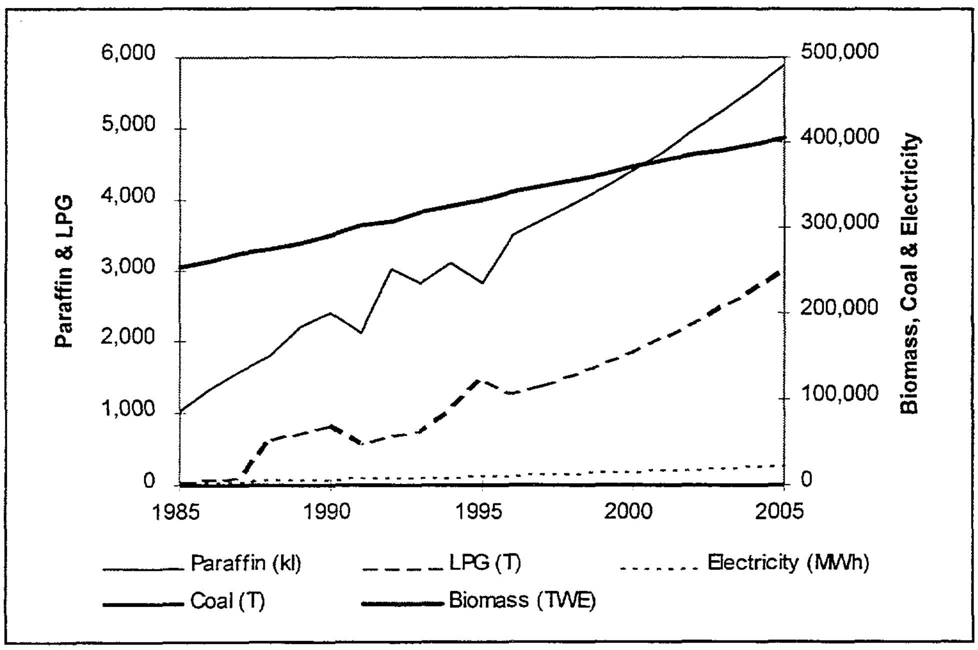
Figure 2.3: Swaziland Company Town Household Fuel Consumption: Trends and Projections



2.9 Depending on the company, electricity and paraffin may also be provided to employees as a benefit. Medical care, schooling, food and housing, are being provided in most company towns at no charge. The practice whereby companies provide basic services was established to attract workers to areas without infrastructure in both public and private sector activities. It also ensured a labor force that was well clothed and fed, and well taken care of in other respects, so that they could devote their undivided attention to working, rather than spending much time trying to satisfy basic needs through imperfect markets. This has led to a situation of dependency which is inefficient from an economic welfare point of view. Such dependency may be an asset from the point of view of the company, but it may prove to be a burden for the workers and Government when downsizing or other adjustments occur. Government, therefore, may wish to engage in a discussion with the companies concerned, and SEB, to determine ways and means to change this situation. It is clear that such a change cannot be sudden and that it may be difficult to apply on an industry-wide basis, since each company town situation is likely to be unique.

2.10 The patterns of fuel consumption in *rural areas* also depend on location and income. Wood and crop residues meet the bulk of cooking and heating needs in rural households (Figure 2.4). Crop residues and dung generally meet a larger share of cooking and heating needs in areas of relative fuelwood scarcity (Lasschuit, 1994, Tables 4, 5, and 6). Paraffin consumption for cooking is distinctly higher in areas of fuelwood stress.

Figure 2.4: Swaziland Rural Household Fuel Consumption: Trends and Projections



2.11 The environmental and economic aspects of the rural areas' high dependence on biomass energy are explored in the next chapter.

3

BIOMASS FUELS: ISSUES AND OPTIONS

Deforestation

3.1 Experience in other countries of Sub-Saharan Africa suggests that commercial fuelwood supply patterns for major urban areas often play a greater role in forest depletion than rural fuelwood demand, since wood for urban markets is often felled, while rural dwellers meet their needs largely by gathering dead wood and branches. Swaziland may present an exception to this observation. The unique pattern of rural settlements, mainly individual homesteads, relatively high cash incomes of a substantial share of rural dwellers, and fuelwood scarcity have led to fuelwood becoming a cash commodity even in rural areas. Roughly 20% of rural households purchase at least some of their fuelwood (Lasschuit 1994, Table 10). Previous studies point to a declining forest resource base on or near Swazi National Land. This is the result of a decline in the sustainable yield available from a diminished forest stock, coupled with rising wood consumption or disappearace for all purposes -- fuel, land clearing, and forest products -- driven by rapid population growth. A recent FAO study finds that Swaziland has one of the highest population pressures on the land of all countries in the SADC region (Ragumamu, 1993).

3.2 In human terms, deforestation means that more time and effort is spent collecting wood, and wood is conserved by cooking fewer meals per day than would be done normally. Both of these responses to fuelwood scarcity are reported in Lasschuit (1994). Moreover, increasing numbers of people have had to resort to the burning of dung and crop residues. While use of dung and crop residues as fuels may be a traditional and sustainable agricultural practice, they are inferior fuels, and their removal from the land may lead to soil degradation, reduced fertility, and lower agricultural yields, thereby imposing real costs on Swaziland and its subsistence farmers.

3.3 A disproportionate share of the cost of deforestation is being borne by subsistence farmers with low cash incomes. Many rural households report a diminishing resource base, and a substantial share of purchased fuelwood (Lasschuit, 1994). These findings not only reflect fuelwood scarcity, but also probably a rising gap in living standards between members of the rural subsistence economy and members of the rural cash economy. As such, consistent poverty alleviation, rural development, and resource management policies could play a vital role in addressing the adverse impacts of land degradation and deforestation on the rural poor. Energy sector policies and programs (rural and urban) should be consistent with these broader economic and social desiderata.

Fuelwood Supply

3.4 The total plantation area of Swaziland is 162,400 ha, and the indigenous forest area is 463,000 ha, or 36% of the total land area.[11] The area dedicated to man-made forests (for paper and pulp industries) is increasing, while indigenous woodlands are decreasing. The latter development is the result of degradation of the indigenous forest resources, due mainly to overgrazing, annual bushfires, and uncontrolled exploitation of the forest cover. The renewable resource base has not been managed sustainably, and this has resulted in decreased availability of firewood, timber for construction purposes, and medicines, as well as increased soil erosion and a loss of biodiversity. The effects are most felt in the middle-veld (the area with the highest human and animal population density), but are not limited to that area. Forest degradation outside commercially managed tree plantations is in fact structural. Because indigenous forest resources are being exploited without being managed,[12] their productivity is decreasing. Many rural consumers feel the crunch of reduced fuelwood availability across the country. In 1995, the estimated annual production increment was 317,000 tons, while the estimated demand was 475,000 tons, implying a "shortage" of 158,000 tons. The forest deficit (Table 3.1) has been calculated on the basis of the forest inventory by Hess, *et al.*, 1990 (see footnote 6), who quantified standing stock per hectare (both forested areas and trees outside the forest) and mean annual increment of the standing stock. Results of a national household energy consumption survey (Gajo, 1989; see footnote 6) were then used to identify the national wood deficit. The situation is serious, because fuelwood is still the major household fuel in rural Swaziland, as seen above.

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11 1990 estimates in Hess, *et al.*, (see footnote 6).

12 Most people are aware of the negative impact of forest cover depletion, but what little indigenous control exists is weak and generally ineffective. The Swaziland Environment Authority has a program to combat desertification, including forest cover protection.

Table 3.1: Estimated Indigenous Forest Deficit 1994 ('000 T)

Indigenous forest increment a/	317
Firewood consumption b/	363
Non-firewood demand a/	112
Indigenous forest deficit	158

a/ Hess 1990.

b/ mission estimates based on Lasschuit 1994 and 1995.

Consumer Reaction

3.5 Household surveys show that consumers in fuelwood deficit areas have reacted to this situation by reducing their firewood consumption and, for the poor, walking farther to collect wood. In addition, substitution fuels are now beginning to be used in certain areas. Crop residues are used by more than 50% of rural households in fuelwood deficit areas, while dung is also being used to some extent, in particular in wood-poor areas. Finally, paraffin is the most important second fuel for cooking in rural households, though the quantities consumed are small. LPG penetration is still limited, both due to its high cost and its distribution network which is limited to urban areas.

3.6 Though the rural population is aware of the loss of forest cover, rural dwellers in fuelwood scarce areas have adapted -- they use less wood, buy it, walk farther, or substitute wood. The planting of new trees and schemes to protect or manage existing ones are less common responses. Wood is available for purchase throughout the country at very low resource cost -- it appears that transport margins for woodfuels constitute over 75% of delivered prices. Hence, prices at the source do not give enough incentive to maintain the resource base. Because of the prevailing characteristics of land tenure, forest resources are treated as commonly owned and relatively free. This situation would be most appropriately addressed though a clear specification of property or land rights as proposed below.

Government Programs: Woodlots versus Land and Watershed Management

3.7 Following several studies (mainly financed by GTZ), the Government initiated a number of community woodlots to demonstrate methods for their establishment and management. Since they have neither matured nor are productive yet, they are not appealing to rural consumers at this time. Although farmers plant trees, surveys show that they mainly plant multipurpose trees, such as fruit and shade trees, and rarely show interest in trees mainly for fuelwood or timber. While communities with pilot woodlots fence off large areas and plant seedlings (fencing and seedlings provided by government for free; labor for planting, weeding and fencing provided by communities), it is often the case that only a small fraction of the area is being planted. A number of constraints are responsible for this situation, including the unavailability of extension staff to train community members and the lack of transport opportunities to enable regular monitoring. While the intention is to plant the remaining area as well, the communities have not planted it at their own cost, and this could be seen as a reflection of the perceived value of these plantations. Initially, Government had consulted the communities to understand their fuelwood requirements, but there has been no follow-up or review of the pilot projects' progress. Therefore, Government has neither data on what tree species communities want to promote, nor on cost-benefit ratios applying to such activities[13]. Also, since the Government has fully financed the woodlots, it has not been able to assess the true degree of interest on the part of the rural communities, because their willingness to pay has not been ascertained.

3.8 Government has indicated that the cost of the pilot woodlots would amount to about E13,560 (US$2,712) per hectare[14]. This figure included purchasing of seed, labor to raise tree seedlings for six months, transporting seedlings to the planting site, and the fencing material used per hectare. Government is currently in the process of evaluating the fuelwood pilot woodlots to assess their impact on rural communities and the possibility of future expansion of the pilots to cover the whole country. This exercise was to be undertaken during the period May - July 1997.

3.9 But even if the rural communities were interested (and some communities have expressed interest), woodlots are not the most economic use of the land, and should mainly be established on land not suitable for agriculture and grazing. Timber lots and agriculture provide higher yields, and the former offer firewood as a by-product. Also, there would have to be many woodlots to address the shortfall in fuelwood availability. Providing about 160,000 tons annually would require 50,000 hectares of well-managed black wattle fuelwood lots[15]. This was, therefore, never the main thrust of the woodlot

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[13] The Government is in the process of carrying out a survey and mapping of all planted woodlots in the country where all the technical data will be collected and recorded. Tree species that are being promoted now, i.e. gums (Eucalyptus) and wattle (Acacia mearnsii) are good for their social, economic and environmental benefits which accrue to rural communities and help enhance social welfare and living standards. To complement the existing information, Government is also in the process of conducting a formal tree seed or tree seedlings user preference study which will establish the preferred tree species and their uses.

[14] A rough calculation shows a cost of wood of E150 - E250 per ton, excluding the cost of labor for establishing the plantation, the cost of harvesting, transporting to the market, and wholesale/retail operation. It is unlikely that plantation wood can compete with what is now freely available on the market.

[15] Among the indigenous species, black wattle shows the most promising annual increment -- 4.3 m3 according to the Forest Resource Inventory reported in Hess, *et al.*, 1990 (see footnote 6). At 760kg / m3, well-managed lots could produce 3.3 T/ha which means that roughly 50,000 ha of dedicated fuelwood

program as this would be too expensive. The woodlots were aimed more specifically at training individual farmers and communities in planting and management, as indicated. Compared to the land covered by indigenous forests, it is clear that the woodlot option would require a substantial commitment of land and human resources, as well as effective local management. Given the obstacles to effective woodlot management that have been experienced to date (reviewed below), and the high costs involved, Government should reassess its sponsorship of community woodlots other than through measures to raise public awareness about the planting of trees in local communities.[16]

3.10 There is an environmental and energy justification for woodlots: wood availability in rural areas will increase if soil erosion is lowered and serious land and forest management practices are applied by rural dwellers. Prudent public policies would focus on promoting effective land management practices aimed at watershed management and erosion control. Currently, Government is spending large amounts on dredging reservoirs for hydroelectric facilities, the need for which is caused by erosion brought on by the absence of watershed management. Effective action on these fronts would yield more woody biomass as a by-product.

3.11 The bottom line is that, while rural dwellers in certain areas of the low-veld and middle-veld are finding it increasingly difficult to gather fuelwood, the chief cause of the scarcity is a lack of effective land and watershed management. If better management systems were in place, there would not be a fuelwood problem. While this statement is generally true for many developing countries, it is especially accurate in Swaziland where an effective scheme for land management does not exist. Government should redirect its efforts to protect the biomass resource base by promoting effective land management, including multi-purpose tree planting by local communities and watershed management schemes. A carefully revised community woodlot scheme could also form part of this effort. Obstacles to effective woodlots are reviewed below.

3.12 Commercial fuelwood lots with indigenous species (public, private, or community-based) have been shown to have a positive Net Present Value (NPV). However, the NPV of eucalyptus woodlots may be as much as three to six times higher

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plantations would need to be managed to sustainably produce 158,000 tons annually. Today, there are roughly 25,000 ha of black wattle plantations or 'jungles' in parts of Middleveld and Lubombo plateau; most of the products obtainable from these plantations are sold in South African timber and bark tannin markets.

[16] The Forestry Section of the Ministry of Agriculture and Cooperatives maintains that Government is not wasting its efforts and resources in supporting the woodlot pilot project. The Section believes that planting trees, for a variety of purposes including fuelwood, is an integral part of the development strategy for enhancing the livelihood of the people. Trees ameliorate the soil and help combat land degradation and desertification. They are a factor in agricultural production, since they improve soil fertility and productivity, and they can make a significant contribution to economic growth and better welfare in rural areas. Proposals to plant trees, specifically for providing fuelwood in deforested areas, should be seen as part of a holistic development approach.

than that of lots planted to indigenous species. Research on other species should be considered as well, particularly on marginal lands, since fuelwood plantings are rarely the first-best use of prime land, as stated.

3.13 Farmers' preference for trees which can be used for fruit, timber or shelter with fuelwood as a by-product indicates that these other wood uses are more highly valued. Fuelwood plantings may be among the least attractive land uses in densely populated areas where the biomass resource base is under stress. Agro-forestry practices might partially respond to these problems, but they would need to be developed in detail to determine their economic viability. If appropriate, they should be included in the development of integrated energy solutions for specific areas.

3.14 Although the infrastructure to disseminate tree seedlings exists, appropriate practices are known, and many farmers are educated and trained in the relevant technologies and management practices, there is an acute shortage of trained forestry extension workers and vehicles for field work. The government is currently addressing this problem through the public sector management programme and other reform initiatives.

3.15 Finally, the quasi absence of sales points where consumers can buy fuelwood in urban areas (most fuelwood is procured on an informal basis and transported by pick-up truck on demand) seems to indicate that the economic demand for a product called "commercial fuelwood" does not exist[17] -- however, greater understanding of the fuelwood market is required for Government to be able to focus any future interventions appropriately.

Policy Options

3.16 Several options exist for protecting Swaziland's biomass resource base: (1) measures to increase supply, including new plantings and better management of existing resources; (2) measures to reduce offtake through fuelwood conservation; and (3) measures to reduce offtake through fuel substitution. However, as long as the perceived value of wood remains low, these options can only be marginally successful. Promotion, training, education, and extension can facilitate progress, but to achieve the full potential of these options, the price of fuelwood would need to move more in line with the actual cost of wood replacement.

Supply Measures

3.17 *Management of Indigenous Resources*: An important issue in the management of indigenous resources is the need to clarify the nature and scope of communities' control over the indigenous biomass resource base. Currently, people from

[17] As opposed to commercial products such as timber, poles, tannin, etc.

outside the community can gain access to a community's resource base for their own purposes. This is contradictory to good management practice and may contribute to degradation. It would seem advisable to pass a rule, or law, to put local communities in charge of their forests. In order to ensure rational management of the available indigenous forest cover, an appropriate quota for annual offtake of wood should be established for each community through free deliberation between the forestry service and the community concerned. The community would be free to extract more than the annual agreed upon quota, but subject to paying a penalty equal to the economic cost of the excess extracted. Some communities already have incipient management systems along these lines, but in order to improve them, perceived fuelwood prices would need to move higher. It is necessary to determine the economic cost of fuelwood as a basis for defining the excess offtake penalty. This may be done on the basis of the substitution value in terms of coal, paraffin, or LPG, or with reference to the cost of wood grown on woodlots.

3.18 Moreover, effective implementation of this option would require a thorough market study of the existing fuelwood supply system. The objective of this study would be to identify major sources of supply and ownership of the resource base, and to analyze the structure and prices of the fuelwood trade. Little is known about the ownership characteristics of indigenous forests or, more generally, lands from which wood originates. Owners of forest resources commonly have little appreciation for the economic value of trees[18]-- during the mission, a private forest was sold for E15,000 and within one month the purchasers had harvested and sold only 1/6 of the forest for E30,000. Draft terms of reference are given in Annex 1 for a fuelwood supply systems study.

3.19 *Commercial Use Of Biomass Residues:* Another option to increase the supply of biomass is the commercial use of biomass residues in the form of briquettes for use in urban areas. The residues of paper and pulp factories, sawmills, and black wattle plantations could constitute sources of household fuel and industrial boiler fuels. More data are needed on the nature and quantities of residues from these commercial operations, as well as the current use of residues and associated values.

3.20 Moreover, cuttings and trimmings, and lops and tops are commonly left on the forest floor in commercial plantations. Commercial operators do not allow people to retrieve these trimmings, as free access to plantations could pose a fire hazard. There is a need to quantify the amount of wood lost in this fashion and, if substantial, to consider alternative methods for making trimmings and tops available, if this can be done without engendering a negative impact on nutrient conservation.

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[18] Not all farmers are aware of the actual value due to lack of market information. As a result, they sell too cheaply. However, the Ministry of Agriculture and Cooperatives through the Forestry Service do offer services to members of the public and farmers in both Swazi Nation Land and title Deed Land for evaluating and determining monetary value.

3.21 Government should gather data on these aspects forthwith. Draft terms of reference are given in the Annex 2. Once this information is available, a consultant familiar with the densification of biomass can be retained to determine whether or not residue densification constitutes a product which is able to compete with fuelwood in the market. Past studies neither took into account all residues nor all technical densification options, such as the agglomeration technology which is cheaper than the technologies considered so far. The gasification of forestry waste to generate electricity for supply to the grid is another option to be explored.

Fuelwood Conservation: Improved Stoves

3.22 Measures to increase supply can only make a difference in the long term. Shorter-term solutions require measures that encourage interfuel substitution and improved biomass stoves. Improved stoves have been found to be capable of contributing toward a reduction in fuel use and thus pressure on forests.

3.23 Fuel and stove usage in Swaziland have been well documented (Lasschuit, 1994 and 1995). Most wood and biomass fuels are used in open fires with tripods or three-legged pots. Net conversion efficiencies for cooking range between 10% and 15%.

3.24 There are no efficient woodstoves on the market in Swaziland. The only option available for switching to a more modern device for cooking with biomass fuels is a heavy iron coal stove with four openings imported from RSA. These stoves are very expensive when new: E 2,000 - E 2,500,[19] and there is an active trade in used stoves. These large coal stoves carry substantial prestige. Despite their cost, they are used by as many as 25% of rural households to burn fuelwood. However, since they are designed for RSA coal, they are inappropriate for either wood or Swazi coal. They convert fuelwood energy less efficiently than a three-legged pot on an open fire (Lasschuit, 1994). As they are used by higher income households that would be able to purchase stoves designed for wood, this identifies a key area for action.

3.25 Lasschuit (1994) describes preferred characteristics of wood stoves for Swazi conditions and examines rural households' willingness to pay for a cleaner and more convenient modern alternative to the open fire. The author suggests that several stove designs available in neighboring countries may be appropriate for Swazi conditions with little modification. Lasschuit provides a good starting point for designing measures to introduce efficient woodstoves into Swaziland.

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[19] This is equivalent to half the average annual household income of rural households in the 2nd income quartile and 10% of the average annual household income of rural households in the highest income quartile.

3.26 Worldwide experience with improved biomass stoves has shown that, with few exceptions, they do not significantly reduce pressure on forests.[20] Hence, improved biomass stoves should be promoted in conjunction with other programs to reduce fuelwood consumption. Program objectives should include the reduction of the financial cost of cooking, the reduction of indoor air pollution and the enhancement of convenience.[21]

3.27 Using wood to cook in coal stoves requires 20% more wood than an open fire. However, considering that coal stoves are commonly placed inside the house and open fires are often outside or in a separate room or hut, it may be that the additional convenience of main house heating during the winter months makes existing coal stoves as efficient or more so than the open fire. Nevertheless, fuelwood demand may be reduced somewhat by introducing appropriate woodstoves that are similar to existing coal stoves, with openings for multiple pans and an oven for baking or grilling, but designed for efficient wood combustion.

3.28 At existing fuelwood purchase prices, a coal stove insert costing E100 would pay for itself in fuel savings in six months, if it merely made the coal stove as efficient as an open fire, when used for cooking purposes only.[22] For rural dwellers who use an open fire, Government may wish to establish whether the development and eventual commercialization of a dedicated multipurpose woodstove would be a legitimate and viable option to pursue. In order to determine this, the services of a specialist in stove design and dissemination should be retained to assist the Government in assessing this option. Draft terms of reference are given in Annex 3.

Reducing Offtake Through Fuel Substitution

3.29 Pressure on forests, as well as the burden of fuelwood scarcity on rural women, may be most effectively mitigated in the medium term by encouraging substitution of other fuels for wood. The chief options are (1) paraffin; (2) LPG; (3) coal; and, theoretically, (4) biogas and (5) solar cookers.

3.30 *Paraffin:* Paraffin appears to provide a good substitute for fuelwood in Swaziland. It plays a major role throughout the world in the energy transition from traditional to more convenient commercial fuels. Also, paraffin is already widely known as a fuel for lighting and cooking in the rural areas of Swaziland, where it can be bought in non-standardized quantities and, therefore, is well suited to the rise and fall of cash

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[20] Foley, G. and W. Mostert, "Why fuelwood projects are so difficult", Working Paper, DANIDA Energy Sector Policy Review, March, 1991.

[21] Barnes D., K. Openshaw, K. Smith, and R. van der Plas, "What Makes People Cook with Improved Stoves?", FPD Energy Series Working Paper #60, the World Bank, 1993.

[22] Assuming average fuelwood use by rural households of 4,000 kg/year (Lasschuit, 1994; see footnote 7) at a cost of E60/250kg van load.

incomes of rural families. The relative cheapness of paraffin stoves currently on the market makes this fuel even more attractive to poorer households than the other economically viable fuel, LPG.

3.31 To make full use of paraffin as a cooking fuel, however, higher quality paraffin stoves need to be introduced into the market. The wick stoves now available are cheap, as indicated, but shoddy and with a limited life and low power output. While the Primus pressure stove has a high power output, it is difficult to operate and not very stable. It is recommended that Chinese pressurized stoves, which also offer a two-burner version, be tested in collaboration with private wholesalers and retailers, in a sample of households. If these stoves were found to satisfy consumer preferences, their sale could be promoted through commercial channels.

3.32 *LPG:* Despite its attractive characteristics, paraffin is not now a preferred cooking fuel. Households which can afford LPG switch from wood to LPG, rather than paraffin or coal. However, an LPG bottle, regulator, and burner are relatively expensive, as is the cost of the fuel itself. And the distribution network for LPG is limited to urban areas. Rural consumers' access to this fuel would need to be promoted.

3.33 Two companies currently distribute LPG in Swaziland, Shell and Swaziland Oxygen. Neither company dominates the market (roughly an even split), and LPG appears to be competitive, since prices were revised downwards in October 1995 and current margins are not excessive. If margins were higher, other oil companies that currently distribute LPG in South Africa would enter the LPG market in Swaziland. In short, competitive pricing seems to prevail, and Government should not consider regulating LPG. Moreover, both companies will soon begin a joint information and safety campaign to build and extend LPG markets. LPG can be expected to play an increasing role in meeting future household energy needs in Swaziland.

3.34 *Coal:* Swaziland is endowed with a known reserve of roughly 1 billion tons of high quality anthracite coal. At the current extraction rate of 400,000 TPA, Swaziland's economic reserves will last a very long time. While this smokeless coal is ideally suited as a household fuel, Swaziland's anthracite is entirely exported. This is how it obtains its highest economic value (industrial boiler fuel for export). Coal mined at Maloma is currently being sold at E235/ton. With a net minemouth price of roughly E78/ton, Swazi anthracite would be a very expensive household fuel. One disadvantage of using Swazi anthracite as a household fuel is that it is difficult to light. Most popular coal stoves are designed for the more easily ignitable bituminous coals.

3.35 The use of anthracite coal as a possible source of indigenous power in the future has been a subject of discussion over the years. Government's interest in its use is increasing as Swaziland's energy imports grow. The government, with the assistance of TDA, is at the moment carrying out a study to determine the timing for, and the economic size of, a coal fired power plant. The use of Swazi coal in industrial boilers is disadvantaged by the fact that the boilers are designed for bituminous coal, and the cost of conversion is presumed to be high.

3.36 Bituminous coal is imported from RSA for industrial applications and for distribution to households in company towns. Bituminous coal is used as a household fuel only in company towns where it is provided free of charge to employees as part of their compensation.

3.37 *Biogas:* International experience with biogas digestors shows that family biogas units are generally uneconomic to operate. Water is scarce in many rural areas and cattle roam freely in the summer months, thus making it difficult to get enough dung for biogas feedstock. Moreover, international experience has shown that biogas digestors are quite complex to operate, require a fairly precise mix of feedstock and water, and require a relatively high investment cost which will be an obstacle to adoption by rural households. In addition, the potential contribution of biogas digestors toward reducing pressure on forest resources is practically nil. It is therefore recommended that the Government do not spend time or money on this subject, due to its irrelevance to the situation of Swaziland. However, if demand for technical and economic information on biogas arises, the Government should be in a position to provide these data along with information about alternatives.

3.38 *Solar Cookers:* Although solar cookers can perform quite well and would substantially reduce fuelwood consumption if used on a daily basis, international experience has shown that households are not willing to accept them on a large scale. Reasons cited are related to reduced convenience compared to traditional alternatives: not all types of food can be cooked, one needs to plan ahead with cooking, and solar cookers need constant attention (place toward the sun, protect food from animals, and protect children from hurting themselves). In addition, on cloudy days one has to use the traditional alternative. Under these circumstances, households are usually not willing to spend E200 or more for a solar cooker. Solar cookers are best used under circumstances that combine high concentration of fuel use in an area with excess unproductive household time, such as, for example, in refugee camps.

4

ELECTRIFICATION

Rural

4.1 The Swaziland Electricity Board (SEB) is a government-owned company established under the Electricity Act of 1963. It i) has authority to set its own tariffs and other charges so that revenues exceed expenditures; ii) is responsible for developing and extending power, while seeking to reduce the cost of it; and iii) has an obligation to serve any customer within 100 yards of its lines (E30 are currently being charged for a new connection within 100 yards). With its existing network and (iii), the SEB covers about 80% of the country. Beyond 100 yards, SEB requires customers to pay part of the capital cost of providing service. Combined with the independent nature of people living in individual homesteads, this policy leads to a substantial public good problem in rural electrification. Under existing policy, the extension of rural lines is prohibitively expensive to all but the wealthiest rural households. Hence, most rural dwellers would rather wait until someone else provides the line to within 100 yards, such that they can be connected for the minimal connection fee. SEB's current inefficient pricing results in under-provisioning of grid-based rural electrification in Swaziland.

4.2 The number of SEB's residential customers has grown at an annual rate of roughly 6% over the past decade, and the residential sector accounts for about 20% of total SEB sales. According to Lasschuit (1995), 39% of households in urban towns and 35% of households in company towns used electricity in 1994. Less than 3% of rural households were connected. Options for rural electrification are now being considered by Government. Pent-up demand is considerable, judging from the fact that as much as 50% of rural household cash expenditure is devoted to the purchase of batteries, candles, and paraffin (in decreasing order of importance), as well as radio, television, and lighting. Due to the prevailing settlement pattern, rural electrification in Swaziland will be expensive. The extension of the grid may not be a viable option for most rural households. A tariff study should specifically address how rates should be set to help generate revenue to finance rural electrification, at least for basic services.

4.3 Even in industrialized countries, rural electrification has only come about with public subsidized support. Therefore, one possibility would be for a local development bank or trust fund to make available low-cost financing to the private sector such that cheaper and longer credit terms can be offered to the public. In this respect, it is encouraging to note that 500 solar home systems are now being promoted on a pilot basis by means of the creation of a customer credit facility supported by the Swazi private sector with financial assistance from a private Dutch investor.

4.4 One option to rationalize conditions and set the stage for grid extension would be to have SEB connection fees shared by the households in a community. SEB currently bears no risk in extending rural lines -- an extension must be fully financed by the customer, or the line is not built. A substantial barrier to grid-based rural electrification may be removed by sharing the cost of extensions between all households which stand to benefit. Schemes such as rural electricity cooperatives (through which rural consumers construct, operate, and own rural lines) have a long and successful track record in other countries. Access to finance would help accelerate rural electrification schemes, as would subsidies from general tax revenues or cross subsidies from urban to rural consumers through tariff policy. While this report does not advocate any particular scheme at this time, policy makers have a variety of alternatives to consider for financing economically viable grid extension in Swaziland. Ongoing discussions under the SCORE program provide an appropriate forum for considering the options.

4.5 While grid extension must continue to be considered, the options of off-grid diesel and photovoltaic (PV) hybrids should also being examined. Government may wish to assess more decentralized options for electrification alongside grid extension. In particular, the resource cost of each segment of grid extension should be evaluated. Next, it should be calculated how many households could be given electric service through household PV for the same resource cost. It is also necessary to consider the tradeoffs between reliability and cost of alternative technical specifications for rural lines.

4.6 Solar (PV) home systems could be a promising option for households for whom grid-based service would be prohibitively expensive. However, knowledge about this option is still rather limited (only about 600 PV systems have been introduced since 1991) and, therefore, consumers should be made aware of its advantages, disadvantages, and its costs. Solar electric equipment is available in different sizes, catering to different needs. A small solar electricity generator (solar module or panel) of 12 Watt could be added to already existing car battery-DC lights-television systems to reduce the frequency of battery recharging at a designated recharging station. A solar lantern significantly increases lighting benefits to rural households, while offering a fairly rapid payback of the investment. Outdoor anti-theft lights and systems to recharge both 12 volt and ni-cad batteries for radios are other possible options. The availability of attractive credit for a variety of larger solar home systems (20 to 50 Watt) would provide rural consumers with conditions and choices that would likely be compatible with larger scale use of this technology. A commercial approach, guided by full cost recovery, a broad selection of equipment, and competition among suppliers would be the most appropriate way to promote PV systems suited to Swazi conditions.

4.7 Other alternatives to grid extension can and should be explored. In case of a fairly concentrated demand for electricity in a remote area too far from the grid to warrant line extension, decentralized supply could be studied. Whether this is done through diesel, hydro or any other local option is a matter of economic evaluation. Institutional arrangements to be examined in such a case would include cooperatives, communities, or a local IPP (independent power producer, which could be a local entrepreneur, factory, etc.). Alternatively, where the demand for electricity is too low and dispersed, solar electricity might be viable. A private company has recently started promoting and selling solar home systems.

Urban

4.8 It is remarkable that in a country with relatively high per capita income and a robust cash economy, less than 40% of urban and peri-urban households are electrified, as indicated earlier. Electricity authorities in other countries with similar cash income levels routinely serve more than 80% of urban dwellers. This observation is even more notable in view of the fact that an electricity connection is among the most desired services of low income urban households, second only to a clean supply of water. It is not apparent why the current urban electrification rate is so low, especially since SEB has a mandate to connect all households that request a connection, and since, as mentioned, SEB's connection fee is well below cost. Although SEB is not operating at a loss, it has a problem with a high number of outstanding debtors and debtor days, and a high incidence of defaults. Therefore, it would seem necessary for SEB to develop and implement both a policy aimed at improving billing and collection (pre-payment meters, security deposits, credit for appliances) and connecting remaining urban households as soon as possible.

4.9 The structure of tariffs is in need of reform such as to pass appropriate signals to each sector and generate sufficient revenue to cover expenditures. The tariff structure should at least reflect the tariffs of the bulk supplier, ESKOM.

4.10 Large blocks of residential customers (large flats or company towns) might be charged an industrial tariff (if demand rises over 50 kVA). But this needs further study as the structure of industrial tariffs is substantially different from residential tariffs. Mhlume has some experience with this. They argue that the industrial tariff encourages economic demand.

5

ENERGY PLANNING

5.1 The purpose of an Energy Planning Unit (EPU) is to provide inputs for social and economic development planning, with special reference to energy. Ideally, an EPU should have a relatively small permanent staff of highly skilled professionals covering the range of skills most appropriate to the needs of the country's energy sector. To undertake its role effectively, an EPU must have sufficient administrative powers to request data and information and to objectively monitor and evaluate the performance of energy projects, programs and parastatals. The EPU should perform its function in such a manner that it earns the respect of the major actors in the energy sector. Until now, energy planning and policy making have been the task of the Energy Unit (EU) of the Ministry of Natural Resources. The Unit has four professionals and one advisor.

5.2 The mission was unable to review present human resources and compare them to needs. This is a specialized task and should be undertaken simultaneously for the entire energy sector. With the assistance of the in-house energy advisor, the EU should review and compare the present number and quality of staff with a projection of requirements. Recommendations should then be formulated regarding the ways and means of meeting any deficiency or correcting any distortion foreseen. Such a review of manpower and training needs to be undertaken with some urgency.

5.3 Given the extremely limited human and financial resources of government, programs to address issues in the energy area should be strictly prioritized. At the moment, many government initiatives are undertaken to address pressing energy issues at 100% Government cost. However, these programs are neither monitored nor evaluated. Government, therefore, does not know whether pilot interventions should be repeated on a larger scale, what their cost/benefit ratios are, whether given proposals will solve the problems they were intended to address, and whether the target population is willing and able to pay for any of the interventions. Any future Government activity should be designed and budgeted in such a way that pilot interventions will be monitored and evaluated, and -- in the first place -- designed and executed in a way which will permit the drawing of conclusions about sustainability and replicability from financial, technical, and institutional points of view.

5.4 The envisioned outputs should be in line with the general and specific objectives of the sector. Of primary importance are national energy policy guidelines, and strategies for investment and implementation. The EPU must be very selective and modest in its goals, undertaking additional tasks only in the highest priority areas for energy management and development. These areas include the annual review and update of national energy policy, combined with an analysis of energy demand management. To that end, Government should require as a part of industrial and commercial policy the annual reporting of a consistent and non-repetitive set of information from all ministries including MNRE, based on an annual census of manufactures. This annual survey should include information now gathered by MNRE in its annual industrial energy survey. MNRE should modify its survey to request annual production and consumption of fuels, rather than capacity. Further, the EPU should carry out an annual review of projects and programs in progress. Finally, it could publish occasional reports, including special preinvestment studies and policy analyses, as well as working papers on special projects and programs, such as the pilot PV solar project, rural electrification program and proposed cook stove consultancy.

5.5 In this connection it has been recommended elsewhere that MNRE establish a Renewable Energy Cell, a Renewable and Rural Energy Technology Qualification and Testing Center, and a Renewable and Rural Energy Information Center. Given the chosen general approach (allowing the private sector to allocate resources in sectors that do not exhibit the characteristics of market failure) and the observation that cost-effective renewable energy technologies are now marketed by the private sector, it would be advisable for Government *not* to act on these recommendations. However, it is important that dialogue with NGOs and the private sector continue and coordination among all different actors take place. It has also been recommended that an assessment of the solar and wind resource regimes in Swaziland be undertaken. However, given what is already known about wind and solar regimes, there appears to be *little basis* for Government to undertake formal assessments. A detailed hydro energy assessment has also been recommended, but the priority of this recommendation cannot be judged in the context of the present Household Energy Strategy Study.

ANNEX 1: DRAFT TERMS OF REFERENCE FOR A STUDY OF THE FUELWOOD MARKET CHAIN

A1.1 The objectives of the proposed fuelwood supply and marketing study are to:

(a) establish market networks in three major centers of demand for monitoring the type of bio-fuels and prices being traded;

(b) determine precise spatial representations of the fuelwood production, distribution and marketing systems;

(c) contribute to the understanding of price formation for fuelwood, including identification of primary resources, charges and production costs, producer margins, transportation costs, and wholesale and retail margins; and

(d) assess the structure and function of the fuelwood trade and its commercial significance.

A1.2 The study of the fuelwood business should include the following:

(a) Identification of the main participants such as farmers, wood cutters, wood sellers, wholesalers, retailers, etc. For each of these groups, an assessment needs to be made of the role they play, level of education, part/full time activity, and net income derived from the fuelwood business.

(b) Study of the main fuel flows with a view to analyze both material and financial flows and transactions. Fuelwoods should be identified by category and source. This requires a map of the origins and destinations of the products, with the volumes. If complete mapping is not possible then at least the total fuelwood supply balance should be computed.

(c) Determination of market prices and trends. This includes the product packaging (truck load, small bundles) as well as analysis of past supply trends.

(d) Defining and analyzing interactions or transactions between participants in the production, distribution and marketing chain. The linkages between resource owners, producers, transporters and dealers should be the focus of the analysis.

(e) Assessment of the influence of environmental change on the nature of the business. Changes in the physical environment are likely to influence the business. The availability of high quality fuelwood resources is under pressure, which has consequences for production and natural resource utilization. Also, the demand pattern will be changing over time, influencing supply in quantitative and qualitative terms. It is important to understand the transition away from, or toward, biomass with changes in income, consumer preference and resource availability, and their likely environmental and economic implications.

A1.3 This study can be executed through:

(a) interviews, for each major demand center, of a number of each social category mentioned above.

(b) inflow surveys of the incoming fuelwood traffic so that an estimate can be made of the volume/weight for each type of vehicle.

A1.4 Ideally, the implementation of the survey should be done four times in the year, during seven days, for each of the main incoming roads. Two modes of surveying should be employed:

(a) systematic counts of any woodfuel carrying vehicle; and

(b) selected, in-depth survey of say 10 vehicles.

In both cases, the surveyors would record the vehicle type, woodfuels category, load size, and the direction of traffic. For the in-depth survey, records should also be made of: origin, destination, total quantity to be sold in which form (bulk, small lots), the likely buyers (retailers, final consumer), purchasing price, expected selling price, unit of weight of the product, and type of product. As to the transporters, it should be investigated whether they spend full time hauling woodfuels, and whether they also haul other products on the return trip to the origin.

ANNEX 2: DRAFT TERMS OF REFERENCE FOR A WOOD RESIDUE/BRIQUETTING FEASIBILITY STUDY

A2.1 You will be responsible for a detailed technical, economical and institutional assessment of the feasibility of the use of wood residues as a fuel in Swaziland. You will be primarily responsible for systematically identifying and evaluating the technical, economic and institutional merits of major opportunities available for wood residues to be used as a household or industrial fuel. Finally, you will have to identify the scope for private sector operation of the briquetting of wood residues, electricity generation through gasficiation of wood residues, and what policies and supporting instruments should be in place to bring this about.

A2.2 Your specific responsibilities will be to:

(a) Review and verify the data collected by the Government on the type, level and patterns of wood residues produced by the wood processing industries. Based on this information, you should develop a basic profile of the existing and future available supplies.

(b) Determine potentially attractive end-uses for processed or converted residues such as wood chips, briquettes, charcoal, and electricity. Based on the information developed you should identify specific opportunities to increase offsite use of wood residues as a fuel. You should further develop preliminary technical designs and cost estimates of industrial and commercial systems required to increase the offsite use of residues. You should evaluate these options against the existing use or cost of disposal of these residues. Based on the results of the analysis, you should identify specific investments options that clearly demonstrate the technical, institutional and economic feasibility of increasing the onsite and offsite use of wood residues for energy purposes.

(c) Finally, you should identify the general development, policy and infrastructure requirements necessary to support the wider use of wood residues as a fuel.

(d) Given the above you should write a final report that must, at a minimum, provide:

(i) An analysis of the present and future supply of wood residues by wood processing industries;

(ii) A listing of the best technically and economically feasible options for increasing onsite and offsite use of wood residues;

(iii) An indication of the short and long term policy options that are necessary to promote the wide use of wood residues for energy purposes;

(iv) A clear strategy and program for follow-up including clearly defined projects with preliminary equipment specifications and cost estimates; and

(v) A definition of technical assistance, infrastructure and investment requirements that are necessary for the implementation of the recommended program.

A2.3 Within six weeks of your stay in Swaziland you will produce a draft final report with your findings and recommendations.

A2.4 In order to reduce the cost of this consultancy the Government should collect the following data:

Wood processing residues:

(a) full name and location (including access road) of each wood processing facility;

(b) type of facility: milling operation - plywood, paper & pulp, furniture, etc.;

(c) the maximum production capacity of the facility;

(d) the quantity (volume, weight, etc.) of wood processed in 1985-95 and expected production for 1996;

(e) quantity of each output actually produced (lumber, plywood, veneer, chipboard, etc.) in 1985-95 and expected output in 1996;

(f) annual operating period of the facility;

(g) type of residues produced (i.e. sawdust, bar, offcuts, shavings, sanderdust, etc.) and their quantities;

(h) estimates of the type and amount of residues used by each facility for its own energy or other requirements;

(i) estimates of the type and amount of residues sold commercially and/or given away to others for consumption. For residues sold commercially, indicate type of buyer and price at which sold;

(j) if electricity is generated on-site, indicate the method of power generation;

(k) determine the amount and type of wood residues available for conversion for use as a fuel;

(l) prioritize and rank target wood industries using criteria of availability of wood wastes, present and future capacity utilization, present heat/electricity sources, age/condition of plant.

Logging residues:

(m) establish (by field sampling and measurement, if need be) the quantity and physical characteristics of typical forest residues, including crown, remaining boles, buttresses, large limb, known downs, dockings at the logging bay, and wood waste produced in road clearing and snigging.

ANNEX 3: DRAFT TERMS OF REFERENCE FOR A WOODSTOVE CONSULTANCY

A3.1 Wood is still the major cooking and heating fuel in Swaziland. Wood is either being used in open fires (rural areas) or in coal stoves. Tests have shown that using a coal stove to cook with wood is less efficient than an open fire. However, consumers (25% of households) like their coal stove, because it is modern and solid, and allows cooking of two and more pots as well as baking in the integrated oven. Though coal is being used (mostly by employees in company towns that receive it free from their employers), consumers do not like coal as a fuel and prefer wood. Given the fact that wood is getting scarce in many parts of Swaziland, it would be beneficial for these consumers to be able to use wood in their existing stoves in a more efficient way or to be able to buy new improved woodstoves. It therefore will be your task to assist a local counterpart agency (New Dawn Engineering in Manzini) in acquiring the necessary know-how to develop improved coal stoves as well as dedicated woodstoves.

A3.2 In particular, you will:

(a) review all relevant literature with regard the experience with and use of coal and wood in households in Swaziland and assess its usefulness for your task;

(b) develop, together with the local counterpart organization, a working model of a firebox inset for existing coal stoves which will permit the continued use of wood, but at much higher efficiencies than achieved in coal stoves without such an inset;

(c) advise the local counterpart organization on the relevant parameters that will permit it to develop a dedicated woodstove for the Swaziland households. Such a stove must have the same characteristics as the existing coal stoves (solid and modern look, more than one pot can be used, an oven); and

(d) recommend a scheduled and costed development program, including field testing in a small control group of consumers to ascertain fuel consumption, time saving, safety, stability and consumer acceptability.

A3.3 Within six weeks of your stay in Swaziland you will produce a draft final report with your findings and recommendations.

ANNEX 4: HOUSEHOLD FUEL USE PROJECTIONS

A4.1 This annex presents fuel use trends and projections for the residential sector of Swaziland. Historic information is obtained from distribution company sales data (time-series) and from household energy surveys (cross-section). The surveys identify patterns of household fuel choice and use by income and location. Sales figures often provide the most reliable total consumption estimates for conventional fuels. For any given conventional fuel, it is common for total quantity estimates from sales and from surveys to be inconsistent by a factor of 2 or more. In the case of Swaziland, however, sales figures for petroleum fuels and electricity in 1993 were very close to 1993 household energy survey estimates and, as such, provide a reasonable basis for analysis and planning.

A4.2 The 1993 urban and rural household energy surveys provide the basis for trends and projections presented here. For 1985 through 1995, it is assumed that paraffin, LPG and electricity consumed in rural and urban households maintained the same relative share as in 1993. For example, 45% of all paraffin consumed in households in 1993 was consumed in rural households. This share is assumed to remain fixed for 1985 through 1995. For 1996 through 2005, demographic trends and fuel use growth rates from 1985 through 1995 are combined to project conventional fuel use in households in each area (rural, company towns, and urban). Traditional fuels are calculated as the residual needed to meet basic energy needs for cooking.

Time Series Supply Figures

A4.3 A great deal of effort was put into developing the Swaziland Energy Information System (SEIS), and it contains the best coherent set of data on fuel supplies, imports, exports and prices in Swaziland through 1992. A thorough SEIS is one of the key functions of government in the energy area as it gives the most compelling basis for pursuing strategies and formulating effective policy in the sector. Information in the SEIS has been the basis of energy balances published by the Energy Unit of MNRE. SEIS provides the historical time series that underlies this exercise.

A4.4 Data from SEIS for paraffin, LPG, and electricity are presented in Table A4.1. Figures for coal in SEIS are clearly estimates and appear not to be tied to any real-world measurements or data. Paraffin and LPG, on the other hand, are from the oil industry itself. The difficulty with interpreting household use from oil industry figures is that distributors sell to small commercial customers as well as to residential customers. As such, our assumption that all retail sales from retail and independent dealers are consumed in the residential sector is biased upwards. However, without further information on the sectoral breakdown of sales, this is a reasonable assumption.

A4.5 Total residential electricity sales from SEB and others are reported in Table A4.2. SEIS also reports residential sales by urban and rural households, but this is obtained by the simple assumption that 95% of residential sales are urban.

Table A4.1: Sales Figures from Distributors/Authorities

Year	*Paraffin (kl) a/*	*LPG (T) b/*	*Electricity (GWh) c/*
1985	2,317	186	78,456
1986	3,005	299	82,279
1987	3,573	466	85,416
1988	4,031	2,709	90,155
1989	4,879	3,124	107,275
1990	5,350	3,522	116,951
1991	4,753	2,488	128,432
1992	6,711	2,950	131,702
1993			141,818
1994	6,923	4,468	152,710
1995	6,294	6,237	164,440

a/ Total retail sales (MNRE).

b/ Total sales at retail outlets and by independent dealers (MNRE).

c/ 1985-1992 residential sales (MNRE -- SEIS); 1993-1995 mission estimates.

Cross-section Survey Figures

A4.6 Several good household energy surveys have been conducted in Swaziland since 1985. The most recent were rural and urban surveys conducted in 1993 and 1994 by Lasschuit. Key results are presented in Table A4.2 below. These are important as they give essential insight into what each fuel is used for and what share of households in each area are using a particular fuel. This is critical for projecting the role of fuel substitution in the medium term in meeting household energy needs. Moreover, results of these surveys along with certain cooking efficiency assumptions give us a critical measure of end-use cooking energy that is also essential for projecting fuel substitution and the viability of options to deal with issues in the residential sector.

Table A4.2: Household Fuel Use Patterns, 1993/1994

			annual units / cap			*annual units*1000*		
	units	*MJ/unit*	*Rural*	*Towns*	*Urban*	*Rural*	*Towns*	*Urban*
Dung	kg	12	2.7	0.0	0.0	1,758	0	0
Crop Res	kg	15	22.5	0.4	0.5	14,529	33	67
Fuelwood	kg	16	469.7	209.0	341.0	302,678	16,125	44,000
Coal	kg	26	0.1	546.8	17.3	34	42,192	2,231
Paraffin	lt	35.9	4.4	9.4	21.2	2,815	724	2,730
LPG	kg	45.5	1.2	15.1	9.9	753	1,165	1,275
Electricity	kWh	3.6	13.3	450.0	645.8	8,544	34,722	83,333
Mean hh size: survey			8.8	4.3	6.6			
Census household size			6.4	3.4	4.3			

Sources: Lasschuit 1994 & 1995 (databases) and CSO census projections.

A4.7 Estimates of per capita residential fuel use in urban areas and company towns are derived from total fuel use figures reported in Lasschuit, 1995 Annex 5. Estimates of per capita residential fuel use in rural areas are derived from Lasschuit, 1994 Annex 5 using the following sample weights and (sample) average household size of 8.8.

	Sample Weight
Mahlangatsha	110
Ntfonjeni	327
Lulakeni	130
Tikhuba	73
Luve	117
Zikhoteni	243
All	1,000

Fuel quantities used for cooking were estimated using the assumptions tabulated below:

	Effic	*Cooking Share (%) b/*			*Cooking End-Use MJ/Cap/Yr*		
	(%) a/	*Rural*	*Towns*	*Urban*	*Rural*	*Towns*	*Urban*
Dung	12	100	100	100	4	0	0
Crop Res	12	100	100	100	41	1	1
Fuelwood	12	100	100	100	902	401	655
Coal	11	100	100	100	0	1,564	49
Paraffin	35	47	65 a/	80 a/	26	77	213
LPG	50	50	95 a/	90 a/	13	326	202
Electricity	70	10 a/	25 a/	35 a/	3	284	570
					989	2,652	1,689

a/ Mission estimates.

b/ Share of residential consumption used for cooking.

Source: Lasshuit 1994 and 1995 and mission estimates.

A4.8 These estimates show that the major end-use (cooking) requires roughly 1,500 MJ/capita/year of end-use energy. For the purposes of projecting fuel usage and substitution, it is assumed that this basic need remains fixed but can be provided by different fuels. Moreover, the survey results give some insight into what share of households use electricity or paraffin for cooking. These are key multi-use fuels as they commonly also provide lighting services. Hence, it is essential to estimate what share of households cooking needs will be met by each. All other fuels are assumed to be used exclusively for cooking.

A4.9 It is not clear that the rural estimates can be generalized to the rural population as a whole as the sample frame was not drawn to be representative in any way. However, the rural survey results are generalized to the rural population of Swaziland using the sample weights shown above (fuel use is reported by sample area in Lasschuit, 1994). All historical trends and projections should be treated as indicative.

A4.10 Results from the 1988 national household energy survey are highly suspect. Fuelwood use and primary fuel use was measured in a subset of households, but households were also asked how much and how frequently they purchased paraffin, LPG, and coal. It is unclear what quantities were reported and how discrepancies were resolved. Moreover, in estimating total fuel use, the author took average usage figures from the measurement survey and multiplied it by the number of households who used the fuel, but it is unclear how paraffin (which is both a cooking fuel and a lighting fuel) was to be treated. The 1993 survey, which asked for responses and measured fuels for cooking/heating and lighting, is preferable and is used here as the only reliable source of fuel use estimates for households in Swaziland for the purposes of this study.

Trends and Projections

A4.11 The shares of residential paraffin, LPG, and electricity used for cooking were estimated for 1993 using the above assumptions. The historical trends and projections, detailed in the tables below and illustrated in Figures 1, 2, and 3, assume that 1993 shares remain fixed. Historical residential consumption estimates are sales figures from SEIS. Using the cooking end-use needs assumed above and population projections for rural, town, and urban areas, the residual cooking needs are assumed to be met by biomass fuels in the same shares as determined in 1993. In the figures, all traditional fuels are presented as an aggregate Tons of Fuelwood Equivalent (TWE) needed to meet basic cooking needs derived from 1993 urban and rural surveys.

A4.12 Certainly, fuel substitution is a dynamic process. As such, the assumption that fuel shares remain fixed is wrong. For example, while electricity appears to be a major cooking fuel for upper income urban residents, just how much of urban residential power is used for cooking is unknown. Whether electricity will continue to provide a great deal of cooking services or will decline in response to adoption of LPG is an open question. While it is clear that the shares of modern fuels used for cooking will not remain fixed and that the shares of cooking services provided by biomass fuels will change over time, this first order approximation yields a general picture of household fuel use trends and projections that capture the dynamic of the household fuel transition now underway in Swaziland.

A4.13 Despite the need for some heroic assumptions to obtain reasonable historic trends and projections, this exercise already shows that: i) the potential for additional substitution of conventional fuels for wood is extremely limited in urban areas and company towns; ii) the potential for paraffin substitution for fuelwood in the rural areas where wood is marketed may be very promising as a substitution strategy; and iii) coal appears to be used very wastefully in company towns.

Table A4.3: Swaziland Population Projection

Year	*Annual Growth Rate (%)*				*Population Projections (thousands)*				*Population Shares (%)*		
	Rural	*Towns*	*Urban*	*All*	*Rural*	*Towns*	*Urban*	*All*	*Rural*	*Towns*	*Urban*
1985					501	54	90	644	78	8	14
1986	3.4	4.8	4.8	3.7	518	56	94	668	78	8	14
1987	3.4	4.8	4.8	3.7	536	59	98	693	77	8	14
1988	3.2	4.7	4.7	3.5	553	62	103	717	77	9	14
1989	3.2	4.7	4.7	3.6	571	64	108	743	77	9	15
1990	3.2	4.7	4.7	3.5	589	67	113	769	77	9	15
1991	3.1	4.6	4.6	3.5	607	71	118	796	76	9	15
1992	3.1	4.6	4.6	3.4	626	74	123	823	76	9	15
1993	3.0	4.5	4.5	3.4	644	77	129	851	76	9	15
1994	3.0	4.5	4.5	3.3	664	81	135	879	75	9	15
1995	2.9	4.5	4.5	3.3	683	84	141	908	75	9	16
1996	2.9	4.4	4.4	3.3	703	88	147	938	75	9	16
1997	2.4	4.4	4.4	2.9	720	92	154	965	75	10	16
1998	2.4	4.4	4.4	2.9	737	96	160	993	74	10	16
1999	2.4	4.4	4.4	2.9	755	100	167	1,022	74	10	16
2000	2.4	4.4	4.4	2.9	773	105	175	1,052	73	10	17
2001	2.4	4.4	4.4	2.9	791	109	183	1,083	73	10	17
2002	2.1	4.4	4.4	2.75	808	114	191	1,113	73	10	17
2003	2.1	4.4	4.4	2.75	825	119	199	1,143	72	10	17
2004	2.1	4.4	4.4	2.75	843	124	208	1,175	72	11	18
2005	2.1	4.4	4.4	2.75	860	130	217	1,207	71	11	18

CSO medium variant projections (towns and urban growth are mission estimates).

Table A4.4: Swaziland Residential Consumption Forecast: Biomass Fuels

Year	*Dung (T)*				*Crop residues (T)*				*Fuelwood (T)*			
	Rural	*Towns*	*Urban*	*All*	*Rural*	*Towns*	*Urban*	*All*	*Rural*	*Towns*	*Urban*	*All*
1985	1,405	0	0	1,405	11,618	44	71	11,732	242,032	21,336	46,584	309,952
1986	1,448	0	0	1,448	11,966	45	71	12,082	249,294	21,644	47,048	317,985
1987	1,492	0	0	1,492	12,333	45	73	12,451	256,931	21,919	47,937	326,788
1988	1,519	0	0	1,519	12,558	28	60	12,647	261,626	13,655	39,907	315,188
1989	1,559	0	0	1,559	12,889	24	53	12,966	268,514	11,640	35,175	315,328
1990	1,603	0	0	1,603	13,254	22	51	13,328	276,129	10,606	33,774	320,510
1991	1,668	0	0	1,668	13,785	33	61	13,880	287,191	15,872	40,513	343,576
1992	1,702	0	0	1,702	14,069	30	57	14,156	293,104	14,549	37,705	345,359
1993	1,758	0	0	1,758	14,529	33	67	14,629	302,678	16,125	44,000	362,803
1994	1,796	0	0	1,796	14,847	21	52	14,920	309,309	10,195	34,151	353,654
1995	1,842	0	0	1,842	15,227	9	45	15,280	317,215	4,232	29,643	351,090
1996	1,892	0	0	1,892	15,644	16	47	15,707	325,915	7,784	30,971	364,670
1997	1,932	0	0	1,932	15,972	13	44	16,028	332,735	6,255	28,846	367,835
1998	1,972	0	0	1,972	16,303	10	40	16,353	339,634	4,985	26,328	370,947
1999	2,013	0	0	2,013	16,638	8	35	16,681	346,608	3,932	23,373	373,912
2000	2,053	0	0	2,053	16,976	6	30	17,012	353,650	3,057	19,933	376,640
2001	2,095	0	0	2,095	17,316	5	26	17,347	360,753	2,332	17,009	380,094
2002	2,130	0	0	2,130	17,612	4	22	17,637	366,900	1,729	14,524	383,153
2003	2,166	0	0	2,166	17,903	3	19	17,924	372,965	1,229	12,412	386,605
2004	2,201	0	0	2,201	18,191	2	16	18,209	378,972	814	10,616	390,402
2005	2,235	0	0	2,235	18,476	1	14	18,491	384,905	470	9,090	394,465
		1988-1995 growth		2.8%		1988-1995 growth		2.7%		1988-1995 growth		1.6%
		forecast 96-2005 growth		1.9%		forecast 96-2005 growth		1.8%		forecast 96-2005 growth		0.6%

Table A4.5: Swaziland Residential Consumption Forecast: Conventional Fuels

Year	*Coal (T)*				*Paraffin (kl)*				*LPG (T)*				*Electricity (MWh)*			
	Rural	*Towns*	*Urban*	*All*	*Rural*	*Towns*	*Urban*	*All*	*Rural*	*Towns*	*Urban*	*All*	*Rural*	*Towns*	*Urban*	*All*
1985	26	29,267	1,547	30,841	1,040	268	1,009	2,317	44	68	74	186	5,295	21,518	51,643	78,456
1986	27	30,670	1,621	32,318	1,349	347	1,309	3,005	71	109	120	299	5,553	22,567	54,160	82,279
1987	28	32,140	1,699	33,867	1,604	413	1,556	3,573	110	170	186	466	5,764	23,427	56,225	85,416
1988	29	33,665	1,780	35,474	1,810	466	1,755	4,031	639	988	1,082	2,709	6,084	24,727	59,344	90,155
1989	30	35,247	1,864	37,141	2,191	564	2,125	4,879	737	1,140	1,247	3,124	7,239	29,422	70,613	107,275
1990	31	36,890	1,950	38,871	2,402	618	2,330	5,350	831	1,285	1,406	3,522	7,892	32,076	76,983	116,951
1991	32	38,596	2,041	40,669	2,134	549	2,070	4,753	587	908	993	2,488	8,667	35,225	84,540	128,432
1992	33	40,360	2,134	42,527	3,013	775	2,922	6,711	696	1,076	1,178	2,950	8,888	36,122	86,692	131,702
1993	34	42,192	2,231	44,457	2,815	724	2,730	6,269	753	1,165	1,275	3,193	9,571	38,896	93,351	141,818
1994	35	44,089	2,331	46,455	3,109	800	3,015	6,923	1,054	1,630	1,784	4,468	10,306	41,884	100,521	152,710
1995	36	46,055	2,435	48,526	2,826	727	2,741	6,294	1,471	2,276	2,490	6,237	11,097	45,101	108,242	164,440
1996	37	48,087	2,542	50,667	3,493	899	3,387	7,779	1,275	1,972	2,158	5,406	12,020	48,853	117,248	178,121
1997	38	50,209	2,655	52,901	3,702	953	3,590	8,245	1,403	2,170	2,374	5,947	12,982	52,761	126,627	192,371
1998	39	52,424	2,772	55,235	3,925	1,010	3,806	8,740	1,543	2,387	2,612	6,542	14,021	56,982	136,758	207,761
1999	40	54,737	2,894	57,671	4,160	1,070	4,034	9,265	1,698	2,625	2,873	7,196	15,142	61,541	147,698	224,382
2000	41	57,153	3,022	60,215	4,410	1,135	4,276	9,820	1,867	2,888	3,160	7,915	16,354	66,464	159,514	242,332
2001	41	59,674	3,155	62,871	4,674	1,203	4,533	10,410	2,054	3,177	3,476	8,707	17,662	71,781	172,275	261,719
2002	42	62,307	3,295	65,644	4,955	1,275	4,805	11,034	2,259	3,494	3,824	9,577	19,075	77,524	186,057	282,656
2003	43	65,056	3,440	68,540	5,252	1,351	5,093	11,696	2,485	3,844	4,206	10,535	20,601	83,726	200,942	305,269
2004	44	67,927	3,592	71,563	5,567	1,432	5,399	12,398	2,734	4,228	4,627	11,589	22,249	90,424	217,017	329,690
2005	45	70,924	3,751	74,720	5,901	1,518	5,723	13,142	3,007	4,651	5,090	12,748	24,029	97,658	234,379	356,065
			1988-1995 growth	4.6%			1988-1995 growth	6.6%			1988-1995 growth	12.7%			1988-1995 growth	9.0%
			forecast 96-2005 growth	4.4%			forecast 96-2005 growth	6.0%			forecast 96-2005 growth	10.0%			forecast 96-2005 growth	8.0%

LIST OF REPORTS ON COMPLETED ACTIVITIES

Region/Country	*Activity/Report Title*	*Date*	*Number*
	SUB-SAHARAN AFRICA (AFR)		
Africa Regional	Anglophone Africa Household Energy Workshop (English)	07/88	085/88
	Regional Power Seminar on Reducing Electric Power System Losses in Africa (English)	08/88	087/88
	Institutional Evaluation of EGL (English)	02/89	098/89
	Biomass Mapping Regional Workshops (English)	05/89	--
	Francophone Household Energy Workshop (French)	08/89	--
	Interafrican Electrical Engineering College: Proposals for Short- and Long-Term Development (English)	03/90	112/90
	Biomass Assessment and Mapping (English)	03/90	--
	Symposium on Power Sector Reform and Efficiency Improvement in Sub-Saharan Africa (English)	06/96	182/96
Angola	Energy Assessment (English and Portuguese)	05/89	4708-ANG
	Power Rehabilitation and Technical Assistance (English)	10/91	142/91
Benin	Energy Assessment (English and French)	06/85	5222-BEN
Botswana	Energy Assessment (English)	09/84	4998-BT
	Pump Electrification Prefeasibility Study (English)	01/86	047/86
	Review of Electricity Service Connection Policy (English)	07/87	071/87
	Tuli Block Farms Electrification Study (English)	07/87	072/87
	Household Energy Issues Study (English)	02/88	--
	Urban Household Energy Strategy Study (English)	05/91	132/91
Burkina Faso	Energy Assessment (English and French)	01/86	5730-BUR
	Technical Assistance Program (English)	03/86	052/86
	Urban Household Energy Strategy Study (English and French)	06/91	134/91
Burundi	Energy Assessment (English)	06/82	3778-BU
	Petroleum Supply Management (English)	01/84	012/84
	Status Report (English and French)	02/84	011/84
	Presentation of Energy Projects for the Fourth Five-Year Plan (1983-1987) (English and French)	05/85	036/85
	Improved Charcoal Cookstove Strategy (English and French)	09/85	042/85
	Peat Utilization Project (English)	11/85	046/85
	Energy Assessment (English and French)	01/92	9215-BU
Cape Verde	Energy Assessment (English and Portuguese)	08/84	5073-CV
	Household Energy Strategy Study (English)	02/90	110/90
Central African Republic	Energy Assessement (French)	08/92	9898-CAR
Chad	Elements of Strategy for Urban Household Energy The Case of N'djamena (French)	12/93	160/94
Comoros	Energy Assessment (English and French)	01/88	7104-COM
Congo	Energy Assessment (English)	01/88	6420-COB
	Power Development Plan (English and French)	03/90	106/90
Côte d'Ivoire	Energy Assessment (English and French)	04/85	5250-IVC
	Improved Biomass Utilization (English and French)	04/87	069/87
	Power System Efficiency Study (English)	12/87	--
	Power Sector Efficiency Study (French)	02/92	140/91
	Project of Energy Efficiency in Buildings (English)	09/95	175/95

Region/Country	*Activity/Report Title*	*Date*	*Number*
Ethiopia	Energy Assessment (English)	07/84	4741-ET
	Power System Efficiency Study (English)	10/85	045/85
	Agricultural Residue Briquetting Pilot Project (English)	12/86	062/86
	Bagasse Study (English)	12/86	063/86
	Cooking Efficiency Project (English)	12/87	--
	Energy Assessment (English)	02/96	179/96
Gabon	Energy Assessment (English)	07/88	6915-GA
The Gambia	Energy Assessment (English)	11/83	4743-GM
	Solar Water Heating Retrofit Project (English)	02/85	030/85
	Solar Photovoltaic Applications (English)	03/85	032/85
	Petroleum Supply Management Assistance (English)	04/85	035/85
Ghana	Energy Assessment (English)	11/86	6234-GH
	Energy Rationalization in the Industrial Sector (English)	06/88	084/88
	Sawmill Residues Utilization Study (English)	11/88	074/87
	Industrial Energy Efficiency (English)	11/92	148/92
Guinea	Energy Assessment (English)	11/86	6137-GUI
	Household Energy Strategy (English and French)	01/94	163/94
Guinea-Bissau	Energy Assessment (English and Portuguese)	08/84	5083-GUB
	Recommended Technical Assistance Projects (English & Portuguese)	04/85	033/85
	Management Options for the Electric Power and Water Supply Subsectors (English)	02/90	100/90
	Power and Water Institutional Restructuring (French)	04/91	118/91
Kenya	Energy Assessment (English)	05/82	3800-KE
	Power System Efficiency Study (English)	03/84	014/84
	Status Report (English)	05/84	016/84
	Coal Conversion Action Plan (English)	02/87	--
	Solar Water Heating Study (English)	02/87	066/87
	Peri-Urban Woodfuel Development (English)	10/87	076/87
	Power Master Plan (English)	11/87	--
	Power Loss Reduction Study (English)	09/96	186/96
Lesotho	Energy Assessment (English)	01/84	4676-LSO
Liberia	Energy Assessment (English)	12/84	5279-LBR
	Recommended Technical Assistance Projects (English)	06/85	038/85
	Power System Efficiency Study (English)	12/87	081/87
Madagascar	Energy Assessment (English)	01/87	5700-MAG
	Power System Efficiency Study (English and French)	12/87	075/87
	Environmental Impact of Woodfuels (French)	10/95	176/95
Malawi	Energy Assessment (English)	08/82	3903-MAL
	Technical Assistance to Improve the Efficiency of Fuelwood Use in the Tobacco Industry (English)	11/83	009/83
	Status Report (English)	01/84	013/84
Mali	Energy Assessment (English and French)	11/91	8423-MLI
	Household Energy Strategy (English and French)	03/92	147/92
Islamic Republic of Mauritania	Energy Assessment (English and French)	04/85	5224-MAU
	Household Energy Strategy Study (English and French)	07/90	123/90
Mauritius	Energy Assessment (English)	12/81	3510-MAS
	Status Report (English)	10/83	008/83
	Power System Efficiency Audit (English)	05/87	070/87

Region/Country	*Activity/Report Title*	*Date*	*Number*
Mauritius	Bagasse Power Potential (English)	10/87	077/87
	Energy Sector Review (English)	12/94	3643-MAS
Morocco	Energy Sector Institutional Development Study (English and French)	07/95	173/95
Mozambique	Energy Assessment (English)	01/87	6128-MOZ
	Household Electricity Utilization Study (English)	03/90	113/90
	Electricity Tariffs Study (English)	06/96	181/96
	Sample Survey of Low Voltage Electricity Customers	06/97	195/97
Namibia	Energy Assessment (English)	03/93	11320-NAM
Niger	Energy Assessment (French)	05/84	4642-NIR
	Status Report (English and French)	02/86	051/86
	Improved Stoves Project (English and French)	12/87	080/87
	Household Energy Conservation and Substitution (English and French)	01/88	082/88
Nigeria	Energy Assessment (English)	08/83	4440-UNI
	Energy Assessment (English)	07/93	11672-UNI
Rwanda	Energy Assessment (English)	06/82	3779-RW
	Status Report (English and French)	05/84	017/84
	Improved Charcoal Cookstove Strategy (English and French)	08/86	059/86
	Improved Charcoal Production Techniques (English and French)	02/87	065/87
	Energy Assessment (English and French)	07/91	8017-RW
	Commercialization of Improved Charcoal Stoves and Carbonization Techniques Mid-Term Progress Report (English and French)	12/91	141/91
SADC	SADC Regional Power Interconnection Study, Vols. I-IV (English)	12/93	--
SADCC	SADCC Regional Sector: Regional Capacity-Building Program for Energy Surveys and Policy Analysis (English)	11/91	--
Sao Tome and Principe	Energy Assessment (English)	10/85	5803-STP
Senegal	Energy Assessment (English)	07/83	4182-SE
	Status Report (English and French)	10/84	025/84
	Industrial Energy Conservation Study (English)	05/85	037/85
	Preparatory Assistance for Donor Meeting (English and French)	04/86	056/86
	Urban Household Energy Strategy (English)	02/89	096/89
	Industrial Energy Conservation Program (English)	05/94	165/94
Seychelles	Energy Assessment (English)	01/84	4693-SEY
	Electric Power System Efficiency Study (English)	08/84	021/84
Sierra Leone	Energy Assessment (English)	10/87	6597-SL
Somalia	Energy Assessment (English)	12/85	5796-SO
South Africa Republic of	Options for the Structure and Regulation of Natural Gas Industry (English)	05/95	172/95
Sudan	Management Assistance to the Ministry of Energy and Mining	05/83	003/83
	Energy Assessment (English)	07/83	4511-SU
	Power System Efficiency Study (English)	06/84	018/84
	Status Report (English)	11/84	026/84
	Wood Energy/Forestry Feasibility (English)	07/87	073/87
Swaziland	Energy Assessment (English)	02/87	6262-SW
	Household Energy Strategy Study	10/97	198/97
Tanzania	Energy Assessment (English)	11/84	4969-TA
	Peri-Urban Woodfuels Feasibility Study (English)	08/88	086/88
	Tobacco Curing Efficiency Study (English)	05/89	102/89
	Remote Sensing and Mapping of Woodlands (English)	06/90	--
	Industrial Energy Efficiency Technical Assistance (English)	08/90	122/90

Region/Country	*Activity/Report Title*	*Date*	*Number*
Togo	Energy Assessment (English)	06/85	5221-TO
	Wood Recovery in the Nangbeto Lake (English and French)	04/86	055/86
	Power Efficiency Improvement (English and French)	12/87	078/87
Uganda	Energy Assessment (English)	07/83	4453-UG
	Status Report (English)	08/84	020/84
	Institutional Review of the Energy Sector (English)	01/85	029/85
	Energy Efficiency in Tobacco Curing Industry (English)	02/86	049/86
	Fuelwood/Forestry Feasibility Study (English)	03/86	053/86
	Power System Efficiency Study (English)	12/88	092/88
	Energy Efficiency Improvement in the Brick and Tile Industry (English)	02/89	097/89
	Tobacco Curing Pilot Project (English)	03/89	UNDP Terminal Report
	Energy Assessment (English)	12/96	193/96
Zaire	Energy Assessment (English)	05/86	5837-ZR
Zambia	Energy Assessment (English)	01/83	4110-ZA
	Status Report (English)	08/85	039/85
	Energy Sector Institutional Review (English)	11/86	060/86
	Power Subsector Efficiency Study (English)	02/89	093/88
	Energy Strategy Study (English)	02/89	094/88
	Urban Household Energy Strategy Study (English)	08/90	121/90
Zimbabwe	Energy Assessment (English)	06/82	3765-ZIM
	Power System Efficiency Study (English)	06/83	005/83
	Status Report (English)	08/84	019/84
	Power Sector Management Assistance Project (English)	04/85	034/85
	Power Sector Management Institution Building (English)	09/89	--
	Petroleum Management Assistance (English)	12/89	109/89
	Charcoal Utilization Prefeasibility Study (English)	06/90	119/90
	Integrated Energy Strategy Evaluation (English)	01/92	8768-ZIM
	Energy Efficiency Technical Assistance Project: Strategic Framework for a National Energy Efficiency Improvement Program (English)	04/94	--
	Capacity Building for the National Energy Efficiency Improvement Programme (NEEIP) (English)	12/94	--

EAST ASIA AND PACIFIC (EAP)

Asia Regional	Pacific Household and Rural Energy Seminar (English)	11/90	--
China	County-Level Rural Energy Assessments (English)	05/89	101/89
	Fuelwood Forestry Preinvestment Study (English)	12/89	105/89
	Strategic Options for Power Sector Reform in China (English)	07/93	156/93
	Energy Efficiency and Pollution Control in Township and Village Enterprises (TVE) Industry (English)	11/94	168/94
	Energy for Rural Development in China: An Assessment Based on a Joint Chinese/ESMAP Study in Six Counties (English)	06/96	183/96
Fiji	Energy Assessment (English)	06/83	4462-FIJ
Indonesia	Energy Assessment (English)	11/81	3543-IND
	Status Report (English)	09/84	022/84
	Power Generation Efficiency Study (English)	02/86	050/86

Region/Country	*Activity/Report Title*	*Date*	*Number*
Indonesia	Energy Efficiency in the Brick, Tile and Lime Industries (English)	04/87	067/87
	Diesel Generating Plant Efficiency Study (English)	12/88	095/88
	Urban Household Energy Strategy Study (English)	02/90	107/90
	Biomass Gasifier Preinvestment Study Vols. I & II (English)	12/90	124/90
	Prospects for Biomass Power Generation with Emphasis on Palm Oil, Sugar, Rubberwood and Plywood Residues (English)	11/94	167/94
Lao PDR	Urban Electricity Demand Assessment Study (English)	03/93	154/93
Malaysia	Sabah Power System Efficiency Study (English)	03/87	068/87
	Gas Utilization Study (English)	09/91	9645-MA
Myanmar	Energy Assessment (English)	06/85	5416-BA
Papua New Guinea	Energy Assessment (English)	06/82	3882-PNG
	Status Report (English)	07/83	006/83
	Energy Strategy Paper (English)	--	--
	Institutional Review in the Energy Sector (English)	10/84	023/84
	Power Tariff Study (English)	10/84	024/84
Philippines	Commercial Potential for Power Production from Agricultural Residues (English)	12/93	157/93
	Energy Conservation Study (English)	08/94	--
Solomon Islands	Energy Assessment (English)	06/83	4404-SOL
	Energy Assessment (English)	01/92	979-SOL
South Pacific	Petroleum Transport in the South Pacific (English)	05/86	--
Thailand	Energy Assessment (English)	09/85	5793-TH
	Rural Energy Issues and Options (English)	09/85	044/85
	Accelerated Dissemination of Improved Stoves and Charcoal Kilns (English)	09/87	079/87
	Northeast Region Village Forestry and Woodfuels Preinvestment Study (English)	02/88	083/88
	Impact of Lower Oil Prices (English)	08/88	--
	Coal Development and Utilization Study (English)	10/89	--
Tonga	Energy Assessment (English)	06/85	5498-TON
Vanuatu	Energy Assessment (English)	06/85	5577-VA
Vietnam	Rural and Household Energy-Issues and Options (English)	01/94	161/94
	Power Sector Reform and Restructuring in Vietnam: Final Report to the Steering Committee (English and Vietnamese)	09/95	174/95
	Household Energy Technical Assistance: Improved Coal Briquetting and Commercialized Dissemination of Higher Efficiency Biomass and Coal Stoves (English)	01/96	178/96
Western Samoa	Energy Assessment (English)	06/85	5497-WSO

SOUTH ASIA (SAS)

Bangladesh	Energy Assessment (English)	10/82	3873-BD
	Priority Investment Program (English)	05/83	002/83
	Status Report (English)	04/84	015/84
	Power System Efficiency Study (English)	02/85	031/85
	Small Scale Uses of Gas Prefeasibility Study (English)	12/88	--
India	Opportunities for Commercialization of Nonconventional Energy Systems (English)	11/88	091/88

Region/Country	*Activity/Report Title*	*Date*	*Number*
India	Maharashtra Bagasse Energy Efficiency Project (English)	07/90	120/90
	Mini-Hydro Development on Irrigation Dams and Canal Drops Vols. I, II and III (English)	07/91	139/91
	WindFarm Pre-Investment Study (English)	12/92	150/92
	Power Sector Reform Seminar (English)	04/94	166/94
Nepal	Energy Assessment (English)	08/83	4474-NEP
	Status Report (English)	01/85	028/84
	Energy Efficiency & Fuel Substitution in Industries (English)	06/93	158/93
Pakistan	Household Energy Assessment (English)	05/88	--
	Assessment of Photovoltaic Programs, Applications, and Markets (English)	10/89	103/89
	National Household Energy Survey and Strategy Formulation Study: Project Terminal Report (English)	03/94	--
	Managing the Energy Transition (English)	10/94	--
	Lighting Efficiency Improvement Program Phase 1: Commercial Buildings Five Year Plan (English)	10/94	--
Sri Lanka	Energy Assessment (English)	05/82	3792-CE
	Power System Loss Reduction Study (English)	07/83	007/83
	Status Report (English)	01/84	010/84
	Industrial Energy Conservation Study (English)	03/86	054/86

EUROPE AND CENTRAL ASIA (ECA)

Bulgaria	Natural Gas Policies and Issues (English)	10/96	188/96
Central and Eastern Europe	Power Sector Reform in Selected Countries	07/97	196/97
Eastern Europe	The Future of Natural Gas in Eastern Europe (English)	08/92	149/92
Kazakhstan and Kyrgyzstan	Opportunities for Renewable Energy Development	11/97	16855-KAZ
Kazakhstan	Natural Gas Investment Strategy Study, Volumes 1, 2 and 3	12/97	199/97
Poland	Energy Sector Restructuring Program Vols. I-V (English)	01/93	153/93
Portugal	Energy Assessment (English)	04/84	4824-PO
Romania	Natural Gas Development Strategy (English)	12/96	192/96
Turkey	Energy Assessment (English)	03/83	3877-TU

MIDDLE EAST AND NORTH AFRICA (MNA)

Arab Republic of Egypt	Energy Assessment (English)	10/96	189/96
Morocco	Energy Assessment (English and French)	03/84	4157-MOR
	Status Report (English and French)	01/86	048/86
	Energy Sector Institutional Development Study (English and French)	05/95	173/95
Syria	Energy Assessment (English)	05/86	5822-SYR
	Electric Power Efficiency Study (English)	09/88	089/88
	Energy Efficiency Improvement in the Cement Sector (English)	04/89	099/89
	Energy Efficiency Improvement in the Fertilizer Sector (English)	06/90	115/90

Region/Country	*Activity/Report Title*	*Date*	*Number*
Tunisia	Fuel Substitution (English and French)	03/90	--
	Power Efficiency Study (English and French)	02/92	136/91
	Energy Management Strategy in the Residential and Tertiary Sectors (English)	04/92	146/92
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