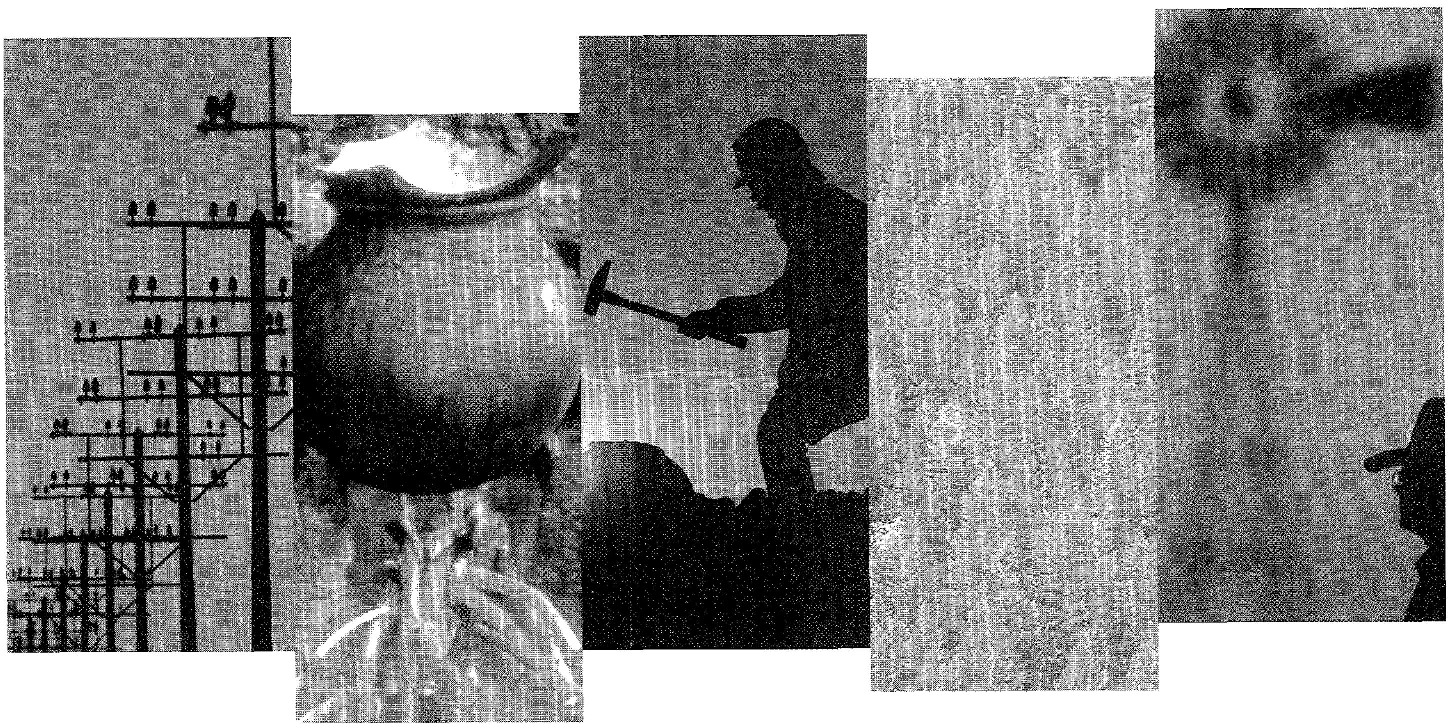
Uganda

Rural Electrification Strategy Study

ESM221
September 1999



Energy

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Management

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Programme

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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 as part of the World Bank's Energy, Mining and Telecommunications Department. ESMAP provides advice to governments on sustainable energy development. Established with the support of UNDP and bilateral official donors in 1983, it focuses on the role of energy in the development process with the objective of contributing to poverty alleviation, improving living conditions and preserving the environment in developing countries and transition economies. ESMAP centers its interventions on three priority areas: sector reform and restructuring; access to modern energy for the poorest; and promotion of sustainable energy practices.

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UGANDA: Rural Electrification Strategy Study

September 1999

Joint UNDP/World Bank Energy Sector Management Assistance Programme
(ESMAP)

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Figures and Tables

Preface

This report is based on the findings of a series of World Bank missions to Uganda conducted from September 1995 through September 1997 as part of the ESMAP Rural Electrification Strategy Study. The missions' purpose was to assist the Ministry of Energy and Mineral Development (MEMD) in formulating a comprehensive national strategy for rural electrification. Although much public attention goes to the performance of the Uganda Electricity Board (UEB) in urban areas, very little is known about events in the field of rural electrification. This study evaluates progress, identifies barriers, and proposes solutions to accelerate access to electricity for rural people. Because the study's initial results deviated far from commonly accepted knowledge, they led to much discussion among representatives of the Ugandan Government, the private sector, NGOs, and donor organizations, causing considerable delays in finalizing the report. This was time well spent, however, as it allowed for rural electrification issues to be put on the Ugandan policy agenda.

Acknowledgments

The team is grateful to all those who assisted with this study. The Permanent Secretary for Energy in the Ministry of Energy and Mineral Development, Mr. Fred Kabagambe-Kaliisa, provided continual support and encouragement. Mr. Godfrey Turyahikayo, Commissioner for Energy, had overall responsibility for all facets of this study. He led the local team, supervised the consultants, and provided extensive and invaluable input into the design, implementation, analysis and write-up of this report. His staff at the Energy Department—particularly Ms. Cecilia Nakiranda, Mr. Paul Mubiru, Mr. John Tumuhibise, Mr. M. Bangi, and Mr. Turyahabwe Elsam—contributed extensively to the design, field surveys, and analysis of this study. Messrs. Arsen Mbonye and Henri Bidasala supervised the demand surveys. Mr. E. Hatanga of the Energy Department, who sadly passed away during the course of this study, also contributed considerably to the study.

Many representatives of the private sector and government gave generously of their time and resources. In particular, the team would like to thank the many district officials, the district officers, district agriculture and forest officers, and other district representatives who gave the team information, guidance, and assistance. The team is especially grateful to the Uganda Manufacturers Association, the Uganda Coffee Development Authority, the Uganda Tea Growers Association, the Hima and Tororo Cement Factories, the Madhvani Group, British American Tobacco, the Uganda Revenue Authority, the Ministry of Local Government, the Statistics Department (and other departments within the Ministry of Finance and Economic Planning), the Uganda Investment Authority, Incafex Solar (U) Ltd, Solar Energy for Africa, and many others for their time and support.

Mike Bess of Energy for Sustainable Development (ESD) Ltd. served as external consultant to this study, assisted by Messrs. Cornelius Kazoora and Arthur Mugyenzi of the Sustainable Development Centre. Other external consultants were Mr. Voravate Tig Tuntivate (on the demand surveys) and Sunil Mathrani (on power sector aspects). Mr. Tuntivate and the Energy Department staff prepared the detailed rural and peri-urban study that forms much of the background to this overall report. Mr. Robert van der Plas of the World Bank's Energy Sector Management Assistance Programme (ESMAP) supervised the overall study.

Abbreviations and Acronyms

avg	Average
BAT	British American Tobacco Company
CDC	Commonwealth Development Corporation (UK)
cif	Cost, insurance, and freight
COU	Church of Uganda
DAO	District Agriculture Officer
DFID	Department for International Development (ex-ODA) of the UK Government
DFO	District Forest Officer
EC	European Commission
ESMAP	Energy Sector Management and Assistance Programme (UNDP/World Bank)
EU	European Union
FAO	Food and Agriculture Organization
FD	Forest Department (MEMD)
fob	Free on board
genset	Small diesel and petrol/gasoline generators
GOU	Government of Uganda
hh	Household
IBRD	International Bank for Reconstruction and Development (World Bank)
KFW	Kreditanstalt für Wiederaufbau (German Agency for Reconstruction and Development)
MAAIFP	Ministry of Agriculture, Animal Industry and Fish Production
MCIC	Ministry of Commerce, Industry and Co-operatives
MEMD	Ministry of Energy and Mineral Developments
MFPED	Ministry of Finance, Planning and Economic Development
MLG	Ministry of Local Government
MNRE	Ministry of Natural Resources and Environment (formerly MNR)
MOH	Ministry of Health
MTWA	Ministry of Tourism, Wildlife and Antiquities
NGO	Non-Governmental Organization
NORAD	Norwegian Agency for International Development
ODA	Overseas Development Administration (now DFID) of the UK Government
pa	Per annum
PDRD	People's Democratic Republic of Korea
PFO	Principal Forest Officer
SDC	Sustainable Development Centre
SIDA	Swedish International Development Agency
sli	Start, light, ignition (type of lead-acid car battery)
UCDA	Uganda Coffee Development Authority

UEB	Uganda Electricity Board (MNRE)
UIA	Uganda Investment Authority
UMA	Uganda Manufacturers Association
UNDP	United Nations Development Programme
UNTCD	United Nations Technical Co-operation Department
USP	Uganda Power System
UPT	Uganda Posts and Telecommunications
URA	Uganda Revenue Authority
USAID	United States Agency for International Development
USh	Uganda shilling
USTDA	United States Trade and Development Agency
UTGA	Uganda Tea Growers Association

Units of Measure

g	Gram
GJ	Gigajoule (1,000 million joules = 10^9 joules)
GW	Gigawatt (1,000 million watts = 10^9 watts)
GWh	Gigawatt-hour (= one thousand million [10^9]watt hours)
hp	Horsepower
Joule	Amount of energy to move 9.81 kg one meter
kcal	Kilocalorie (1,000 calories)
kg	Kilogram (1,000 grams)
kVA	Kilovolt-ampere
kW	Kilowatt (1,000 watts)
kWh	Kilowatt-hour (1,000 watt-hours)
m	Meter
MJ	Megajoule (1 million joules = 10^6 joules)
MT	Metric ton (1,000 kg)
MW	Megawatt (1 million watts = 10^6 watts)
MWh	Megawatt-hour (= 10^6 watt hours)
TJ	Terajoule (one million megajoules)
Wp	Watts peak

Comparative Measures

1m^3 stacked =	0.7 m^3 solid wood
1m^3 solid =	600 kilograms (0.6 metric tons)
1m^3 stacked =	420 kilograms (0.42 metric tons)
1 kg wood =	15 megajoules (air-dried)
1 kg charcoal =	30 megajoules

Currency Equivalents

as of September 1997

1000 Uganda Shillings = US$0.952
USh 1050 = US$1

Executive Summary

1. Uganda offers planners, policy makers, governments, donors, and utilities a surprising and exciting new perspective on rural electrification. Rural people in Uganda currently pay high prices for a limited and inefficient supply of modern energy, particularly for electricity. The results of this study show that fairly high levels of rural electrification can be achieved in the absence of both major government or donor intervention and national utility investments. This experience in turn suggests that new approaches to rural electrification can be developed that considerably accelerate the rate of access to electricity in rural Africa.

2. Rural and peri-urban Ugandans use several forms of energy to make up for the lack of access to grid electricity, and they pay large sums of money for this "privilege." Virtually every household uses kerosene for lighting: 100 percent of the 2000 households in the survey were found to use about USh5000 worth of kerosene per month.[1] The most basic electricity needs are met by dry-cell batteries (ordinary, disposable alkaline batteries), and this study shows that 94 percent of the survey sample use them and pay USh6000 per month. Ugandans probably spend more than US$100 million per year[2] on these batteries to power their radios, cassette players, and flashlights, for an average of US$72 per household (equivalent to a "tariff" of US$400 per kilowatt-hour). This fact alone demonstrates a tremendous willingness to pay for basic electricity, and represents a major item of rural household expenditure.

3. Of the Ugandan households in the survey sample that are not connected to the grid, about 9 percent—nearly 5 percent of all rural households in the 12 districts—own and operate lead-acid (car) batteries to power their TVs and lights, and spend about USh10,900 on them (an annual cost of about $120, including costs for charging, transport to the charging station, and the amortization costs of the battery, for an average of US$3.0 per kilowatt-hour). Today, there are probably about an equal number of Ugandans with a grid connection as with a car battery for their electricity supply.[2] Many Ugandan firms have purchased their own generating sets, have installed the equivalent of one-third of the capacity of the national utility (more than 60 megawatts), and spend nearly US$19 million annually to generate more than 100 gigawatt-hours per year (an average of US$0.19 per kilowatt-hour).

4. This clearly shows rural people's great desire to enjoy the same benefits of electricity that urban people so easily take for granted. It also demonstrates their willingness and ability to mobilize finances to make substantial investments and sacrifices to gain access to that electricity.

5. The implications of this are far-reaching. In a more supportive environment, it is likely that more cost-effective, economically and financially viable means could be found to accelerate rural electrification rates. This would likely yield great social and economic gains in part because of the benefit to local businesses: one-half of all imported generators are put to economic

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[1] These are the results of the 2000-household energy demand survey. Targeting prime areas for rural electrification, the survey covered about an equal number of peri-urban and rural households in trading centers and villages along roads that are accessible all year. The survey covered 12 districts where 46 percent of all nonelectrified Ugandan households are located. The survey is statistically representative for about 550,000 households in these 12 districts, or 47 percent of the total nonelectrified households in these districts.

[2] See Annex B for extrapolation details.

use running agro-processing plants, mills, dairies, and light industries and powering restaurants, hotels, and a wide range of other services, thereby creating employment in rural and peri-urban areas.

6. In 1986, few rural Ugandans had access to electricity. Currently, nearly one-tenth of the rural population can light their homes, listen to the radio, and watch television, without government or donors having spent one dollar on electrification. The challenge now is to fashion an institutional structure that will accelerate and strengthen these developments without dampening this individual drive and spirit. This cannot be done in isolation and must be developed in close collaboration with the power sector reform efforts.[3] In particular,

- The government should
  - Liberalize the electricity sector to permit qualified operators to generate electricity in rural and peri-urban areas and sell it to third parties at mutually agreed prices;
  - Allow the national grid to be used for the transport of electricity, for a reasonable fee, to enable generators to sell to willing buyers at any location;
  - Work with district governments and private investors to define the best framework for developing group or collective electricity systems that rationalizes electricity generation to reach larger numbers of people more quickly;
  - Provide tax and other fiscal incentives to investors to invest in the electricity generation system, with special incentives to those investors and NGOs who finance systems providing electricity to groups of consumers rather than only to individuals (i.e., finance the creation of utilities); and
- Donors should provide technical assistance and support to promote the development and private investment in the rural electricity supply, including alternative energy sources for electricity—particularly small-hydropower, biomass, solar, and wind energy.

7. For this to occur, Uganda needs a better institutional framework to promote, support, and accelerate rural electrification. The ideal institutional framework would:

- Provide a supportive, regulatory role in rural, decentralized electricity development by
  - Developing "rules of the game" for rural electrification, including defining the roles each set of stakeholders should play, and under what conditions;
  - Playing the arbitrator between competing interests to ensure the rules of the game are followed, and that the market stays open and receptive to new investors, particularly small-scale investors;
  - Monitoring and evaluating the progress of development in the sector, and promote the "success stories" so that others can learn from them;
- Serve as a channel for national, international and private technical assistance and training for investors, consumers and other key stakeholders in the rural, off-grid electricity sector by
  - Serving as a clearinghouse for investors and consumers by providing them with key information (financial, legislative, legal, licensing, etc.) on how to participate in the development of the rural off-grid sector;

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[3] These changes are incorporated in the proposed Electricity Law.

  - Providing the public with information on how they can participate in the sector's development, what their rights are in the sector, as well as their responsibilities;

- Promote rural electrification to international donors and investors to raise capital and investment for rural electrification. It would give banks and financial institutions the confidence and support necessary to play their role of raising capital for financing the sector.

8. This framework could take a number of forms. Experience in other countries suggests that it would be best if key stakeholders and players in the system were to form an autonomous, private, "rural electricity support unit" or "national rural electrification association." Local and international donors and investors could play an important role in the creation of this institution.

9. Such a (small) unit would work closely with the Ministry of Energy and Mineral Development's Energy Department and UEB, but would be as autonomously as possible. It's main objective is to promote and facilitate rural electrification. It will identify bankable projects and bring appropriate partners (beneficiaries, private firms, financial institutions, Government Agencies, donors) to the table for the realization of these projects. It will also bring appropriate partners together in case of activities that are not bankable but fully financed by donors or the government (i.e. subsidized projects or programs).

10. The challenge is to harness Ugandans' demonstrated dynamic initiative into more collective, group activities (e.g., private utilities, mini-grids, decentralized charging stations using renewable energy and hybrid systems) without stifling their individualistic and autonomous enthusiasm for self-improvement. Government should be encouraged to help establish the institutional framework to promote private initiatives and investments, decentralized development, and regulation of electricity that suits a multitude of geographic and economic situations, rather than being set for one unified system—as is the case today.

11. Ugandans have demonstrated they can independently harness tremendous resources to electrify their rural areas. The challenge now is to help them channel their resources and energies more efficiently and collectively by furnishing them with institutional and other forms of support. They will then succeed in electrifying their off-grid areas much more quickly and at a much lower costs to consumer and country. Although this is technically and financially feasible, it will require substantial institutional capacity-building.

1

Introduction

1.1 Uganda provides an excellent example of how people, when faced with major constraints in the provision of, and access to, electricity, find their own ways to meet their growing demands. With less than 5 percent of Uganda's population connected to the electricity grid, and with the national utility unable to meet rapidly growing urban demand, rural and peri-urban Ugandans have taken electrification into their own hands.

1.2 Today, probably as many Ugandans are "electrified" through the use of lead-acid batteries, small diesel and petrol[4] generators (gensets), and photovoltaic systems as are connected to the national grid. Ugandan households and businesses have imported, and use, well over 60 megawatts of private generating plants, representing almost one-third of the Uganda Electricity Board's[5] (UEB) total installed hydroelectric and diesel generating capacity.[6]

1.3 About 9 percent of non-grid connected, rural and peri-urban households in peri-urban areas and in rural trading centers and surrounding villages have invested in lead-acid SLI[7] batteries for their electricity needs. In these areas, ten times as many Ugandans are electrified through these means as are supplied by UEB. Twice as many rural industries generate their own electricity as take it from the grid. Ten times as many rural enterprises (from sawmills to rural hotels, shops, and other service establishments) supply their own electricity as take it from the grid. These are the positive aspects of Uganda's rural electrification, demonstrating that people, through their own initiatives and means, are willing and able to mobilize their own financial and technical resources to realize the benefits of rural electrification without government or donor support or initiatives.

1.4 This has occurred in an *ad hoc*, independent, totally unplanned manner (from a government or utility perspective). Uganda's rapid rural electrification has taken place through hundreds of thousands of individual investments. Virtually no collective rural electrification, such as mini-grids or small utilities, has taken place. This has resulted in oversizing of generators to meet

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4 *Petrol* is gasoline.

5 The national electricity company.

6 The MNRE estimates that more than 80 megawatts of private diesel and petrol generators is in use in Uganda (MNRE, October 1997). The current study was able to review Uganda Revenue Authority (URA) import statistics for mid-1993 to mid-1997. These show that some 60 megawatts, representing more than US$20 million, of petrol and diesel generators were imported during that period. It is safe to assume, then, that at least another 10-20 megawatts of generators were imported both before and after this period.

7 Start, light, ignition.

individual needs: more often than not, consumers buy generators that are available rather than order them from abroad to meet their specific energy requirements.

1.5 This results in consumers with surplus generation capacity "wasting" their surplus electricity instead of selling it to neighbors—who, because they need electricity, often buy their own oversized generator. Repeated hundreds of times, these decisions are sub-optimal from both an individual's and the nation's point of view. Interviews and work carried out in the three urban areas of Kampala, Jinja, and Entebbe show that at least 20 megawatts and perhaps as much as 30 megawatts of capacity is underutilized by the industries that have purchased their generators. At least 5 megawatts of capacity in rural and small urban areas is unused due to oversizing and lack of sales of surplus electricity to potential consumers.

1.6 The economic and financial costs for autonomous rural electrification are high. At considerable foreign-exchange expense, Ugandans have brought into the country thousands of relatively small generating sets (representing several tens of millions of US dollars in investment), the spare parts for those generators (also representing millions of dollars), the diesel fuel and petrol necessary to run those gensets, and the components for hundreds of thousands of batteries. These imports alone have cost Uganda more than US$30 million in capital and more than US$15 million in fuel since 1993. Ugandans using their own gensets pay from twice to seven times as much for electricity as their counterparts fortunate enough to be connected to the UEB grid. Ugandans using their own SLI batteries pay from 15 to 30 times as much per kilowatt-hour for their electricity as those connected to the UEB.

1.7 Electricity is currently generated and used only for internal consumption by these autonomous producers. At present, the legislative framework does not allow them to supply other users, even if these were willing to bear the costs of tariffs higher than UEB's. The legislative framework is under study, and the Ministry of Natural Resources and Environment (MNRE) has proposed the text of a revised electricity law; the ESMAP study provided valuable inputs into this document in that it raised awareness of the nature and magnitude of the problem. The ability to change this framework to one that is more rational rests almost entirely with government. In order to facilitate rural electrification, this framework must be improved.

1.8 With government and external support supplying such a framework to encourage and accelerate private investment in rural electrification, a win-win situation could prevail. National benefits would increase, while private benefits would be expanded. The government is moving rapidly in this direction through liberalization of the electricity market and restructuring of the UEB. More thought is needed, however, on how best to formulate a strategy that involves consumers, local authorities, industries, and business.

1.9 This report has been prepared with the Department of Energy of the Ministry of Energy and Mineral Development, the Sustainable Development Centre of Kampala, Energy for Sustainable Development of the UK, and the World Bank. It offers supply and demand profiles and analyses of Uganda's current and historical rural electrification, and it proposes a framework for accelerating rural electrification efforts, with reduced costs to households and the nation.

Study Methodology

1.10 The ESMAP Rural Electrification Strategy Study was carried out in two primary stages. The first, carried out in late 1996, consisted of a series of detailed rural and peri-urban demand side surveys covering 2,000 households. The second consisted of a series of supply side surveys carried out in late 1996 and throughout 1997. The supply surveys included visits to twelve districts to interview private generators, equipment suppliers, equipment distributors, electricity consumers, representatives from many different urban and rural industries and enterprises, and government officials at all levels.

Demand Survey and Demand Assessment Methodology

1.11 The energy demand survey was conducted using a multi-stage, random sampling process. Data collection began in October 1996 and was completed in November 1996. A total of 2,000 nonelectrified rural households were sampled, of which 984 households were from trading centers/towns (peri-urban areas) and 1,016 households from surrounding rural villages. (See Annex B for more details about the survey sample.) The survey set out to determine

- The type and quantity of lighting energy and electricity sources used and
- The associated monthly spending patterns of nonelectrified peri-urban and rural households in areas where there is good potential for a renewable energy market and other modes of rural electrification (grid, mini/micro/isolated grid, and non-grid electrification).

1.12 Twelve districts were selected for their presumed potential for renewable energy and rural electrification applications. Selection was based on prior knowledge regarding the general characteristics of the districts, including population density, agricultural activities, and the socioeconomic characteristics. Survey areas selected within these districts were trading centers/towns (peri-urban) and surrounding rural villages accessible by four-wheel-drive vehicles using either tarmac, secondary, or other road. These areas are considered to have better potential for accelerating access to rural electrification than areas that are not accessible by car because of their accessibility and commerce. Therefore, the survey targeted only households in these areas.

1.13 The primary objectives of the survey were to:

- Develop an information base and profile sketch of non-electrified rural households, including their preferences for, their willingness and ability to pay for, and their awareness of alternative electricity services and supply options;
- Identify the costs of existing energy services and compare these with other supply options; and
- Analyze the financial implications to households of rural electrification options to determine what electrification steps could be taken to maintain or improve those households' standards of living.

1.14 The results of the survey are astonishing, particularly the extent to which (1) the rural economy is cash-based and (2) people are spending money on modern energy services. These findings are discussed throughout this report.[8]

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8 The results of this survey are contained in Voravate Tig Tuntivate (1998).

Supply Surveys and Supply Assessment Methodology

1.15 The supply study utilized several means for assessing both current non-grid electricity generation and the resource potential for non-grid and "alternative energy" electricity generation. Data were collected from the Statistics Department, the Ministry of Finance and Economic Planning (MFEP), the Department of Energy, the Forest Department, the Meteorological Department, the Uganda Revenue Authority (URA), the Ministry for Local Government, the Ministry of Health (MoH), and a variety of other public sources.

1.16 The survey team conducted interviews with industrialists and private entrepreneurs through the Uganda Manufacturers Association (UMA), first by telephone and then in face-to-face interviews with a stratified sample of these businessmen and -women. Major electrical equipment suppliers and distributors were interviewed. The private petroleum companies supplied information on petroleum imports, distribution, and prices. The URA, suppliers, and manufacturers furnished statistics on battery imports and manufacturing. Finally, the supply side team visited twelve districts to interview people in the main productive economic sectors: agriculture, saw milling, coffee processing, rice processing, sugar industry, cotton industry, and tea. Visits were made to farms, factories, processing plants, mines, church missions, UEB stations, and others. District officials from all departments were interviewed extensively in all twelve districts. There was tremendous support from all parties involved, and a wealth of information was provided and collected.

1.17 One of the primary areas of concentration for the study was in the field of diesel and petrol generators. Previous work had shown that a fairly large number of diesel and petrol generators (gensets) had been imported into Uganda over the past several years. However, prior to the supply study, no figures were available to determine how widespread this was. The team adopted a multi-pronged approach to defining the non-grid petroleum-driven generating capacity in Uganda. It first went to the URA to obtain import statistics on the volume and costs of imports, and to identify the major importers of gensets. Simultaneous to the petroleum generator surveys, the supply team collected data on a number of other existing and potential electricity generation sources. Secondary materials were utilized to obtain rough estimates for the use of small-hydropower, solar, biomass, wind, geothermal, and other sources of energy for current and potentially future generation of electricity.

1.18 Second, the team interviewed major importers to determine the volume of imports, who was purchasing the gensets, and the issues surrounding the importation and use of gensets. In addition, it visited 33 establishments in 12 districts to identify the reasons for using gensets. These interviews were also intended to provide a much deeper qualitative understanding of the business, and the reasons behind imports. Further, these interviews were designed to verify information obtained from official statistics.

1.19 Third, the team interviewed UEB officials in order to obtain their perspectives on petroleum generator imports and use. This involved developing a profile of UEB's own petroleum genset use and history of use, and the issues surrounding that. Finally, the team also interviewed genset owners and operators. A detailed questionnaire and survey methodology was designed for the surveys and administered to the respondents. (See Annex C for more details on the supply side survey and Annex D for details on the supply resource survey.)

1.20 Uganda was once one of Africa's most developed economies, with a thriving cash-crop–led agricultural sector and a rapidly growing industrial and tertiary base. However, 15 years of civil upheaval set Uganda's economy back many years. Years of no investment or under-investment in the country's energy infrastructure has left Uganda with a tremendous shortfall of energy in the face of rapidly growing demand stemming from Uganda's recent rapid economic and social recovery. Large investments in traditional electricity generation and transmission are required to meet current urban demand.

1.21 Rural demand, which the government has only recently begun to address, would require similarly massive investments. This report explores alternative scenarios for meeting rural electricity demand. Chapter 2 discusses current rural demand for and supply of electricity. Chapter 3 evaluates the different electricity supply options, and Chapter 4 discusses required support from the various stakeholders. Chapter 5 discusses the costs and benefits of the various alternative scenarios, and Chapter 6 recommends ways to develop the most promising scenarios.

2

Overview of Rural Electrification Issues and Options

2.1 This chapter discusses the current state of affairs in Uganda with regard to (1) demand for and (2) supply of off-grid electricity.

Current Off-Grid Demand Profile

2.2 Uganda faces significant constraints to its continued rapid economic recovery because of the lack of adequate electrical power to meet economic and social demand. Less than 5 percent of Uganda's population is served by the Uganda Electricity Board (UEB), the national state utility that maintains and operates the national grid and several isolated diesel power stations in the country (see Table 2-1). Whereas approximately 20 percent of Uganda's urban population is connected to UEB's grid, less than 1 percent of all rural dwellers are connected. Even worse, the percentage of people connected to the grid decreases with every year because of Uganda's rapid population growth and UEB's inability to keep up with the existing system. More than 50 percent of urban Ugandans were connected to UEB in 1970, compared to 18 percent today.

Table 2-1. Urban and Rural Households Connected to the UEB Grid, 1997

Location	*Connections*	*Number of households*	*% households connected*
Kampala, Entebbe, and Jinja Connections	77,000	363,000	21
Other urban connections	49,000	343,000	14.2
Rural connections	14,000	3,461,000	0.0041
Total connections	140,000	4,167,000	3.4

Source: MFEP, Statistics Department. 1991 Census, updated, and adjusted 1997.

2.3 Uganda, like most African countries, is predominantly rural and agrarian. Just over 85 percent of Uganda's population resides in rural areas (approximately 83 percent of all households).[9] Fewer than 15,000 rural households are connected to the grid, or considerably less than 1 percent of Uganda's rural population. Approximately 17 percent of all Ugandan households are located in urban areas. Less than one-fifth of these urban households are connected to the grid. Most of these grid connections are in Kampala, which accounts for more than 50 percent of all grid connections (including those for households, industries, and commercial establishments).

2.4 The demand survey showed that rural households in the survey areas pay, on average, more than US$6 per month for dry-cell batteries (ordinary, disposable alkaline batteries) for torches, radios, and cassette players. This represents slightly more than 4 percent of the entire monthly expenditure for the average surveyed household. If one assumes that households in other areas use dry-cells to a much lesser extent (see Annex B), this would imply that rural households spent the equivalent of more than US$100 million on dry-cell batteries in 1995. However, there is no hard survey data for areas located far from the main roads, and the battery consumption level there needs to be verified. In any case, several hundred million dry-cell batteries[10] were purchased in 1995 for the simplest form of rural electrification. Most of these batteries ended up being thrown away, and thus may pose a serious health and environmental risk.

2.5 For the approximately 9 percent of surveyed households who own and use lead-acid SLI batteries, expenditures are on the order of US$10 per month, or 6.7 percent of their mean monthly incomes (additional to the use of dry-cells, kerosene, or other non-grid energy). The survey found that there are at least 44,000 batteries in use among the 550,000 households represented in the 12 districts. It is estimated that some 100,000 peri-urban and rural households in Uganda use SLI batteries for electrification (See Annex B for extrapolation). This assumes that no SLI batteries are used outside areas covered by the main roads. The total expenditures on SLI batteries (including charging, transport, and capital depreciation) is about US$10 million per annum.[11] Households that use both SLI batteries and dry-cells for rural electrification (approximately 4.3 percent of rural households) spend US$16 per month, or approximately US$192 per year, on electricity.

2.6 The demand survey did not study urban households. With only 126,000 urban households connected to UEB's grid, this implies that not more than 21 percent of Kampala's households are connected (see Table 2-1), and probably less than 15 percent of all other urban dwellers in the rest of the country. If 4 percent of the rural and peri-urban households are using SLI batteries, this would imply that, at a minimum, another 100,00 households in Uganda enjoy electricity services.

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9 There are 2,829,000 urban Ugandans (14.3 percent) and 16,957,000 rural (85.7 percent); there are 707,000 urban households (16.9 percent) and 3,461,000 rural (83.1 percent). (Ministry of Finance and Economic Planning, 1991 Census.)

10 Average price of a battery: US$0.30.

11 One would expect this number to be much higher: more than 80 percent of all urban residents are not connected to the UEB grid, and many should be expected also to be using SLI batteries for electrification. This was also not covered by the survey.

2.7 As Table 2-2 shows, household expenditure on SLI batteries for basic electricity services is as much as UEB customers pay.[12] However, households connected to the UEB grid consumed between 673 to 1,310 kilowatt-hour per annum, compared to households using SLI batteries who consumed 40 kilowatt-hour per annum. They pay the equivalent of US$3.00 per kilowatt-hour, or 30 times as much as their grid-connected counterparts (conversely, they consume one-thirtieth as much per capita as grid-connected households).

Table 2-2. Some Grid Electricity Statistics (1995 UEB Sales)

UEB electricity sales (GWh 1995)	488
Percent UEB load that is residential	55.0%
UEB residential consumption (GWh)	268
Total UEB residential consumers (MNRE)[a]	148,000
Proportion urban UEB residential consumers (MNRE)	90.0%
Urban UEB electricity consumption (1995 GWh, MNRE)	228.1
Per household UEB consumption (kWh 1995, MNRE)	1,310.3
Average price paid by residential consumer per kWh (1995)	$0.10
Urban residential expenditures for UEB (US$millions, 1995, MNRE)	$22.8
Per household expenditures for UEB (US$ in 1995, MNRE)	$154.1

[a] As set out in the National Electricity Strategy Paper, November 1996.
Source: MNRE and Mission data.

2.8 Considering the fact that urban and peri-urban dwellers have considerably higher incomes than rural dwellers, the expenditures noted in the demand surveys show that, even in such a disadvantaged economic position, they pay far more than their urban counterparts for one of the basic amenities of modern life.[13] Moreover, UEB subsidizes both grid-connected and remote

12 Estimates of the number of UEB residential/household consumers vary considerably. In his survey report, Tuntivate (1998) states that there were 148,000 urban and 58,000 rural UEB consumers in 1996. The MNRE, in its draft report "Strategic Plan for the Power Sector" (November 1997), cites 148,000 domestic consumers for UEB. It then goes on to say that the bulk of those are in Kampala-Entebbe, and that these consume 17 times as much as their other urban counterparts. It makes no mention of rural UEB consumers. The World Bank, in its *Uganda Energy Assessment*, goes still further in lowering the estimate residential consumers. It states that the total number of consumers (implying industrial, commercial, and residential consumers) in 1995 was on the order of 110,000, of which "more than half are in the capital, Kampala, and most of the remainder are in the major towns (according to a recent UEB survey, the real number of consumers may be as low as 67,000)." The World Bank and UEB currently estimate 140,000 connections in Uganda. An audit is being carried out to put this issue to rest.

13 This is another example of how urban dwellers are subsidized at the expense of the rural sector. The argument is often made that electricity should be inexpensive in order to maintain social equity and to help the disadvantaged. What this survey clearly shows is that the current system benefits a few who are fortunate enough to live in urban areas and be connected to the grid. The fact that UEB has suffered massive losses during the past three decades, and that most of its consumers are in arrears, further illustrates that the electricity grid argument for "equity" does not hold true. In the case of non-grid electricity users, they are not able to buy batteries or get them charged if they do not pay cash. This is further reinforced by the supply surveys that show the price paid by non-grid-connected people for gensets and the electricity from those gensets.

(diesel)-connected households in net terms.[14] Of those households fortunate enough to live in rural centers with remote diesel stations, UEB provides them a net subsidy of approximately US$225 per annum.

2.9 Non-grid households pay cash for every kilowatt-hour they consume, they never default, and they pay on time at 30 times the grid-connected consumer fee. The importance of Uganda's off-grid electricity economy is further demonstrated by the fact that UEB's budget for rural grid extensions is only US$11 million, and this should be seen within the context that UEB (1) load-sheds 50-60 megawatts each day due to lack of capacity and (2) suffers major financial losses due to lack of payment and collection and to system losses. Meanwhile, non-grid connected Ugandans will annually spend twenty or more times more money on SLI batteries, dry-cells, and generating sets.

2.10 The demand surveys clearly showed Ugandans' ability and willingness to pay for non-grid electricity in the absence of a possibility to connect to UEB. Were more convenient, less expensive options made available to them, the demand surveys showed that people clearly would choose other alternatives (72 percent said they knew about photovoltaics). *These surveys and the basic financial and economic analysis of Uganda's grid operations clearly suggest that there should be a major rethink of the country's off-grid and rural electrification strategy.*

Current Off-Grid Supply Profile

2.11 UEB is under significant pressure both to expand its coverage (the grid) and to strengthen its supplies to current consumers. Shortfalls in generation are on the order of 50-60 megawatts peak, and UEB's distribution system is weak. Conflicting interests lobby for intervention: while industries and commercial establishments constantly demand that UEB improve and strengthen its services, political pressures force UEB to extend the grid ever wider to administrative centers throughout the country (an estimated US$11 million was budgeted for 1998).

2.12 The result is that UEB's entire grid system has become increasingly weak and unreliable. Outlying connections, even those newly connected, get little if any electricity—a maximum of four hours per day. Furthermore, core consumers, such as industries in Kampala, Jinja, Tororo, Mbarara, and Entebbe, get less and less reliable UEB electricity, and invest in their own generating capacity as a consequence. Table 2-3 provides a brief overview of (1) the enterprises interviewed over the course of the supply study and (2) the amount of petroleum generation capacity in which they have invested to meet the grid's shortfall.

2.13 The prospects for UEB to significantly strengthen its national coverage to non-grid areas over the next 20 years are remote. The costs of such work are prohibitive, and UEB's priorities should be to improve supplies and service to its existing core consumers. At present UEB cannot cover its costs from centralized urban customers, much less from distant, isolated customers who consume even less than their urban counterparts. The result is that UEB is hemorrhaging. Every new connection results in further losses, particularly connections to outlying rural areas.

[14] The uniform tariff uniform in Uganda is about US$0.10 per kilowatt-hour. UEB's operating cost for isolated diesel stations is approximately US$1.0 per kilowatt-hour.

2.14 In this situation, UEB has no financial incentive to embark on any further rural electrification, even if it could strengthen its services, raise its tariffs, and improve its collections. Even if UEB were to connect all urban consumers in Uganda's three largest cities (Kampala, Jinja, and Entebbe) this would still leave 75 percent of Ugandans without UEB grid electricity. The Owens Falls extension due for commissioning in 1999 will create another 200 megawatts of capacity. However, the main station at Owens Falls (i.e., the 180 megawatts currently installed) will have to undergo rehabilitation when the new capacity comes on line, reducing the available capacity for at least three more years. Second, lack of generating capacity is not UEB's main problem. It is poor bill collections and lack of distribution capacity. This either requires major investment on UEB's part or on someone else's part. Government's current vision is to privatize distribution, requiring major investments on any buyers' part, who will transfer these costs to the users through higher tariffs. Whatever the outcome, no significant new investment in grid extension is likely for the next five years at the least.

2.15 The supply survey conducted by the MNRE under the ESMAP Rural Electrification Study provides the other side of the picture. More than 100 telephone interviews were conducted with Uganda Manufacturers Association (UMA) members in Kampala, Entebbe, and Jinja. A further 31 field surveys were conducted in 12 districts. These paint a remarkable picture of autonomous electricity supply. Ugandan industrialists have installed more than 35 megawatts of diesel generators in the three largest urban areas. A further 1.1 megawatts is installed in smaller commercial establishment, hotels, restaurants, and shops in these three large urban areas.

2.16 The team's surveys and estimates show an additional 10 megawatts of capacity in other "urban" areas of Uganda (i.e., towns with more than 3,000 inhabitants). Rural surveys show that at least 10 megawatts of non-UEB generating capacity has been installed by a wide range of private enterprises—from dairy processing companies to coffee processors, from saw mills to rural hotels and restaurants. More than 400 coffee-processing plants operate with diesel generators, while more than 20 dairy plants have more than 5 megawatts of installed capacity (run as base load) to meet demand in this fast growing sector.

2.17 What emerges from both the supply and demand side surveys is a picture showing the tremendous willingness and capacity of private Ugandans to pay for electricity to meet their industrial, commercial, and residential demands. Uganda Revenue Authority figures show that private Ugandans have invested more than USS30 million since 1993 to import diesel and petrol generators. (See also Figure 2.1; and see Annex E for facts, statistics, and key assumptions regarding diesel and petrol generators.) Interviews with all major suppliers and distributors, and with major consumers, show that many of these systems are oversized and under-utilized, particularly in urban areas. At least 25 percent of rural private generating capacity, and closer to 90 percent of urban generating capacity, is under-utilized. This represents a major loss to the national economy as this power could be put to effective use to support, promote, and accelerate economic development.

Table 2-3. Supply Survey Sample: Large Petroleum Auto-Generation (kVA), 1997

Major Kampala Autonomous Generators	*kVA*
Mukwano (Oil & Soap)	1,500
Mukwano (AK Plastics)	812
Dairy Corporation	635
Equatoria Hotel	600
Grand Imperial Hotel	600
Sheraton Kampala	560
Mukwano (AK Detergents)	350
Kampala Phone Exchange	316
Uganda Batteries	277
Bank of Uganda	250
EADB	250
Nakawa Phone Exchange	200
Makerere Phone Exchange	200
BAT	187
Mengo Phone Exchange	55
Mbuya Phone Exchange	30
Nsambya Phone Exchange	30
Kololo Phone Exchange	10
Total	6,862

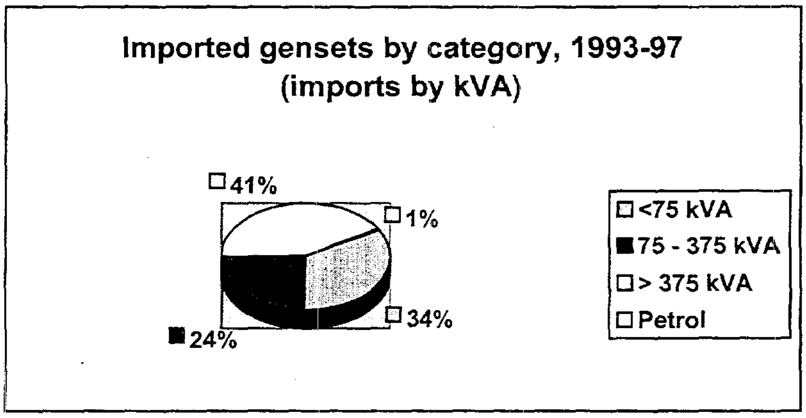
Note: This table only represents those establishment interviewed by the team; that is, no more than 15 percent of the total industrial, large commercial, and large institutional installed-genset capacity in Uganda.

Source: MNRE and SDC field team data.

Ways should be explored to use this underutilized generating capacity to the fullest extent as early as possible.

Figure 2-1. Types of Imported Gensets (1993-1997)

Source: Uganda Revenue Authority.



2.18 Moreover, because of historical UEB and national restrictions, each private generator is currently only allowed to supply the owner's own needs. This leads to considerable underutilized capacity that could immediately be supplied to other consumers. Rural and urban consumers' use of expensive SLI batteries and large investments in private generating capacity demonstrate in the most concrete terms possible that Ugandans are willing to pay far more than the industrial and residential tariffs UEB charges in order to secure reliable supplies for their businesses and pleasure. The task now is to identify how to organize this demand better and to invest in opportunities for electricity supply that are more economically and environmentally sustainable as well as less expensive.

2.19 The existence of 60 megawatts or more of independent, private diesel- and petrol-generating capacity provides ways of meeting much of this suppressed demand. Considerable opportunities exist for investing in the sector to supply these needs. However, Uganda's institutional environment needs to change to enable and to stimulate such development.

2.20 There is no doubt that private producers can be better organized to supply those without power. They can supply into the grid where it exists, or they can sell directly to other consumers where it does not exist. This will require that suppliers have incentives for doing so, which the uniform tariff currently prevents them from having. Pilot demonstration activitiesinvolving the private sector, district authorities, suppliers, and consumers need to be initiated to set the stage for more widespread investments in the sector. The micro- and macroeconomic benefits would be easily demonstrated, and would accelerate development and improve the quality of life for thousands of people—if the government has the will to change the legal and institutional framework for electricity supply.

3

Supply Resource and Technology Options

3.1 Rural electrification in Uganda has been transformed dramatically during the past decade. In 1988 the rural economy was just beginning to recover from more than 15 years of civil strife. Probably no more than one-quarter of the rural population used dry-cell batteries. Lead-acid batteries were used by only a few hundred, perhaps a few thousand, households in all. The only petrol and diesel generators were used by church missions, government establishments, and some better-off individuals. Domestic petrol and diesel generators would not have numbered more than 100. Neither photovoltaics nor biomass were being used to generate electricity. Practically speaking, the only rural electrification in 1988 was UEB's limited grid network, which accounted for no more than 15,000 households.

3.2 Today's off-grid electrification (considering as "electricity" lead-acid batteries, gensets, and PV units) accounts probably for more than 110,000 off-grid households. A genuine electricity transformation has taken place in rural Uganda on a completely independent, autonomous basis, without government or donor support or involvement. The challenge of harnessing that individual innovation and motivation to accelerate rural electrification is the main thrust of this report.

3.3 Uganda has found no exploitable petroleum resources. All petroleum supplies are imported overland at considerable expense. Landed petroleum product prices are higher in Uganda than in many other African countries. In addition, the government taxes petroleum products at a high rate. Although this makes petroleum products an expensive fuel, it conversely allows alternative sources of energy to be cost-effective.

3.4 Fortunately, Uganda is rich in renewable energy resources. It has some of the world's largest, and almost untapped, hydropower resources. Uganda sits astride Africa's two major watersheds, the Nile and the Congo—although less than 10 megawatts of small hydropower, out of a capacity of hundreds of megawatts, is currently exploited. Uganda is rich in woody biomass, crop residues (bagasse, coffee husks, rice husks, etc.), and other renewable resources. Woody biomass already accounts for more than 90 percent of all energy consumed in Uganda. Even in the "formal" industrial and commercial sectors, woody biomass accounts for more than 20 times the energy consumed as all the petroleum products and electricity combined. This chapter discusses the different energy resources potentially available to Ugandan consumers.

Dry-cell Batteries

3.5 The demand-side survey carried out for this study in 1996 showed that some 94 percent of non-grid connected Ugandans in the survey sample used dry-cell batteries for applications ranging from lighting to radios and cassette players. Overall expenditures for dry-cells were on the order of US$6 per month, or US$72 per annum. Most dry-cell batteries were imported, although there now is some local production. Dry-cells are a convenient but very expensive form of electricity, with kilowatt-hour prices of more than $US400. In addition, safe disposal of these batteries poses a problem. In the absence of a collection scheme, batteries are dumped in the user's surroundings. The effect of the batteries' chemicals on the environment is not known.

Lead-Acid SLI Batteries

3.6 The demand survey was the first to address SLI battery use on a significant scale. (However, data on evolution of use and many other aspects are not known.) The demand survey found about 9 percent of the households in the sample using these batteries. It is highly possible that many households first buy a defective, cheap car battery that can still provide several months of useful service at the household level. Once this battery fails, they may buy a new SLI battery. Given charging and discharging conditions, such batteries will probably not last more than 1-1.5 years. Although battery recycling does occur, it is unknown to what extent and what the efficiency of these operations is. Batteries are produced locally as well as imported.

3.7 The survey revealed that people pay up to $7.5 per month for charging the battery and for lugging it to and from the charging place. Depreciation costs of the battery may add another $3-5 per month. The resultant kilowatt-hour price is at least $3. This is the lowest price people will have to pay if they want to watch television when they are not connected to UEB, as alternatives such as solar energy or a genset are more expensive. *SLI batteries provide a useful rural energy service, with low investment costs, although the associated kilowatt-hour costs are high.*

Diesel and Petrol Generators

3.8 The total capacity of generator sets imported into Uganda is shown in Table 3-1. The total value of these imports amounted to more than $30 million from 1993 through September 1997.

3.9 Autonomous investment in electricity generation from petroleum products (diesel and petrol) has accelerated during the past three to four years as UEB has proven unable to meet rapidly increasing demand. There are positive and negative implications to this. The ad hoc, individual investment in these generating sets has cost Uganda more than US$30 million since 1994 and has led to an installed capacity of at least 60 megawatts outside UEB.[15] Diesel and petroleum imports to supply these generators are estimated to be not less than US$10 million annually.

[15] The ESMAP/MNRE Team's industrial, tertiary, and household surveys show a minimum of 40 megawatts of installed capacity, while Uganda Revenue Authority (URA) import statistics from July 1993 to August 1997 show imports of petrol and diesel gensets of at least 51 megawatts.

(Table 3-1: Total Generating Capacity (kW) of Imported Gensets July 1993–September 1997)

	Rated Capacity (kVA)				
Year	*< 75*	*75-375*	*>375*	*Petrol*	*Total*
1993 (from Jul)	910	283	1,600	18	2,811
1994	4,207	1,967	7,867	83	14,123
1995	5,447	3,833	12,533	143	21,956
1996	4,503	2,583	9,600	252	16,939
1997 (to Sep)	1,953	167	3,600	83	5,803
Total	17,020	8,833	35,200	578	61,631

Source: Uganda Revenue Authority.

3.10 Collectively, these private investments supplied Uganda's rapidly expanding industrial and commercial sector with the power needed to keep the economy growing at the pace it has during the past several years. Without this stand-alone power, rural industries such as coffee, tea, and dairy would not have recovered, and the hundreds of millions of dollars these and other productive sectors earn in foreign exchange would not have been realized. Moreover, the important economic benefits of rural development, economic growth, employment, taxes, revenues, and other benefits would not have been realized. Whereas these investments have not been optimal from an economic perspective, they have been very effective from Uganda's developmental perspective. *This should be recognized, and Uganda's national and district leaders should now work to optimally utilize these electricity resources. The two items that most urgently need to be addressed are (1) import tariffs and (2) legislative changes allowing private electricity generators to supply to their neighbors at mutually agreed rates.*

Small Hydropower

3.11 Interviews and fieldwork were carried out during the course of this study in order to obtain technical and economic/financial information pertaining to the development of small hydropower plants. Sources included UEB, publications, and the management of the power plants. In most cases, information was scanty because either it was not well documented, or people were not well informed about the technical and financial details of the equipment and other design parameters. During the study's field visits, three developed sites were visited: Maziba, Kisizi, and Sipi.

3.12 The two largest of the six known small hydropower plants are connected to the grid, whereas the four micro-hydropower plants are operating on a stand-alone basis. The Kikagati plant, which was the first hydropower plant to be commissioned in Uganda, is connected by a 33-kilovolt line to the grid at Mbarara. It is not operational, however, having been damaged by floods in 1961 and 1964. It was finally closed in 1971.

3.13 Uganda has reserves of small[16] hydropower on the order of 400 to 500 megawatts, if not greater. For the purposes of this study, only sites and facilities of 2 megawatts or less were considered, representing slightly less than 2.5 megawatts in total (see Table 3-2; further details of this part of the survey appear in Annex F.) Some 17.8 megawatts of potential hydropower capacity

[16] *Small* is defined as less than 10 megawatts.

has been identified at the remaining sites. Thus, only within the context of sites that have been studied, Uganda is using just a fraction of its small hydropower capacity. A further 29 locations have been tentatively identified by the team through the draft "Uganda Hydropower Development Master Plan."[17] These sites have not been studied, although it is estimated that their capacity would be, at a minimum, another 12.5 megawatts.

3.14 Very little reliable or centralized information on small hydropower is available. Although quite a number of studies have been carried out during the past 25 years, each carried a separate agenda, and none was coordinated with the others. Almost inevitably, wherever work has been undertaken to estimate Uganda's hydropower potential, it has been done so from the point of view of estimating the potential for large hydropower. Those sites not satisfying the large-hydropower criteria have had almost no further work or studies carried out on them. Table 3-2 provides fairly extensive information on the five operating small-hydropower sites, plus one site (Kikagati) that is not currently operational.

Table 3-2. Small Hydro Installed Capacity in Uganda, 1997 (kW)

Location	*Date Installed*	*Owner*	*Type of Facility*	*Power Rating (kW)*
Maziba	1963	UEB	Dam	1,000
Kikagati	1934	UEB	Diversion	1,250
Kisizi	1970	COU	Diversion	60
Kagando	Mid-1990s	COU	Diversion	*Note:* The Kikagata site is not currently operational. *Source*: Various, including team's field visits.
Kuluva	1995	COU	Diversion	120
Sipi	1995	Dr. Chebrot	Diversion	1.5
Total				2,491.5

Note: The Kikagata site is not currently operational.
Source: Various, including team's field visits.

3.15 The main potential for small-scale (i.e., less than 2 megawatts installed capacity) hydropower development exists in the following areas:

- Rivers draining Mt. Elgon in Eastern Uganda
- The extreme southwestern portion of Uganda
- Rivers draining the West Nile, near Arua (Northwest)
- Rivers draining the Ruwenzori mountains in the West.

Small and micro-hydrpower could substantially contribute to Uganda's electrification. The economic merit of developing a site should be mainly determined by the local demand characteristics.

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[17] Sir Alexander Gibb, "Hydropower Development Master Plan," final draft, 1994.

Biomass

3.16 Although a number of sources of biomass could be used to produce electricity in Uganda, the country's economic and technical situation has not led to this as it has in some other developing countries. Major potential sources of biomass for electricity include the sawmills and the wood industry, sugar mills, coffee and tea estates and processing centers, rice, and other milling centers.

3.17 Two major financial issues and one technical issue govern the financial viability of biomass electricity plants. The first financial issue is the lack of raw material. The sawmills and coffee and rice facilities, although numerous, do not produce enough biomass waste to justify investment in a plant. The second financial issue concerns the decentralized nature of agroindustrial processing. That is, while there is some on-site electricity demand in many agroindustrial businesses (not as much as at saw mills), the individual plants are too far from one another to justify investment in electricity generation equipment.

3.18 The technical issue concerns the use of steam to generate electricity. Unless steam is utilized (e.g., process heat, co-generation), considerable energy is wasted in the process of generating electricity. A typical steam plant generates heat and electricity on a ratio of 6 or 7 to 1. Notwithstanding the waste, there is the physical requirement of having enough fuel to produce enough power for electricity on a continuous basis. Less than one-quarter of the coffee plants meet this criterion without transporting coffee residues some distance. The same holds even more true for small-scale sugar production, cotton wastes, and almost all other biomass wastes with the exception of wood.

Bagasse

3.19 Bagasse, the plant residue generated by sugar extraction, could be utilized to generate excess power for sale to UEB for distribution into the grid. Currently, 7.2 megawatts of power capacity is installed in Uganda, as Table 3-3 shows. However, none of this power is sold, and all is used on the site of the three plants (see Annex G for more details on the energy potential of sugar factory waste). The Kagira Sugar Works has negotiated a contract for the sale of electricity into the grid.

Table 3-3: Existing Sugar Plant Electricity Generating Capacity

Site	*Current Capacity (MW)*	*Potential to Export (MW)*
Kagira	4.5	15-20
Lugazi	1.5	4-5
Kinyara	1.2	3-4
Total	7.2	22-29

Source: USTDA, private sugar companies.

3.20 The U.S. Trade Development Agency has carried out a feasibility study for expanding the Kagira sugar plants' co-generation capacity from 4.5 megawatts to 15-20 megawatts. This would be exported to the grid. Costs would be on order of US$14 million. This would imply investment costs of less than US$1,000 per kilowatt installed, which is better than UEB could obtain for most thermal plant investments, and certainly better than new small-to-large hydropower plant development. Moreover, once the investment is made, the recurrent costs (e.g., fuel, operations) would be very low. No imported petroleum would be required, and the power source would be both local and renewable. Similar retrofits could be made at the Lugazi and Kinyara sugar plants. *Large-scale sugar factories would be a good source to consider for additional electricity generation, either to feed into the grid or to distribute locally.*

3.21 Additionally, there are some 39 "jaggeries," or small-scale sugar enterprises. Traditionally, they have been used in Uganda to produce distilled spirits. The major sugar works' recovery means that this market is now disappearing. Nonetheless, the problem of using the jaggery[18] plants to generate electricity is far more significant than their loss of market share. Almost all jaggeries are far from the national grid. They should be prime candidates for generating electricity because they produce more than 100,000 tonnes of bagasse, supplemented by firewood, every year. However, their plants are old and under-capitalized. They lack sufficient technical and financial resources to invest in efficiency improvements, much less an electricity generating plant. *As shown in more detail in Annex G, it is very unlikely that this smaller sugar sector can contribute towards Uganda's rural electrification.*

Wood Wastes

3.22 Uganda has a large number of sawmills and wood-processing facilities. It is rich in forestry, from the point of view of both natural forestry and forestry plantations. Logging and sawmills are large sources of forest residues. In 1994, there were 37 sawmills in Uganda's forests, 11 in natural forests and 26 in plantation forests.

3.23 As shown in Annex H, there is great scope for sawmills to generate their own electricity *in situ*, as is done in many parts of the world. However, as with the sugar jaggeries, Uganda's sawmills are very inefficient. Their utilization capacity is no greater than 30 percent (i.e., 70 percent of the wood processed by the plants ends up as wastes and residues). The amount of wood residues produced at the mill sites (for both natural and plantation forests) has been conservatively estimated at 39,000 cubic meters.

3.24 In addition, great quantities of wood are harvested in the forests and plantations and left as waste. The team estimates that logging in natural forests results in residues left *in situ* of approximately 49,000 cubic meters. These are either burnt for charcoal, burnt on site, left to rot, or collected by local people for use as household fuel. The same wastage obtains in the plantation sector, where at least 63,500 tonnes of wood residues and wastes are left in the plantations. Altogether, between the wastes generated at the point of production (in the forests or plantations) and those generated at the mills, nearly 88 percent of all wood is wasted. Although some is used for charcoal and other forms of household energy, the extent to which this is done is unknown.

3.25 The incentive for utilizing these residues (and minimizing them) would be much greater if wood were further processed (e.g., for fine timber, furniture, or veneer). Such processing would require steam heat for processing. This would justify the investment in plants for steam and for co-generating electricity. Thus, while waste could be reduced, so could the value of both the

[18] *Jaggeries* are small, often artisanal sugar mills; the more artisanal, the simpler their processes.

product and the waste. Plants would have greater energy demands, and would place a higher value on the wood waste as a by-product for energy.

3.26 *Wood processing in Uganda is so dispersed and at such a low level of technology that there is little likelihood of any electricity generation from wood waste in the near future.* Most of the mills are poor and under-capitalized. As with the jaggeries, the owners lack the technical expertise or incentives for making the types of investment needed for co-generation, even though they invest considerable funds in diesel fuel to run their mills. The high cost of capital, the distances from centers of demand, and the scale of the technology required will, as with sugar jaggeries, prevent this sector from providing electricity for a long time to come.

Coffee Husks

3.27 The team visited a number of coffee processing plants and held extensive discussions with the Uganda Coffee Development Authority (UCDA). A listing of all plants, pulperies, and processing mills is provided in Annex I. The cost of fuel (coffee husks) was derived from information provided by Uganda Clays, Ltd., a ceramic industry that fires its kilns using coffee husks. The industry pays, on average, approximately US$23 per tonne for coffee husks, including transportation. The team assumed that a power plant would generate electricity at a cost of approximately US$0.16 per kilowatt-hour (see Annex I).

3.28 Considering that the average domestic tariff in Uganda is approximately US$0.10 per kilowatt-hour, biomass plants in Uganda would not appear at first glance be competitive with grid electricity. However, consumers who are not connected to the grid and who use diesel generators pay between 1.5 and 6 times the grid price. *Decentralized biomass power plants using coffee husks, rice, wood wastes from sawmills, and other materials could offer an attractive prospect for rural electrification.* If the industries produce power from their own residues, thereby eliminating fuel costs, the cost of electricity can be further reduced.

3.29 The Kigulu coffee factory is a good example. It generates 556 tonnes of coffee husks annually, of which only one-half is available for energy; the other half is used for soil conditioning. The energy that could be produced by the plant is 4,448 gigajoules. A thermal generator operating at 35 percent efficiency would produce 443 megawatts annually. Assuming that the plant operates for 10 hours per day, 300 days a year (the period during which it is in normal production), an installed generating capacity of 144 kilowatts could be obtained with a full load factor. For a small plant, estimated investment costs are US$1,575 per kilowatt. The kilowatt-hour costs of such a plant are approximately US$0.12—about equal to UEB's highest tariff.

Rice Husks

3.30 Rice is produced primarily in the eastern parts of Uganda in Iganga, Bugiri, Pallisa, and Mbale Districts. In 1996 Uganda produced 28,000 tonnes of rice, yielding more than 15,000 tonnes of rice husks. The survey showed that most of the rice mills are concentrated around townships, where the rice harvest is collected from smallholders. Mbale municipality alone, for instance, has 33 small rice mills. The mills generate considerable quantities of husks, which pose major disposal problems. Often the rice husks are burnt on site, creating environmental problems.

3.31 The issues concerning the financial and technical viability of using coffee husks for rural electrification also apply to rice residues (and cotton and other agricultural residues). That is, without significant on-site or local heat demand, and without major electricity demand on-site, few locations will make economic or technical sense. Moreover, *unless there is inexpensive concentration of raw materials, the costs of transporting over distance will make crop residues prohibitively expensive for electricity generation.*

Summary

3.32 Before biomass can contribute significantly to rural electrification, some fairly difficult financial and technical hurdles must be cleared. In general, jaggeries, saw mills, coffee plants, and rice mills are small and poor, and use old equipment. They lack both the expertise and capital necessary to convert their existing plants to electricity production, although most rely on old diesel mills or gensets to provide them with power.

3.33 Although there are opportunities to use biomass for power generation throughout Uganda, depending on the local demand for electricity and the local biomass supply, this will not contribute significantly to Uganda's rural electrification. However, technological changes—such as availability of lower-cost biomass gasification equipment that has higher thermal efficiencies than combustion—may change this picture in the future.

Photovoltaics

3.34 Photovoltaic (PV) systems have been in use in Uganda since the early 1980s. During the 1980s virtually all PV systems were brought in by donor and nongovernmental groups and by the government. Donors brought in the systems primarily for health (vaccine refrigeration), for schools, and for their own personnel. The government imported them for such uses as repeater and relay systems for telecommunications and the Uganda Railways, for isolated government and military outposts, and for health services. (See Annex J for data on solar resource distribution and potential in Uganda.)

3.35 Today, the PV picture is rapidly changing. Photovoltaic systems now serve two distinct groups of consumers in Uganda. The first group continues to be the donor-funded public sector, which includes hospitals, clinics, and health centers in particular, but also schools, telecommunications, military, and other government consumers in other parts of Uganda. There are more than 1,000 installed photovoltaic systems serving this client base, and the number is increasing. Three large hospitals will soon be electrified by large photovoltaic systems funded under a Spanish government aid program. The Ministry of Health's (MoH) Extended Programme for Immunization, supported by the UN, has funded more than 270 solar refrigerators in Uganda, and a further 30 are currently being tendered under MoH auspices.

3.36 The other main category of photovoltaic consumer is private households that buy small solar home systems (SHS), ranging mainly from 10 to 100 watts, from private suppliers. Early estimates in 1995 suggested there were several thousand systems of this type in place. Many considered this estimate too high. However, since that time, ten new solar photovoltaic companies have been established in Uganda, and the government acknowledges that at least several thousand home photovoltaic systems are currently in use.

3.37 A major UNDP/Global Environment Facility program will put a further 2000 systems in place in an attempt "to support the private sector." The ten companies estimate they install approximately 100-150 systems a month, although the actual number is probably higher. Surprisingly, the demand survey did not locate many solar PV systems.[19] This is even more remarkable considering that 72 percent of the respondents said they knew about photovoltaics. One can only assume that television advertising (several solar companies advertise frequently on several of Uganda's private television stations) reaches a wider audience than Uganda's fledgling PV distribution companies.

3.38 Whatever the estimates, the number of photovoltaic systems is increasing at a rapid pace, mirroring earlier developments in Kenya in the 1980s, although far more donor support than took place in Kenya. *Photovoltaic electricity does make sense for Uganda from an economic point of view, particularly (1) when there exists both demand and the ability to pay and (2) in the absence of viable options for collective supply* (i.e., village-based, mini-grid, UEB, etc.). The development of photovoltaics in Uganda should be driven by the market and led by the private sector.

Wind

3.39 Uganda is not favored by a particularly windy climate. This is to be expected in a central continental setting. As Annex K shows, very few areas in the country have reasonable wind regimes, and almost none have average wind speeds high enough for large-scale electricity generation.

3.40 However, new systems for small-scale wind generation are now on the market that do not require high wind speeds to generate enough electricity to charge batteries, and there are numerous sites with a micro-climate suitable for these systems. These systems operate at wind speeds as low as 4 meters per second, and are now internationally available at very affordable prices (i.e., less than US$1,000 for a 1.2-kilowatt wind turbine with inverter and battery system). These systems are ideal for battery charging. This is currently being explored in Uganda as there are a few systems in operation. *Given the large number of SLI batteries in use in the country, small wind-powered generators could be as competitive, if not more so, than PVs, particularly if production of these generators takes place in Uganda or elsewhere in East Africa.*

Geothermal

3.41 Geothermal potential for electricity generation is estimated at more than 450 megawatts of thermal capacity in the West Rift Valley area. Some studies have been carried out by the Geological Survey Department. There is interest on the part of the government and some external investors because Kenya now has more than 100 megawatts of geothermal generation installed, and some observers believe that Uganda's resources could be developed in a similar fashion. *Geothermal energy should be evaluated in the framework of the Uganda Power System's expansion, and should be determined by economic considerations*, fitting into the master plan for electricity sector development.

[19] The demand survey found five solar home systems, or 0.25 percent of the total sample.

4

Requirements for Developing Supply-Side Options

4.1 This chapter presents the ambitious framework for rural electrification that the Ugandan government is currently preparing within the context of its plan to develop the overall electricity sector. If the government delivers on the framework it is laying out, many of the prerequisites for rapid development of rural electricity will be met, and the economics of that development will be rationalized. That is, the government will be setting the scope for mobilizing private capital and initiative via a framework that is more rational and more cost-effective, both economically and financially. This should (1) rapidly accelerate rural development through the supply of more and lower-cost energy services in rural areas and (2) reduce the national economic costs of doing so.

Government Participation in this Study

4.2 The Ugandan government has been intimately involved with the development of this rural electrification study. It has participated actively in the development and administration of surveys and in the analyses of the results. All key ministries and departments—especially the Department of Energy, but also UEB; the Ministry of Finance, Planning and Economic Development; the Forest Department; and the Uganda Revenue Authority, among others—have assisted not only in providing data and information, but also in discussing the issues and options relating to off-grid electrification.

Strategy for the Power Sector

4.3 The Ugandan government is working hard to develop an overall electricity-sector framework whose financing and implementation are based on greater private sector involvement. According to its draft "Strategic Plan for the Power Sector," It is pushing to decentralize the development of power where the grid will not extend in the near future, and is strongly in favor of "harnessing non-conventional energy resources including mini-hydro, solar energy, geothermal, biomass and wind resources through private investments to assist in rural electrification."[20]

4.4 The government's vision of the future power system in Uganda is one in which UEB will own and operate Owens Falls and other existing large facilities, the national transmission grid, and the integrated operation of the Uganda Power System. There will be privately-owned, regulated regional distribution companies, separate from UEB and further capitalized by the private sector,

20 MNRE, "Strategic Plan for the Power Sector" (1997).

with "reasonably priced electric services (including socially desirable subsidized services, such as 'lifeline' rates for financially disadvantaged customers."[21] The government also foresees privately owned and decentralized power systems operating in peri-urban and rural areas not currently served by UEB. The government will establish an autonomous "Regulatory Commission" (RC) that will oversee the development of this decentralized power system.

The RC will be responsible for

- "Establishing transparent rules" for prices
- Issuing licenses, protecting consumers, etc.
- Setting standards
- Monitoring services
- Setting terms for interconnection
- Settling disputes.

4.5 The government envisions a three-phase approach to this. During the first phase, the government will enact a new Electricity Act that will improve UEB's operations, and will negotiate investments in the power sector with large private investors. During the second phase (1998 to 2001) "the MNRE will develop a comprehensive rural electrification and distribution plan consistent with the GOU's policies and objectives, including the funding mechanisms." The third phase (beyond 2001) will see the government deepening and strengthening private sector involvement, particularly in rural electrification.

Private Sector Participation

4.6 As the government's strategy foresees, there is considerable scope for private sector involvement in these efforts. It is also encouraging to note that the government, at all levels, has recognized the contribution the private sector has already made in this development. The strategy document cites existing investments in 80 megawatts of private, autonomous diesel and petrol generation. This recognizes that the private sector has already invested more than US$20 million in such generation, and spends as much as US$8 million a year on fuel and spares.

4.7 If the private sector has been able to raise this amount of money (averaging US$10 million for capital, fuel, and spares for private gensets alone) without government help, then it should not be difficult to raise even more capital with government encouragement. However, such encouragement must fit within a rural, off-grid electrification plan. The plan should be a long-term one that (1) defines government and local priorities and (2) recognizes the private sector's own wishes and initiatives. It should not be promoted on an *ad hoc* basis.

4.8 This encouragement should start with public education and awareness of the opportunities for the private sector to generate and sell electricity to the public at prices that fully reflect production costs and a reasonable return on investments. In fact, the government should go further and permit third-party access through the grid for willing suppliers to sell at whatever price to willing consumers. The government could charge a transmission fee for suppliers, as is practiced in other parts of the world. However, they should use the office of the soon-to-be created Regulator to set the framework for such sales.

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[21] *Ibid.*

4.9 Additionally, the government should provide a range of incentives, including tax breaks and tax holidays for approved investments. It should seek to maximize investments that provide collective electricity benefits (i.e., investments in schemes that supply more than one individual consumer) whether these are in the field of diesel, small hydropower, biomass, PV, or any other energy source. The government should work to educate consumers to the fact that electricity sold through a grid should be sold at its economic cost.

Uganda Electricity Board

4.10 The Uganda Electricity Board (UEB) openly acknowledges that it does not want to be in the business of rural electrification. Although political pressures have driven UEB to extend the grid to almost all district centers, economic reality means that those centers (and most other consumers) get very little electricity, on a very unreliable basis. This is not solely UEB's fault, and government has recognized that UEB should basically get out of the business of decentralized, rural electrification.

4.11 One issue that appears strongly in the government's strategy is enshrined in the sense of "equity" and "assisting the disadvantaged." This manifests itself through a single tariff charged, regardless the cost to UEB, to all consumers in Uganda. If this continues to be applied to UEB in the future, it will surely hinder UEB's economic viability. Moreover, if the government ensures that any supplier using the UEB network abides by these same single-tariff rules, it will effectively stifle accelerated private investment in rural electrification.

Donor and Other Support

4.12 There is currently considerable donor interest in Uganda's rural electrification. It is important that donors (1) support the Ugandan government's drive to privatize rural electrification and (2) stimulate private efforts to develop collective electricity supply systems. Donors have a particularly important role to play in providing technical assistance and support for the development of "alternative energy" sources, particularly biomass and small hydropower. However, their most important role should be to furnish finance and credit for private sector investment in and development of rural electrification. Donors can supply funds to banks and investment funds specifically designated for rural, off-grid electrification.

5

Costs and Benefits of Supply Side Options

5.1 This chapter describes (1) current rural electrification costs and benefits in Uganda and (2) the costs and benefits of rationalized rural electrification.

Current Rural Electrification Costs and Benefits

5.2 Current rural and off-grid conditions in Uganda demand that two sets of costs and benefits be considered: those associated with UEB and those associated with private, non-UEB entities. In UEB's case, the costs and benefits have to do with classical rural electrification. These can be divided into costs and benefits from the generation of electricity in isolated locations and from grid extension to rural areas.

Costs and Benefits for the Uganda Electricity Board

5.3 Table 5-1 provides for UEB's isolated diesel stations, the associated costs borne by UEB. This should be compared to the benefits gained from payments by the few who are connected to these isolated grid stations. The uniform tariff allows customers connected to the isolated grids to pay the same for electricity as the urban main grid connected customers. UEB thus looses large sums of money in the isolated grids.

5.4 As can be seen from Table 5-1, the two stations at Nebbi and Adjumani did not operate during the 1995-96 period, although costs were incurred. For the remaining five UEB isolated stations, UEB spent more than US$320,000 per year for just 1,451 consumers. Given the fact that all of those consumers, in total, paid UEB only US$92 per year for the two years in question, UEB subsidized each of these fortunate few on an average of US$138 per year or more than $200,000 per year for all customers combined. UEB's own studies, while somewhat more conservative, nonetheless show that the electricity board still subsidizes urban consumers massively, with the total ranging in millions of US dollars per annum.

Table 5-1. UEB Diesel Generation in Isolated Stations (1995-1996 Averages)

Station	*KWh (pa, 1995-96)*	*Avg. No. of Customers (1995-96)*	*UEB costs (US$/kWh)*	*UEB costs (US$ pa)*	*UEB costs (US$ per customer)*
Arua	558,254	772	$0.25	$139,563	$181
Nebbi	36,387	0	$0.25	$9,096	n/a
Adjumani	1,392	0	$0.25	$348	n/a
Moroto	323,449	194	$0.25	$80,862	$418
Moyo	87,429	112	$0.25	$21,857	$195
Kapchorwa	7,056	82	$0.25	$1,764	$ 22
Kitgum	321,960	292	$0.25	$80,490	$276
Total/Avg.	1,335,926	1,451	$0.25	$333,982	$230

n/a = not applicable.
Source: UEB.

5.5 It is difficult to obtain reliable figures on the costs and benefits to UEB of interconnected grid extension. UEB estimates that it spends US$10,000 per kilometer for grid extension. Extending grids to market towns and other urban areas is not really rural electrification *per se*. It is, indeed, grid extension. However, considering the fact that most of Uganda's autonomous diesel and petrol genset investment takes place in urban and peri-urban areas with varying degrees of connection to the grid, comparisons can be made. The fact is that, even with unreliable power to these centers (i.e., an average of four hours per day), consumers still enjoy massive subsidies when connected. Again, they pay no more than the equivalent of US$0.10 per kilowatt-hour for electricity.

Costs and Benefits for Off-Grid Consumers

5.6 Quantifying private, off-grid costs and benefits of rural electrification in Uganda is much easier than trying to unbundle UEB's costs and benefits because the private costs and benefits are entirely transparent. Private consumers using dry-cell batteries, SLI batteries, PV systems, and diesel/petrol gensets pay the full financial costs for their use and the delivery of energy.[22]

Dry-cell Batteries

5.7 Dry-cell batteries are used by 94 percent of the rural population in the survey sample. Each household spends, on average, US$72 per annum on dry-cells. They pay more than US$400 per kilowatt-hour to provide basic lighting and entertainment through radios and cassette players. In essence, there is hardly any comparison between what they spend per kilowatt-hour and what a grid-connected consumer spends. The kilowatt-hour expenditure is not nearly as important as the fact that the average off-grid user of dry-cell batteries spends US$72 per year on electricity, while the average grid-connected rural or small town UEB consumer is subsidized by US$230 per year.

22 In Uganda, financial and economic costs are practically in line because of such factors as the openness of the economy and the open exchange rate.

5.8 This is the most important comparison to make, and it is a major issue of "equity" and "advantage/disadvantage" that government and donors should consider when planning national electrification programs. When discussing consumers' willingness and ability to pay, planners and policy makers should consider that the average rural, off-grid consumer raises cash to pay US$6.00 per month for dry-cell electricity, and that collectively consumers spend more than US$100 million per year. These expenditures could definitely be rationalized into a system that provides better returns and higher benefits per consumer than is currently the case.

Lead-Acid (SLI) Batteries

5.9 When a private consumer purchases a car battery for the equivalent of US$50, and pays US$1 per charge plus transportation costs (three times per month, on average), there are no hidden costs, and she or he is paying the full economic cost for this service (excluding any opportunity cost for the time spent transporting the battery or waiting for it to be charged, if either is additional to what she or he would be doing anyway). A private user of a car battery, therefore, pays an average of US$3.00 per kilowatt hour, compared to the UEB consumer who pays US$0.10 per kilowatt-hour—a 30-fold difference. Both consumers gain many of the same benefits, including electricity for lighting, a radio, a cassette player, a television, and possible a video player. The non-UEB consumer may realize more reliable service, but that depends on location and other factors.

5.10 Doubtless, the non-UEB consumer would gladly connect to the UEB grid to pay 30 times less for electricity. The demand surveys clearly indicated this, and UEB's own experience indicates the tremendous demand for grid extension and connections. However, the expansion of UEB connections will not continue much longer, and government already foresees that "rural electrification" services to remote towns and market centers will soon be in the private domain. With that in mind, it is certain that no private investor will invest in a generating plant for a village or center and only charge US$0.10 per kilowatt hour. It is equally certain, however, that consumers will be more than happy to pay the economic price for reliable power from private suppliers, so long as it is less expensive than what they are paying for now.

Diesel/Petrol Generators

5.11 The other form of non-UEB rural electrification taking place is that powered by autonomous diesel and petrol gensets. Again, as with SLI batteries, the costs are transparent and are close to the real economic costs to the consumer (if not the nation).

5.12 Although it is difficult to pinpoint the average cost per kilowatt-hour for private diesel and petrol gensets given the wide range of sizes and makes, good estimates can be made. Costs for generators range from approximately US$350 per kilowatt for the larger gensets (greater than 375 kilovolt-amperes) to US$500 per kilowatt for the smaller diesel gensets (less than 37.5 kilovolt-amperes). Costs per kilowatt for petrol gensets are on the order of US$700. Given that, the two following cost tables can be derived (see Tables 5-2 and 5-3).

5.13 The petrol-genset household pays the equivalent of US$0.78 per kilowatt-hour. This is nearly one-quarter the price of a battery, but still seven times what the household would pay to UEB if connected. As the table shows, the price per kilowatt-hour decreases with the size and usage of the genset, the most important price determinant being size. The light industrial user pays the equivalent of US$0.18 per kilowatt-hour, which is approaching UEB charges (and is certainly close to the long-term marginal cost of new UEB generation). Considering the reliability factor, it is little wonder that so many Ugandan industries connected to the grid purchase and use their own generators.

Table 5-2. Private Generators: Medium Load Assumptions

Application	*Unit of Measure*	*Household*	*Household*	*Dairy*	*Light Industry*
Size	kVA	1.5	15	50	150
	kW	1.2	12	40	120
Lifetime	years	5	7	10	15
Discount Rate	%	12	12	12	12
Operations	hours/day	2	4	6	6
	hours/year	730	1,460	1,716	1,716
	kWh/year	876	17,520	68,640	205,920
Capital cost (CIF, duty, tax & installation)	US$ installed	1,000	7,500	17,500	48,750
	US$/year	267	1,589	3,013	7,021
	US$/kWh	0.30	0.09	0.04	0.03
Fuel consumption	liters/hour	0.5	4	10	20
	liters /kWh	0.42	0.33	0.25	0.17
	liters /year	365	5,840	17,160	34,320
Fuel cost	US$/liter	1.00	0.80	0.80	0.80
	US$/year	365	4,672	13,728	27,456
	US$/kWh	0.42	0.27	0.20	0.13
O&M, lubes, and spares	US$/year	50	375	875	2,438
	US$/kWh	0.06	0.02	0.01	0.01
Annualized costs	US$/year	682	6,636	17,616	36,915
	US$/kWh	0.78	0.38	0.26	0.18

Note: This table assumes that households use their systems primarily in the evenings, and that households with the petrol-driven 1.5kVA systems are worse off than those with the diesel-driven 15kVA systems. The table also assumes that dairy and light industry might receive some UEB electricity via a grid connection; hence, their hours of use are relatively low.

Source: MNRE/ESMAP team.

5.14 Table 5-3 assumes that these private gensets are now used in more of a base-load mode—that is, they are functioning most of the time. This is in contrast to back-up or peak load, when the generator functions only at certain limited times when it is needed. In particular, it is assumed that the consumers are not connected to the grid, choose not to use the grid, or do not receive grid electricity. As usage increases, household costs per kilowatt-hour decrease more than those of dairy and light industry. The latter stems from the assumption that both gensets are sized according to the equipment/demand load, and that there can be few economies from running longer hours.

5.15 This is not an unrealistic assumption. Among the 33 private owners of diesel and petrol gensets interviewed, average operating loads were on the order of 75 percent—which is both fairly high and fairly close to the optimum for diesel and petrol gensets (in terms of fuel and equipment efficiency). This is shown in Table 5-4.

Table 5-3. Private Generators: Base Load Assumptions

Application	*Unit*	*Household*	*Household*	*Dairy*	*Light Industry*
Size	kVA	1.5	15	50	150
	kW	1.2	12	40	120
Lifetime	years	3	5	7	10
Discount Rate	% per year	12	12	12	12
Operations	hours/day	4	8	8	8
	Hours/year	1,460	2,920	2,288	2,288
	kWh/year	1,752	35,040	91,520	274,560
Capital cost (CIF, duty, tax & installation)	US$ installed	1,000	7,500	17,500	48,750
	US$/year	399	2,002	3,707	8,393
	US$/kWh	0.23	0.06	0.03	0.02
Fuel consumption	l/hour	0.5	4	10	20
	l/kWh	0.42	0.33	0.25	0.17
	l/year	730	11,680	22,880	45,760
Fuel cost	US$/l	1.00	0.80	0.80	0.80
	US$/year	730	9,344	18,304	36,608
	US$/kWh	0.42	0.27	0.20	0.13
O&M, lubes & spares	US$/year	50	375	875	2,438
	US$/kWh	0.03	0.01	0.01	0.01
Annualized costs	US$/year	1,179	11,721	27,942	57,551
	US$/kWh	0.67	0.33	0.24	0.16

Source: Mission/MNRE data.

Table 5-4. Loads and Load Factors for 33 Private-Generator Consumers, 1997

Size	*Number Interviewed*	*Rated kW*	*Utilized kW*	*% Utilized*	*Hours/day*
>200 KVA	12	3,476	2,345	74.8	6.9
50-200 kVA	10	604	396	72.7	8.6
<50 kVA	11	103	66	86.3	5.5
Total/avg	33	4,183	2,807	77.4	7.0

Source: MNRE, SDC.

5.16 In the 12 districts surveyed, the team found that load factors for generators were higher than anticipated. Indeed, although smaller gensets were used for fewer hours per day than larger ones (5.5 hours per day compared to 8.6 and 6.9), they were better matched to demand, with high load factors. However, the average load factor for large gensets was not bad, averaging well above 70 percent.

5.17 This has several implications. Unlike earlier assumptions, this indicates that there is not a lot of surplus power out in non-grid areas to sell to consumers without their own gensets. It implies that gensets are being purchased to meet demand in a fairly good technical and financial manner. It also indicates that, while there is scope in rationalizing power investments in larger generators serving more consumers (see below), current investments and use are not particularly bad from the consumers' point of view.

Photovoltaics

5.18 Increasing numbers of consumers are turning to photovoltaic electricity (PV) to meet their off-grid needs. Several thousand PV solar home systems have been installed since the early 1990s.[23] Ugandan PV-industry sources indicate that during the last year there has been an upsurge in the purchases of small (24 watts peak) kits by consumers. The kit generates enough electricity to power three 8-watt lights and a radio. Industry spokesmen indicate that more than 100 of these units were sold each month in 1997.

5.19 The main reason for the large interest in the kits are their relative cheapness: one kits costs about US$500, plus another US$100-150 for transport and installation. While this system is not very robust and will have a relatively limited lifetime, it is inexpensive, easy to use, and—like a car battery—readily available. The cost implications of such a system are on .the order of US$27 per watt,for a total installed price of US$650 per system.

5.20 Table 5-5 provides a fairly simplistic set of assumptions about, and calculations for, a simple 24–watts-peak solar home system in Uganda. It assumes that the least expensive option will have a shorter lifetime, whereas the more expensive one will last longer because of its better balance of system (BOS), battery replacement needs, and utilization. This provides values per kilowatt-hour for PV, with the lowest for the PV systems that are more expensive but better designed and maintained. In light of experience elsewhere in the developing world., it is safe to assume that the

[23] Perhaps more have been imported "extra-legally" and installed by local technicians or the owners themselves.

figures in both cases are conservative, and that the lifetime of the cheaper system will be longer than defined above, thereby reducing the kilowatt-hour cost.

Table 5-5: Photovoltaic Systems: Price, Load, and Cost Assumptions

	US$ price per unit	
Specification	*$650*	*$1,000*
Unit size (Wp)	24	24
US$/Wp	27.08	41.67
Lifetime (years)	4	10
Hours use per day	3	3
Days per year	365	365
Total hrs operation	4,380	10,950
Load factor	0.6	0.6
Total watt hours	63,072	157,680
Total kWh	63.1	157.7
US$/kWh	10.31	6.34

Source: Various.

Summary

5.21 To summarize the current state of costs and benefits for off-grid electrification, Table 5-6 sets out some comparisons for review. (See Annex B for non-grid assumptions.) Taking all forms of rural electrification into consideration, a conservative estimate is that about one-half of all Ugandan households use electricity on a daily basis. Excluding households using dry-cell batteries and those connected to the UEB grid, an estimated 108,000 rural and peri-urban Ugandans get their electricity from fairly sophisticated, self-arranged systems. Non-UEB households pay between 3.5 and 64 times as much per kilowatt-hour (excluding dry-cells) as UEB consumers. Excluding UEB, rural Ugandans spent more than US$100 million on rural electrification in 1996—more than all UEB clients combined paid to UEB in 1996. If only a fraction of those expenditures could be harnessed to invest in more rationalized, collective electricity systems, the benefits would be enormous.

Table 5-6: Summary of Current Rural Electrification Costs and Benefits (US$ expenditures on an annual and household level)

Rural Electricity supply option, 1996	*Number of households (000 hh)*	*Cost kWh (US$/kWh)*	*Consumption per household (kWh pa)*	*Cost per household (US$ pa)*	*Total Costs (US$000 pa)*
UEB isolated generators	1.45	0.10	921	92	134
UEB grid-connected rural	58	0.10	720	72	4,176
Dry-cell batteries	1410	400	0.0018	72	100,000
Lead Acid (car) batteries	101	3.00	40	120	4,075
Petrol gensets	0.39	0.70	876	615	237
<75 kVA gensets	1.70	0.35	17,520	6,118	10,414
PV households	5.0	6.34	158	100	500

Note: See Annex B for non-grid assumptions.
Source: UEB, MEMD, Mission.

5.22 Table 5-6 shows clearly that dry-cell purchase accounts for the bulk of this expenditure. However, rural consumers spent more than US$4 million on SLI batteries in the same year, a further US$10 million on diesel and petrol gensets (including capital, fuel, and operations), and a further US$0.5 million on photovoltaic systems (including installation and batteries) in the same year.

Costs and Benefits for Rationalized Rural Electrification

5.23 Any examination of off-grid electrification in Uganda quickly highlights the fact that virtually all non-UEB investment in electrification is done in a private, autonomous, and independent fashion. There is almost no collective action to achieve any economies of scale or reductions in cost. Each person purchases her or his car battery and charges it at a charging station operated by the owner-operator; nor is there evidence of any collective purchase or sale of private diesel or petrol gensets.

5.24 This highlights the possibilities for reducing costs per kilowatt hour and per consumer. A number of opportunities exist for reducing these costs. In the first instance, larger diesel generators could be purchased to serve a number of consumers in the immediate surroundings of the generator. Clearly, thousands of rural consumers would be willing to pay for rural electrification if the costs are less than the those associated with the use of SLI batteries.

5.25 Although everyone would like to have UEB-supplied electricity at UEB prices (with reliability, of course), it will soon become apparent that UEB will not be able to provide, or be in the business of providing, electricity to rural consumers. The government is in the process of allowing private decentralized, isolated generation and distribution to take place. Therefore, opportunities will exist for investors to develop collective systems, mini-grids, and the like. As the above analysis shows, although they will surely have to charge tariffs higher than those of UEB, they will be able to invest in large diesel generators and supply electricity at prices far below the cost of operating individual petrol gensets (i.e., greater than US$0.60 per kilowatt-hour) and far below the price of SLI batteries. Indeed, they will be able to charge SLI batteries, and perhaps even reduce the costs of these charges as they realize income from other sources.

5.26 Opportunities will also open up, albeit to a limited extent, in the field of electricity generation from biomass wastes, particularly wood wastes/residues and coffee husks. However, given the wide dispersion of mills, the opportunities for installing electricity-generating systems using these residues will be limited. Moreover, given the isolation of most of these mills, there will be very few opportunities to sell power to others. However, battery charging will be possible in these situations.

5.27 The greatest renewable energy opportunities lie with small-scale hydropower and, in particular, solar energy. Considerable scope exists for hydropower, although far more work on surveying and economic analysis needs to be undertaken before much more development can occur. Moreover, small hydropower is relatively site-specific. That is, demand has to be relatively close to points of supply, and while the development of small hydropower could benefit tens of thousands of rural Ugandans, its benefits will be geographically limited.

5.28 Photovoltaics, on the other hand, offer great hope for meeting rural electricity demand. Although the costs per kilowatt-hour are higher than those for SLI batteries, the convenience and flexibility of a PV home system is much greater. If developments in Zimbabwe or Kenya are any guide, it is quite likely that PV will soon "take off" in Uganda, supplying tens of thousands of households with electricity.

5.29. The costs of each of these alternatives will drop as more systems are developed. The benefits will increase in the same fashion. Uganda has already developed an elaborate, extensive rural electrification system in the face of international and national indifference. With current government and donor strategies coming on line, it is expected that Uganda's rural electrification will accelerate to the benefit of many more of its citizens and to the nation as a whole.

6

Recommendations and Conclusions

6.1 Ugandans have achieved a substantial level of rural electrification during the past decade without government or donor encouragement and intervention. Private capital and capacity have been mobilized successfully on a large scale without draining scarce public resources. Ordinary citizens and businesses have invested large sums of their own money in solutions that, while frequently not optimal, nevertheless served their purposes.

6.2 Hundreds of thousands of people already pay a price for electricity that exceeds the levels necessary to finance grid extension and new capacity. They have no arrears or defaults on payments for rural electricity supply. However, these high prices for non-grid electricity could considerably be reduced and electricity could be provided to many more rural households and businesses. This would require better organization on the part of suppliers, a supportive institutional framework, and an accessible financing mechanism. Under these conditions it is likely that these private investments can be accelerated and be put to better use.

The Institutional Framework

6.3 The ideal institutional framework would play a supportive, regulatory role in developing rural, decentralized electricity by:

- Developing "rules of the game" for rural electrification, including the roles each set of stakeholders should play, and under what conditions;
- Playing the arbitrator between competing interests to ensure that (1) the rules of the game are followed and (2) the market stays open and receptive to new investors, particularly small-scale investors; and
- Monitoring and evaluating the progress of development in the sector, promoting the "success stories" so that others can learn from them.

6.4 The framework would also serve as a channel for national, international, and private technical assistance and training for investors, consumers, and other key stakeholders in the rural, off-grid electricity sector by

- Serving as a clearinghouse for investors and consumers by providing them with key information (financial, legislative, legal, licensing, etc.) on how to participate, and
- Providing the public with information on how they can participate and the nature of their rights and responsibilities in the sector.

6.5 Finally, the framework would promote rural electrification to international donors and investors to raise capital and carry out projects. This would give local banks and financial institutions the confidence and support necessary to play their role of raising capital for financing the sector.

Rural Electrification Support Unit

6.6 These efforts could take on a number of forms. Experience in other countries suggests that it would be best served if a small, autonomous, private "rural electrification support unit" or "national rural electrification association" were formed by key stakeholders and players. Local and international donors and investors should play an important role in creating the unit. The unit's responsibility would be to develop the agenda for, and actual activities in, rural electrification. As such it would bring together actors such as beneficiaries, donors, implementing agencies, and financial institutions.

6.7 The unit should not be in the business of financing rural electrification, as this should be channeled through selected financing institutions for on-lending to implementing agencies or firms. A rural electrification financing mechanism could be established, similar to what is being done in Cameroon. This fund should be financed on a sustainable basis by the Ugandan government (assisted by UEB, donors, development agencies, etc.), and it should be managed by one or more local banks. The rural electrification unit would then be responsible for allocating monies from this fund to leverage contributions from other actors for rural electrification projects.

6.8 The unit would work closely with the Ministry of Energy and Mineral Development's Energy Department as well as UEB, but would ideally be independent of both. It could have a small pool of funds to carry out training, feasibility studies, sector studies, technical studies, workshops, seminars, public education, and, perhaps, pilot project investments co-funded by investors or donors. Most of these activities would need to be co-financed by the beneficiaries.

6.9 The Ugandan government sees rural electrification as a major component of integrated rural development, and its interest goes beyond a mere policy setting: it is likely to provide long-term financing for rural electrification programs and projects. Such activities should be implemented via the rural electrification support unit, which will identify the appropriate actors. Ideally the government would provide funding for the rural electrification fund.

6.10 The government can also support rural electrification by restructuring and liberalizing the electricity sector. This would include

- Allowing qualified operators to generate electricity in rural and peri-urban areas and sell it to third parties at mutually agreed prices;
- Allowing the national grid to be used for the transport of electricity, for a reasonable fee, to enable generators to sell to willing buyers at any location; and
- Providing tax and other fiscal incentives for the creation of mini-utilities.

6.11 One of the first activities would be to bring together all key stakeholders, including all current and potentially interested rural electricity generators, to decide the precise institutional setup. If it is decided to form an association, then it will be necessary to elect a board of directors, appoint an executive, and so forth. An association would have the merit of being guided from the bottom up. However, there is currently no evidence of any grassroots movement in this direction. Experience in the coffee, tea, and cotton sectors in Uganda demonstrates the creation of an association can be beneficial for all actors involved. If it is decided to create a rural electrification unit, this will provide an opportunity to quickly create capacity and proactively develop activities in a more top-down manner.

Institutional Issues

6.12 Regardless of the type of institutional support for rural electrification, the benefits are apparent. Larger, more-commercial electrification—whether brought about through small private utilities, co-operatives, local governments, or hybrids—would reduce the costs of electricity development and delivery. This ultimately will require the formation of "mini-utilities," no matter their form. Government and donors should encourage the formation of these mini-utilities in order to reduce costs and make electricity accessible to an even larger consumer base.

6.13 The creation of mini-utilities is necessary if Uganda's indigenous energy resource base, whether small hydropower or biomass, is to be used on a larger scale. To date, this has not occurred because of a lack of institutional capacity and support, a lack of incentives, an inability to take risk, and the lack of finance to develop the mini-utilities. The current study has shown that individuals can raise relatively large amounts of capital for investments that serve themselves and their businesses. However, the nature of substantial and systematic electricity development, and the level of institutional organization and management required, is in a completely different league than setting up a single 15-kilowatt household genset, or taking that generator and setting up a business to charge 100 SLI batteries a month. Whether the facility in question is a small hydropower plant, a relatively large wood or agricultural waste electricity generating station, or even a relatively large diesel generating station, the following institutional issues need to be addressed:

- **Political risk.** Investors must be assured that if they invest in an electricity generating plant, they will be able to charge commercial fees, use existing infrastructure (i.e., the grid), and to sell to whomever they want at reasonable conditions, without fear of political interference.
- **Access to finance.** Investors need to be able to raise capital for electricity investments. They also need to know that the investments they make, and the plants they build, are secure from all but financial risk—including tenure, access, license, and other operating issues. Many local risks can be overcome through the right institutional setting and through community involvement in the design, planning, and operations of the system.
- **Awareness.** Currently the right to generate and sell electricity at virtually any price exists in Uganda, so long as the UEB grid is not used, and with permission from the MNRE. However, very few people know this. Public and potential investors need to know what is permitted under the law, and the must be encouraged to do it. (Individual investors were already active enough between 1993 and 1997 to raise more than US$25 million in totally private

finance for auto-generation equipment.) In addition, consumers need to know what their options are, where they can get information, what their rights are under existing legislation, and how they can mobilize to raise capital and get into the business themselves.

- **Community involvement.** As cited in almost all district interviews with leaders and decision makers, local communities want, and should, be involved in the electrification process.
- **Support from local authorities.** Uganda has decentralized a wide range of public service functions, and now places a great deal of emphasis on local government. Local governments have considerable authority to raise money, and they actually raise more revenues from the energy sector than from any other source.[24] They are therefore crucial to the success of any rural electrification program. In fact, a substantial number of local governments could actually be investors in such a program.
- **Technical assistance.** System design studies, simple feasibility studies, appropriate technology, and access to technical know-how are all critical to both a rapid expansion of Uganda's rural electrification a reduction in costs to consumers.
- **Training.** Combined with technical assistance, training can raise the skill level to encourage investment in electricity systems, both new technologies and new systems.

Financial Access

6.14 Experience in other parts of the world, including Europe and North America, shows that banks and non-banking financing institutions are reluctant to lend to the power sector, and even more so where renewable energy is concerned. There are several ways to overcome this reluctance, ranging from subsidies to guarantees and from grants to guaranteed purchase schemes. Each of these carries risks for the investor and/or for the government and each may distort the marketplace if not properly applied. Grants are often abused or used in unintended ways; subsidies tend to favor the rich and well-connected; guarantees tend to accomplish the same as subsidies, and end up being politically abused; and guaranteed purchase is beyond UEB's reach.

6.15 Some form of guaranteed finance should be developed through which commercial banks are encouraged to finance rural electrification schemes or projects that meet certain agreed criteria. Interested donors can provide banks with loan capital, even grants, to on-lend to qualified investors in the power sector on regular lending terms. This should be subject to the existence of a proper rural electrification framework.

6.16 By way of assistance to the local banks that manage the rural electrification financing mechanism, one of the roles of the rural electrification unit discussed earlier should be to suggest which projects to support and how much support from donor funds should be awarded.

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[24] See, e.g., Forest Department, *Woody Biomass Energy Study*, 1995.

The Way Forward

6.17 The status of rural electrification can be summarized as follows: rural Ugandans decided not to wait for public service through UEB, but invested en masse in their own supply sources. This has been expensive, uneconomic, and inefficient, but has nonetheless proven that people are ready for it. From the technical and financial points of view, it is fairly clear what needs to be done better in order to improve all forms of rural electrification. From the social and organizational standpoints, however, many uncertainties and information gaps remain. Fortunately, the energy expenditures that people are currently incurring suggest that a strong grassroots impetus already exists for rural electrification.

6.18 In areas with grid supply, after supply shortages no longer occur, low-cost (UEB grid) connections and tariffs for different service levels should be promoted, including progressive lifeline tariffs of the type applied in successful rural electrification programs in Thailand and elsewhere. This will clearly be the least-cost supply option, even if UEB tariffs increase by, say, 50 percent.

6.19 At the same time, in non-UEB grid areas the following different approaches should be promoted:

- Access via existing, private auto-generators[25] with available excess capacity;
- Village-based solutions, whereby either a private supplier, a local government, or a community- or cooperative-based supplier generates and distributes electricity or provides electricity services; and
- Individual household solutions, including solar equipment and batteries charged from a central charging station.

6.20 The village-based solutions should be based on the least-cost supply option, which will depend entirely on (1) the demand characteristics of each village and (2) the resources available there to generate electricity (e.g., hydro, wind, biomass residues, diesel).

6.21 To fill the information gap, it is recommended that the following be carried out quickly and systematically to develop more experience with the different possible institutional approaches:

- Create, on a test basis, a financing mechanism for rural electrification. Identify an organization to run this mechanism until the organizational structure for a more permanent rural electrification support unit can be identified. This would require (1) extensive collaboration with all institutions and firms already interested or working in this field and (2) the creation of links between potential clients, potential electricity suppliers, financing institutions, donors, the government, and other interested parties. On the basis of this experience, recommendations should be made for the institutional set-up to promote rural electrification and to operate the fund on a larger scale.
- Launch immediately a few demonstration projects, particularly village-based ones. These projects should be selected on the basis of (1) contributions from beneficiaries and private sector participants and (2) sustainability—the higher the degree of self-financing, the lower the subsidy required.

[25] People or firms that generate their own electricity.

- In collaboration with donors or NGOs and in consultation with affected communities, prepare a plan for a larger rural electrification investment program.

6.22 Donors can help by making technical assistance and support available to promote the development of, and private investment in, rural electricity generation and distribution along the lines discussed here. Only if a systematic effort is launched to address rural electrification on a large scale will rural Ugandans be able to enjoy the benefits of modern sources of electricity at reasonable costs.

Annex A

List of Contacts

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Annex B

Demand Survey Sample

1. Uganda consists of 4 regions and 38 districts. A total of 3,434,177 households live in the country, of which 446,980 households in the urban areas; the vast majority (2,987,197 households) live in rural areas. Almost all of these rural households (2,929,102 households) have no access to electricity. However, due to political instability in the Northern region 5 districts in the north with a combined population of 378,564 households were excluded from consideration for the survey. As a result, it is estimated that there are about 2,550,537 unelectrified rural households living in 33 districts in all 4 regions. Out of the 33 districts, for the survey only 12 districts were considered (see below). The number of unelectrified rural households in the 12 selected districts consisted of almost half –46 percent- of the total unelectrified rural households. Their combined population was estimated at 1,186,818 households.

2. The universe for the sample design included trading centers/towns (peri-urban) and their surrounding rural villages in the 12 selected districts. Trading centers/towns and villages in the remote areas of these 12 districts were excluded because they are considered to have low market potential for renewable energy and/or other modes of rural electrification. It is estimated that about half (47 percent) of population in these 12 districts live in trading centers/towns (peri-urban) and their surrounding rural villages accessible by car. As a result, the universe of the sample frame is estimated to be 552,419 households.

3. The number of households living in the areas accessible by car were estimated because the exact number of such households does not exist. The estimation methods were based the examination of population density of all districts in the country (excluding five districts in the Northern Region). In general, population density in Uganda is relatively low while road networks are relatively reasonable given that Uganda is considered one of the poorest countries in the world. About 40 percent (13 out of 33 districts) of the districts have population density between 51-100 person per square kilometers. The rest are distributed almost evenly in the ranges of 101 to 150, 151 to 200, 201 to 250, and 251 to 300. The only exception are Kampala and Jinja, which are actually the two largest cities in the countries. Given these densities, for any district with a population density less than 51 persons per square kilometers it is assumed that only a quarter of the population live the areas accessible by car. On the contrary in the districts with the highest population density i.e., density ranges between 251 to 300, it is assumed that three quarter of the population in these districts live in the areas accessible by car (i.e., trading centers/towns (peri-urban) and their surrounding villages).

Sampling Methods

4. A three-stage sampling method was adopted. In the first stage, 12 districts were selected from 4 regions—3 districts from Central, 3 from Western, 4 from Eastern and 2 from Northern (see Table B-1). These districts were selected to represent their respective region. The selection was based on several factors, including technical feasibility for renewable energy applications, potential market, and prior knowledge regarding the general characteristics of the district including population density, agricultural activities, and socioeconomic information of the population. It should be noted that the sample districts selected for the northern region were limited only to the southern part of the region due to political instability.

Table B-1. Districts Selected for the Survey from Each Region

Central	*Eastern*	*Northern*	*Western*
Mubende	Kamuli	Apac	Kabarole
Mukono	Mbale	Lira	Kasese
Rakai	Pallisa		Rukungiri
	Soroti		

Source: MNRE/Mission data.

5. In the second stage, 15 villages and trading centers/towns were selected from each districts.[1] Guidelines for systematic selection of unelectrified trading centers/towns and villages were established for field supervisors to follow. For example, field supervisors had to randomly select (usually flip coins or lottery process) direction when he/she arrived at the cross road or intersection, and randomly select which side of the road to select the areas or conduct the survey. Furthermore, field supervisors were also instructed to discuss the selected districts beforehand with appropriate local officials to discuss the existing electricity distribution networks and plans for electrification. After consulting with local officials, the supervisor selected the area for the sample trading centers/towns and villages. A total of 15 villages and trading centers/town (broken down to 7 and 8 for one district and alternate 8 and 7 for another district) were randomly selected. In addition, for each of the trading centers or towns, 7 or 8 surrounding unelectrified villages with which they have economic and/or trading relations were randomly selected.

6. For the final stage of selection, five or six households would be randomly picked from each village and each trading center/town. Interviewers were instructed to follow an established systematic random walk process. Specifically, one interviewers would start walking from each end of the trading center/town or village (two interviewers were assigned to work in the village or trading center/town for and moved on to another location) from the different side (i.e., left side) of the main transportation route. Each interviewer would randomly pick three households (one at the beginning one in the middle and the last one toward the end of the village or trading center/town) locating on the left of the main transportation route. If interviewer came across an intersection he/she would make a left turn and continue randomly picking the rest of the households for interview.

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1 Villages and trading centers/towns were selected in the field due to unavailability of information on electricity distribution network and plan. Furthermore, listings were not available of trading centers/towns and villages in the selected districts that could be used as a sampling frame.

Extrapolation of Results

7. The universe for the survey consists of about 550 thousand households in 12 districts. (See Table B-2 for details of the survey sample and the results of the extrapolation.) In order to extrapolate the results to the entire population in these 12 districts, the following assumption was made for the users of batteries: the density of battery users in the remaining areas of the 12 districts (by region) is only 40 percent of the density in the covered households (see columns 6, and 7 in Table B-1). Column 6 gives the estimated total number of battery users in the non-covered households, and column 7 the total in the district (covered and non-covered households). This is a reasonable and conservative estimate; actual numbers are likely to be higher.

Table B-2. Summary Results and Extrapolation

Survey					*Extrapolation*		*Estimation*	
car batteries								
	Total rural hh in 33 districts	Total rural hh in 12 district	Covered by survey	car batt used (sample)	Car batt in rest of 12 districts	total batts in 12 districts	Car batt in remaining 21 districts	total in 33 districts
East	749,748	380,717	218,852	11,048	3,268	14,316	5,589	19,905
West	818,549	265,222	111,602	8,397	4,623	13,020	12,490	25,510
Central	781,980	343,308	152,815	20,550	10,247	30,797	17,697	48,494
North	198,053	197,570	69,150	3,977	2,954	6,931	8	6,940
Total	2,548,330	1,186,817	552,419	44,194	21,093	65,287	35,784	101,071
				% of hh with car batt in sample	% of hh with car batt in rest of 12 districts 1)	% of hh with batt in 12 districts	% of hh with car batt in remaining 21 districts 2)	total batt coverage
East				5.0	2.0	3.8	1.5	2.7
West				7.5	3.0	4.9	2.3	3.1
Central				13.4	5.4	9.0	4.0	6.2
North				5.8	2.3	3.5	1.7	3.5
Total				8.0	3.2	5.5	2.4	4.0
					1) assuming coverage in the remaining households in the 12 districts = 40% of the sample			
					2) assuming that coverage in the remaining 21 districts is 75% of that in the 12 districts			
drycell batteries								
	Total rural hh in 33 districts	Total rural hh in 12 district	Covered by survey	sample	12 districts - sample	12 districts	Remaining 21 districts	total in 33 districts
East	749,748	380,717	218,852	205,721	60,861	266,582	193,800	460,382
West	818,549	265,222	111,602	104,906	57,761	162,667	254,527	417,194
Central	781,980	343,308	152,815	143,646	71,625	215,272	206,302	421,574
North	198,053	197,570	69,150	65,001	48,286	113,287	208	113,494
Total	2,548,330	1,186,817	552,419	519,274	238,533	757,808	652,016	1,409,824
				% of hh with drycell batt in sample	% of hh with drycell batt in rest of 12 districts 1)	% of hh with drycell batt in 12 districts	% of hh with drycell batt in remaining 21 districts 2)	total drycell batt coverage
East				94.0	37.6	70.0	52.5	61.4
West				94.0	37.6	61.3	46.0	51.0
Central				94.0	37.6	62.7	47.0	53.9
North				94.0	37.6	57.3	43.0	57.3
Total				94.0	37.6	63.9	47.9	55.3
					1) assuming coverage in the remaining households in the 12 districts = 40% of the sample			
					2) assuming that coverage in the remaining 21 districts is 75% of that in the 12 districts			

Source: Mission team.

Annex C

Detailed Supply Side Methodology

1. The World Bank-MNRE team adopted a straightforward strategy to obtain a detailed supply side profile. They first started by utilizing the wide range of seconday materials, reports and project papers that have been produced over the years. They then developed a program for interviews and visits. They first interviewed key respondents in Kampala, Jinja and Entebbe, representatives from industries, commercial establishments, energy consultants, government agencies, UEB, national trade associations, among others.

2. They developed a program for field visits and a set of questionnaires for interviewing district authorities, representatives of central government agencies, and key economic players in rural areas. They obtained lists of all industries and key enterprises. Interviews were conducted by telephone in the initial stages, in order to obtain as broad an information base as possible. Then, face-to-face interviews were conducted in line with the survey strategy summarized above. All in all, hundreds of representatives of the private, governmental and non-governmental sectors were interviewed.

Petroleum Power Generation Study

Methodology

3. The team first looked at imports, then at the importers, the consultants, the installers, the producers and the consumers. They developed questionnaires for each group, and distributed them. Most of the importers and distributors are in Kampala. They took a letter of introduction from the Commissioner of Energy and went to the companies. They left the questionnaires with them, and agreed when the questionnaires would be prepared. They did the same with the consultants, with covering letters, and delivered questionnaires. Their focus on imports included the type and sizes of generators brought into the country..

4. The team also went to the Uganda Manufacturers Association to obtain a complete list of members. They then stratified those members into large, medium and small enterprises. The team made over 100 telephone interviews to obtain information on whether or not members had standby generators, their capacities, how long they had been used, their frequency and duration of use. They matched these data by interviews of all suppliers and distributors of generating sets in Uganda. The team then obtained complete information from the Uganda Revenue Authority (URA)

on all imports of generating sets (also photovoltaic panels, equipment, wind generating equipment, etc.).

5. For the importers and distributors, they developed a list of eleven companies, of whom six responded with the questionnaires and interviews. They identified five consulting companies, of whom three responded to help with the survey. They then started following up, clarifying questionnaires and the objectives of the questionnaires.

6. To get at the consumers, they looked at UEB as one of the biggest consumers as they have many isolated plants not connected to the grid. They interviewed the Post and Telecommunications to get information. They wrote to Uganda Manufacturers Association (UMA). UMA did not have centralized information on those members who had generators, but they provided the team with a complete list of their members. The team then randomly selected a number of members and telephoned them to see if they had generators. Some of the information was obtained from telephone conversations regarding size, frequency of use. Additionally, some of these were followed up by questionnaires. They contacted milk plants up country and some industries.

7. The Department of Energy often works on energy audits with many of the Kampala based industries. Therefore, they already had information on the capacities and the frequency of use of a number of these industries. The DoE team has worked extensively in Kampala, Jinja and Entebbe, and have visited many of UMA's members' factories in the course of their energy efficiency work. Therefore, the team were able to stratify UMA members into:

8. The work up to this point, particularly suppliers and distributors took much longer than anticipated, as many people were reluctant to respond. However, the most important companies did respond, and the UMA members list proved invaluable for making contacts and for estimating the coverage of diesel standby generation, particularly in the three cities area.

9. The team carried out the following interviews & analyses, summarized in Table C-1:

- **large industries (50 or more employees):** Of the large industries, more than 90 percent of the industries have standby generators. The average capacity of generator amongst large industries is 0.5 megawatts. Approximately 43 members of UMA fit into this category, which would imply that, at a *minimum*, they have 19.4 megawatts installed as standby diesel generators. These data do not include the large hotels which include the Grand Imperial, the Sheraton, the Fairway, Lake Victoria Hotel and Hotel Equatoria, some of whom have generation capacities of over 0.7 megawatts. The survey determined that these hotels account for 3.3 megawatts of installed back-up generation, bringing the minimum generating capacity in the three towns amongst large industries and businesses to over 22.7 megawatts.
- **medium industries (30 to 50 employees):** Of the medium industries, more than 80 percent of these industries have diesel standby generators. The team estimated that UMA has at least 39 members in the three cities (Kampala, Jinja and Entebbe) that fit this "medium" size stratum. The average minimum installed capacity for their generators is 100 kilovolt-amperes. At least 3.1 megawatts (and very possibly more) of installed diesel generation capacity is found with these medium industries.

- **small industries (20 or fewer employees):** Of the small industries, more than 70 percent of these have standby diesel generators. The team estimated that there are at least 25 industries in this category in the three cities. The average minimum installed capacity for these generators is on the order of 50 kilovolt-amperes. Therefore, at least 0.875 megawatts of installed capacity.

10. This shows that a minimum of 26.7 megawatts of diesel standby generation can be found in the industrial and large hotel sub-sectors in Kampala, Jinja and Entebbe. These figures were verified by the team through interviews of suppliers and distributors, by the URA statistical records, and by selected interviews of these industries and enterprises.

Table C-1. Minimum Autonomous Installed Petroleum Generators in Uganda, September 1997 (in megawatts installed)

Category	*Number*	*MW Installed*
Urban		
Large Enterprises	43	19.4
Medium Enterprises	39	3.1
Small Enterprises	25	0.9
Large Hotels	5	3.3
Residential	>300	3.0
Subtotal: Urban		**29.7**
Rural	150	11.3
Total		**40.9**

Source: Team estimates.

11. The **institutional and commercial sector** includes small hotels, restaurants, retail and wholesale outlets in Uganda. The average size of standby generator (primarily petrol-driven) in this group is approximately 1.5 kilovolt-amperes, used mainly for lighting. The team estimate from sales figures and URA statistics that there at least 150 of these enterprises have this size standby generator in the three cities. This would indicate that approximately 0.5 megawatts of standby petrol generating capacity is found within the three large towns. URA statistics, and selected interviews confirmed these estimates.

12. The **residential sector** is more complicated to study as there is such a wide range of residences with a wide variety of sizes of generators. The category of residential consumers who utilize standby generators comprise embassy staff, personnel working for international NGOs, multinationals and donor agencies. The average capacity of these generators is hard to estimate as some embassies and donor agencies provide generators of up to 50 kilovolt-amperes, while the smaller NGOs provide generators in the range of 3 kilovolt-amperes. URA statistics show that these residences have over 3.0 megawatts of standby generation on hand in Kampala alone.

13. These figures should be taken as an absolute minimum of operating capacity. URA figures show at least 60 megawatts of diesel and petrol generators imported from 1993 to 1997. This would indicate that the team's estimates are very conservative. Subsequent estimates by the MNRE and UEB themselves put this figure at 80 megawatts of autonomous genset capacity, much of it in the industrial sector. While much of this capacity was originally imported for standby purposes, it is increasingly used for base load, as UEB are unable to cope with rapidly escalating demand.

Rural Surveys

14. The team hoped to get information on the location of sales of generators in rural areas from the importers and distributors to focus on areas for surveying. Unfortunately, this information was not available. Therefore, the team adopted another strategy to find up-country petroleum product generation. Additionally, drawing upon the Uganda Revenue Authority's list of companies, the team was able to identify up-country members who have either standby generation, or generators which meet their base load requirements. While the URA list does not provide information on size of each generator imported, the value provides a gross estimate of the capacity brought into Uganda for rural electrification over the past 5 years.

15. For the rural surveys, the team chose regions and districts on a basis of such factors as the growth of industry, the growth of new activities such as milk production, agro-processing, among others. This formed the basis for a stratified sampling of rural areas in Uganda. The team made out a work plan for the areas to visit. These included the following districts in the West and Southwest:

- Masaka
- Mbarara
- Kabale
- Rukungiri
- Hoima
- Kibale

They then selected eastern districts including the following:

- Jinja
- Tororo
- Iganga
- Bujiri
- Mbale
- Kapchorwa
- Palisa.

16. The team further visited Mukono, Metiyana and Mubende in central Uganda. Each of these district centers are connected to the UEB grid. The team made site visits and conducted interviews in 12 districts outside Kampala, Entebbe and Jinja in all. Thirty-three detailed interviews were conducted with enterprises. Additionally, UEB provided the team with information on isolated diesel generation in Arua, Nebbi, Koboko, Moyo, Adjumani, Kitgum and Moroto.

17. The team interviewed district and other local leaders, and representatives of national government. In discussions with rural and district officials, it was repeatedly noted that "to effectively disseminate rural electrification programs, there is a need to involve the local leaders right from the inception of the programs." District and other rural leaders consider electricity one of the higher priorities for development, noting that electricity is a necessary input to schools, to the health sector, to the economically productive sector, and to people's daily lives in households.

18. This is reinforced by the economic costs of load shedding, of unreliable and highly variable power supplies, and of the lack of power. Problems of load shedding in all up-country centers are considerable. Many centers only receive electricity for a few hours per day. This is not sufficient to operate an industry, a processing plant or any economic activity which requires constant supply. Periods of load shedding are not known in advance, which makes it very difficult for establishments to plan their economic activities.

19. In total, sixteen districts were selected and twelve were visited. The team developed a list of some establishments, including hospitals and schools, which were visited. However, the other establishments surveyed were located in the field on the basis of discussions with district leaders. The team then visited the establishments with the questionnaires and interviewed them.

20. In total, the team administered 33 questionnaires for petroleum generated electricity in all areas of the country visited. All respondents had generators. For all industries, with the exception of Kapchorwa and Rusheri, the generators were standby, with the establishments connected to UEB and using the generators when UEB power is not available. Several residential consumers were visited who relied exclusively on their own generators.

21. Maintenance services are a major constraint. There is little technical capacity to service and repair generators in many areas. This leads to significant losses and hardships.

Examples of Possible Independent Generating Plant

22. **Mbarara:** A key district for any pilot activity utilizing excess diesel generating capacity is in Mbarara. For example, a dairy plant (GBK Dairy Ltd.) has two generators, 1 x 511 kilovolt-amperes (408 kilowatts) and another generator of 100 kilovolt-amperes (80 kilowatts). The plant's demand is a maximum of 180 kilowatts. Therefore, the plant has a surplus capacity of 300 kilowatts which could be sold to the grid or other consumers. It is connected to the grid, but because of the sensitivity of their processing equipment, they do not use the grid. They use their two generators for base load, for at least 8 hours a day, sometimes longer. The Dairy Corporation in Mbarara township have an installed capacity of 180 kilowatts, of which they require only 125 kilowatts. They are connected to the grid, but they use their generators for base load due to the sensitivity of their processing equipment.

23. Furthermore, there is Banyankole Kweterana Coffee Factory in Njeija, Mbarara District which has a 180-kilowatt generator for their coffee plant. They only require less than 100 kilowatts of this plant. A sister plant has a generator of 160 kilowatts, of which they utilize 80 kilowatts. All these are connected to the grid and could sell their surplus to UEB.

24. **Kapchorwa:** There is a diesel generator of 0.8 megawatts operating a coffee processing plant and a maize mill at Sebi Elgon Co-operative Union, Ltd. The processing plant and mill utilize less than 50 percent of the capacity of the two big generators and a small one. The total capacity of this one plant surpasses UEB's entire generating capacity in Kapchorwa town.

Small Hydropower

Methodology

25. The team first read the literature to determine the existing power stations and the sites for potential hydropower within the range of the study. They spoke with experts in UEB to define how many mini-hydro schemes were registered with UEB. The team then developed questionnaires. They selected the power stations to be visited. Only four power existing power stations fall within the category of 2 megawatts or less. The team visited the Maziba and Kazizi in the West, and River Ruizi in Mbarara. In the east the team visited a small installation on the Sipi Falls. They looked at a number of falls around Mt Elgon in the east, including Simi, Sipi, Siti, Sezewa, etc.

26. The team then looked at different studies for different sites below 2 megawatts. They then tried to obtain data on those sites. They looked at hydraulic data, how much the projects would cost, etc. They analyzed the information to try to determine the viability of the sites, using information on existing power stations, capital costs, availability of manpower for maintenance, installation, etc. The team also looked at the environmental impact of the sites. Their work showed that the viability of mini hydro is great in Western, south western and around Mt Elgon.

27. Numerous small hydro sites have been surveyed over the past one hundred years. As many as a dozen are currently in operation, exclusively for church missions and private enterprises. Several small and micro hydro sites were abandoned during the 1970s and 1980s during the period of massive civil unrest and economic disruption. Over one hundred micro-hydro (less than 100 kilowatts) sites have been identified during the past fifty years although none have been developed. Many lie far away from economic demand.

28. Several small hydro sites have been rehabilitated over the past seven years, including the site serving Kabale and Kisoro under UEB, and two Church of Uganda sites in Western Uganda. Considerable potential exists around Mt Elgon and western Uganda from West Nile to the Ruwenzoris.

29. The following secondary sources were utilized for the small hydro component:

- Godgrey Turyahikayo, E. Hatanga, Tom Otiti and Paula Kibirungi, *Renewable Energy Technologies Dissemination in Uganda, the Case of Small Hydro Power Plants.* African Energy Policy Research Network (AFREPREN), December 1995.
- Kennedy and Donkin Power, Ltd., and UEB, "Hydrology and Hydropower Potential of Non-Nile Rivers," in "Hydropower Development Master Plan: Part 1" (final draft), Volume 7. MNRE, July 1996.

- Uganda Electricity Board, "Electricity Consumption Forecast, Generation Programme, Final Report", in *National Electricity Planning Statistics* (NEPS), Volume 1.2. Electricité de France International, November 1992.

Photovoltaics

Methodology

30. Literature on solar in Uganda is very limited. The Department has carried out work for AFREPREN, but this has been very site specific. The team obtained information on trends in investment, costs, companies and installations. Questionnaires were designed by the team on the basis of the ESMAP terms of reference and the checklist. They designed the questionnaire to cover the entire spectrum of suppliers and distributors. They focused on seven major suppliers, although there are those individuals and companies who supply on an ad hoc basis.

31. Half the companies were very receptive and helped to fill the questionnaires in completely. They obtained a good picture and believe they captured the majority of systems imported.

32. They then interviewed government institutions, primarily from UPT, Uganda Railways and the MoH. They developed questionnaires which were completed by these. The team then interviewed the most important NGOs, including the URDT, who have installed a number of systems in Kibaale District (over 200 systems). The team wanted to visit Kasese, but were held back by the unstable security situation. However, they obtained information from SEFA on the Habitat program in Kasese (150 systems).

33. They looked more carefully at commercial sales by visiting households and institutions who bought systems on a commercial basis. More than 50 individual households and institutions were interviewed in

- Kabale
- Rukungiri
- Mbarara
- Masaka
- Mubende
- Kibaale
- Mutieno
- Jinja
- Mbale
- Tororo
- Kapchorwa.

The team visited hospitals, households and others to verify the information provided by the suppliers.

34. Most of the systems were installed either by NGOs or government institutions. Most were working quite well. A number were experiences problems due to the fact the systems were undersized. Also, virtually all systems (except hospitals and government institutions) were not using

deep discharge batteries. Rather, they were using car batteries. Households were basically satisfied with the poor choice of technology. This is the primary problem of the commercial companies, who lack the experience and the network to properly size the system and provide the right maintenance.

35. The private companies provided sales information on the number of units sold, although their cost data were not reliable. However, the field surveys provided good cost data, which were used to work out the average costs for different types of systems.

Wind

Methodology

36. Little investment in wind power has taken place in Uganda over the past 25 years. Wind mills for water pumping were fairly widespread in Uganda from the 1930s to the early 1970s.

37. A questionnaire was developed to obtain background information from the Meteorological Department. This provided monthly averages of wind speeds at 10 m high at 0600 GMT and at 1200 GMT over varying periods of time. Wind roses for the measuring stations were also provided. This information was made available, but has not yet been processed. An additional questionnaire was designed to input data from an existing private wind electricity generating station at Entebbe. Field visits were conducted to the stations that indicated the best wind conditions for power generation. Interviews were conducted with local officials and individuals to determine whether there were good wind regimes, and further to determine if there was demand for wind power generation.

Biomass

Methodology

38. A literature review was undertaken on biomass for energy at the beginning of the exercise. The EC-funded Woody Biomass Derived Energy Study was consulted extensively for purposes of identifying demand and some supply. A simple interview questionnaire was developed to interview key players. The team selected key biomass for energy users, such as Uganda Tea Growers Association (UTGA), BAT Uganda, Small Scales Industries Association, Uganda Coffee Development Authority (UCDA), the sugar companies, amongst others. These discussions and the information obtained was utilized to develop a program of site visits around the country. Concomitantly, a questionnaire for these field visits was developed for administration during the visits.

39. The team visited the following districts:

- Kabale
- Rukungiri
- Masaka
- Mbarara
- Mubende
- Hoima

- Mitiyana
- Kibaale

40. Security prevented them from visiting the tea factories in Toro up in Kasese. The team then proceeded to the east and visited

- Mukono
- Iganga
- Kumuli
- Palisa
- Tororo
- Mbale
- Kapchorwa

The team focussed on:

- Sawdust from timber mills
- Coffee husks from coffee processing
- Rice husks (in Iganga and Palisa)
- Plantation fuel wood in tea factories (for co-generation)
- Wood for lime kilns
- Sugar jaggeries (bagasse)
- Sugar factories (Kagira, Kiyara and Lugazi factories).

41. No other crop residues were examined such activities as cotton growing is still of relatively minor importance. Consequently these residues were not examined during the course of the study.

Tea

42. They visited tea factories in Mitiyana (Mwera Tea Estate) and they found that the factor was using fuel oil for processing. In the Toro Mitiyana Tea Company has installed a boiler (1.88-megawatt electric rating) which generates steam to process tea. Their electricity requirements are on the order of 80 kilowatts, which could be produced from the boiler. They don't use this as they are connected to the grid and use their own standby diesel generator. They use their plantation eucalyptus as the fuel source for their boiler. They are connected to the UEB grid through a 500 kilovolt-amperes transformer, which supplies the nearby village and over 100 consumers. They expressed interest in installing a turbine to generate electricity if it could meet their needs and if they could sell to the grid.

43. The team then visited the Buganda Tea and Coffee Factory in Mubende. This is an old estate which requires considerable rehabilitation. They use the wood for air drying, not steam processing. The team also visited Kasaku in Mukono. This factory also has a boiler for steam process, rated at 3 tons per hour (150 psi) of steam, rated at more than 1.8 megawatts (electrical). They use their own wood from their own plantation. They are connected to UEB but also have a standby diesel generator. The management showed interest in generating electricity and in generating

electricity. They cited the type of incentives provided by India's government to tea factories to generate surplus electricity to sell to the grid.

44. The team were not able to visit the Geggede Tea and Jaggery Estate. This plant employs a large boiler which provides power both to the tea plant and to the jaggery

Coffee

45. There are 440 coffee processing factories in Uganda. The team visited a number of coffee processing plants. They visited a factory Rukungiri, Werere Coffee Factory and Kasharosa Coffee Factory. Banyankole Kweterene Coffee Factory in Mbarara, Banyankole Kweterene Coffee Grading Plant in Mbarara, and factories in the following districts:

- Rukungiri (2)
- Mbarara (2)
- Masaka
- Iganga (2)
- Kpchorwa (1).

46. Coffee husks are produced in great quantity with no current use. During peak season, most processing plants produce with one to two hullers up to 4 tons of coffee per huller per day, with approximately 2 tons of coffee husk per huller per day. Most factories have at least two hullers, and many have more. Disposal of the coffee husks is a major problem.

47. Many plants, e.g. in Rukungiri, use diesel generators and are not connected to the grid. Others are connected to the grid. Several of the larger producers rely extensively on standby diesel generators during peak production and processing periods. The team estimated that over 1,600 tons of husk are produced per day during the peak season.

48. Given the fact that Uganda produces 400,000 tons of processed coffee per year, over 200,000 tons of coffee husk are produced each year. Given the fact that this residue is currently wasted, and poses severe localized environmental problems, there is considerable scope to utilize coffee husk for generating electricity through thermal production.

Sawmills

49. The team went to the Forest Department on the licensed saw mills in the country. There were 32 licensed sawmills in 1992. The team obtained names and locations for each licensed operator in Uganda. The team focused on 19 licensees who are operating in softwood forests. They visited

- Capital Saw Mills (Kabale)
- Uganda Associated Saw Mills (Kabale)
- Ishasha Basin Development Scheme (Ishasha)
- Ishasha Saw Mills (Ishasha)
- BM Technical Services (Mbarara).

50. These are usually small industries, with one primary saw. They harvest and saw. An average of 25 percent of the round log converted is produced as waste. The waste is just left, while the off cuts are left. Some off cuts are collected by local people for firewood, but little is collected due to the abundance of wood in the areas. Their major source of power for the saws are diesel engines, ranging from 65 HP to 85 HP. One sawmill was using a 160 HP diesel engine.
The team discussed the possibility for utilizing the biomass to generate electricity to power their saws, to provide electricity for their housing, or to provide electricity to other consumers. The operators had no idea that this was a possibility and expressed surprise that their wood waste could be used for generating electricity. The team believe that the waste from wood processing represents the major source of biomass energy for electricity generation, and that sawmills should be an important area for pilot demonstration of this option.

51. The team also visited Nile Ply in Jinja. This factory is using offcuts for their steam generation. The team discussed the options of undertaking cogeneration with their boiler, but the company was not initially interested in discussing this option.

Rice Husks

52. Rice is produced primarily in the eastern part of Uganda, in Iganga, Bugiri, Palisa and Mbale. The team developed a survey questionnaire format and approach. They first visited Tilda Uganda Limited in Bugiri District. This 650 ha scheme is currently being rehabilitated. The team then visited Mbale District. In Mbale township there are small 33 small rice mills. They generate considerable quantities of rice husks which pose major problems for disposal. Very small quantities of husks are used to mix with chicken feed and for brick making. Disposal costs producers, and rice husks are often burnt in situ, posing environmental problems. The team then visited Palisa and encountered the same conditions.

53. Uganda produced 28,800 tons in 1996. This yielded over 15,500 tons of rice husk in 1996. Currently, disposal of rice husk poses major environmental problems. However, rice husks, particularly on a localized basis such as Mbale town, could be utilized to generate electricity.

Sugar

54. There are currently three large sugar estates in Uganda, Kagira Sugar Works, Sugar Corporation of Uganda Ltd. (in Lugazi) and Kinyara Sugar Works Ltd. There are at least 39 smaller jaggeries primarily in the central and eastern parts of the country. The team visited the bigger factories. Kagira and Kinyara are currently co-generating electricity from bagasse. Kinyara currently has a capacity of 2 megawatts of electricity which supplies their own needs, with the surplus fed into UEB's grid. Kagira generates 2.5 megawatts, which supplies its own needs, with the surplus sold to UEB. Kagira is currently in the process of expanding their cogeneration capacity to 15 megawatts.

55. The team visited one jaggery in Mukono, Kianja Estate. This small jaggery produces bagasse which, supplemented with firewood, fires their processing works. Only one of the 39 jaggeries identified by the team uses a boiler. The rest use inefficient techniques to process the cane. Ten tons of cane produce 1.2 tons of jaggery. One ton of cane yields 100 kg to 300 kg of bagasse, depending upon the crushing efficiently.

56. The jaggeries are small and poorly capitalized. The technology utilized for jaggery production (which is mainly used for distilling Ugandan traditional spirit) is poor and inefficient. However, while the scope for improving efficiencies is high, there appears little scope to produce electricity in these small plants; the cost of capital required would probably outweigh the benefits.

Annex D

Supply Resource Survey: Methodology and Questionnaire Format

Purpose

1. The purpose of the study is to obtain as clear a picture as possible the extent to which alternative energy sources and technologies (e.g., wood, other biomass, small hydro, solar, wind, other) are being used, or could be used for rural, off-grid electrification in Uganda. This should provide both a good picture of present resource for power generation, clear indications of trends for development of these resources in this area, and likely short-term developments in this area of rural development. The key supply side issues are as follows:

- What is the technical resource?
- What is the currently exploited resource?
- Where is the resource located relative to demand?
- Where are the resources currently being exploited?
- How are the resources currently being exploited?
- Who is importing the equipment?
- Who is installing the equipment?
- Who is buying the equipment?
- Where is the equipment being installed?
- What are the conditions which have led to resource development for rural electrification in Uganda (historical and present)?
- How much is being paid for the capital equipment?
- What are the costs of installation, operations and maintenance, and other costs (e.g., credit, finance, etc.) for currently installed rural electricity generated power in Uganda?
- Where is the equipment coming from?
- What are the present load curves for resources being utilized for rural electrification (kilowatt-hours/day, time of peak demand, etc.)?
- Is the equipment being used for own generation only, or is it being used to sell electricity to others?

2. The important institutional issues related to current and future rural electrification will be examined in co-ordination with the MNRE, UEB and other parties concerned with promoting rural electrification. Technical, technological, financial, economic and other measures necessary to accelerate rural electrification will be examined to define what measures will have the most impact at geographic and national levels to accelerate rural electrification.

Methodology

3. Three levels of work need to be carried out to fulfil the terms of reference for this study:

- A thorough literature review and review of all relevant documentation, including resource assessments, pre-feasibility and feasibility studies, private sector, government and donor proposals in the rural electrification sector;
- Interviews with UEB, the Energy Department (MNRE), Forest Department (MNRE), Statistics Department (Ministry of Finance and Economic Planning/MFEP for import statistics), the Uganda Revenue Authority/URA, the Commissioner of VAT (for sales statistics), and other relevant Government bodies, including district officers directly concerned with these resources (e.g., District Forest Officers/DFOs, District Agricultural Officers/DFOs, etc.); and
- Interviews with, and documentation on, key private sector suppliers, installers and consultants.

4. A clear, well-referenced picture that clearly sets out resource availability and use on a geographic basis should emerge from this study which sets out in concrete terms where resource electricity is presently installed and used, and where it is being installed, and how important that is for off-grid rural dwellers.

5. This, in turn, should provide a good picture, with recommendations, on the role of resource (biomass, small hydropower, solar photovoltaics, other renewable resources and petroleum generators) development to meet rural electricity demand in the future, with a particular reference to non-UEB rural electrification. Resource potential should be defined clearly, with the present costs and benefits of current exploitation on a geographic basis, in order to offer clear priorities for future resource development in key areas. The work should tie in resource potential at various geographic areas with demand, and potential demand, in order to define optimal resource development to accelerate economic activity in those areas.

6. Additionally, the work should involve extensive interviews with key players including current investors, operators, importers, technicians, etc. to define what they think are the opportunities, constraints (technical, technological, etc.) and proposed solutions to constraints to accelerated rural electrification.

Economic and Financial Analyses

7. Moreover, this study should indicate clearly the financial costs and benefits of current resource electricity/power generation in rural areas. This should set out the costs in terms of foreign exchange for equipment, spares and other inputs (e.g., petroleum), and local costs including operations and maintenance, costs of supplies (e.g., biomass), costs of developing infrastructure (storage, etc.) necessary to exploit these resources.

8. Benefits should at least be quantified in terms of power output (watt hours). Additional benefits, including jobs created (e.g., for biomass supply, for construction, operations and maintenance) should also be quantified. Benefits should be further qualified in the sense of the benefits derived from the use of these resources for electricity generation, specifically for household, commercial and industrial use (i.e., the value of electricity for improving the productivity and operations in these sectors).

9. This should permit the Energy Department to make a clear financial and economic analysis which enables comparison between:

1. Grid petroleum power generation
2. Off-grid petroleum power generation
3. Alternative energy power generation
4. Hybrid power generation (petroleum and alternative energy).

10. It is anticipated that import statistics (MFEP), VAT statistics, URA statistics, UEB data, and other relevant resource and geographic information, along with any other estimates and studies will be consulted and utilized. The Study will rely heavily on interviews with key private sector developers, electricity producers in rural areas, suppliers and consultants who are involved with the development and exploitation of these resources.

Annex E

Diesel and Petrol Generators: Facts, Statistics, and Key Assumptions

Genset Imports

1. The team's interviews with Uganda Manufacturers Association/UMA members, suppliers, UEB, MNRE, district authorities, and private investors, showed that considerable investment had been made in Uganda since the early-1990s in diesel and petrol generating sets. UMA estimated at the beginning of the study that their members had at least 20 megawatts of autonomous genset capacity. Telephone interviews with key members showed that, indeed, there was considerable capacity in the country, mainly imported from 1991 onwards, as economic growth accelerated, and as UEB had increasing difficulties coping with demand.

2. The team then visited the Uganda Revenue Authority, which keeps statistics on all legal imports. Generating sets are divided into diesel and petrol generating sets (with petrol gensets designated as "spark ignition" as opposed to "compression ignition" generators). Data prior to mid-1993 was sporadic, so the team took the data from July 1993 to September 1997, when the field work was completed. Table E-1 provides a synthesis of these data.

Table E-1. Diesel and Petrol Genset Imports, 1993 to 1997 (number of units imported by size and type)

Year \ Capacity (kVA)	*< 75 kVA*	*75-375 kVA*	*>375 kVA*	*Petrol*	*Total*
1993 (from Jul)	91	6	4	12	113
1994	421	39	20	55	535
1995	545	77	31	95	748
1996	450	52	24	168	694
1997 (to Sep)	195	3	9	55	263
Total	1,702	177	88	385	2,352

Source: Uganda Revenue Authority.

3. It should be noted that the URA data are very mixed in quality. There are some major anomalies in these data. For example, one entry for 1995 showed 2,440 gensets rated at less than 75 kilovolt-amperes imported by one company at one time. This clearly was impossible, and probably represented spare parts, and an incorrect entry. Wherever any entries were located of that type (i.e., specifically where an entry showed more than 15 gensets imported at one time), that entry was ignored. There was no way to verify entries of that type. Therefore, the numbers shown in Table E-1

are conservative. However, it is not known by what degree.

4. The range of sizes is quite wide, as Table E-1 shows. That is, while 1,702 gensets of a capacity of less than 75 kilovolt-amperes were imported during the period, it is not know how many of those were 35 kilovolt-amperes, 10 kilovolt-amperes, etc. However, field interviews, interviews with genset suppliers, and observations made by the Energy Department during the course of dozens of industrial energy audits, provided the basis for estimating the average size of generators within each category. Therefore, the team assumed that the sizes per category indicated in Table E-2.

Table E-2. Estimated Size of Gensets Imported, 1993 to 1997 (kVA)

URA category (kVA)	*Est. avg size (kVA)*
<75	10
75-375	50
>375	400
Petrol	1.5

Source: Team estimates based on Uganda Revenue Authority data.

5. Again, as with the number of units imported, the team took a very conservative estimate of size. For example, there are indeed many petrol gensets in the range of 3.5 kilovolt-amperes, and not many below 1 kilovolt-ampere. However, the team wished to develop a minimum threshold that would be credible. The same holds for each of the other size categories.

6. Taking the URA data shown in E-1, and the estimates for sizes shown in Table E-2, the team then estimated the total capacity of diesel and petrol generators imported during this period, as illustrated in Table E-3.

Table E-3. Estimated Total Capacity of Genset Imports, 1993 to 1997 (000 kVA)

	Capacity (kVA)				
Year	*< 75 kVA*	*75-375 kVA*	*>375 kVA*	*Petrol*	*Total*
1993 (from Jul)	910	283	1,600	18	2,811
1994	4,207	1,967	7,867	83	14,123
1995	5,447	3,833	12,533	143	21,956
1996	4,503	2,583	9,600	252	16,939
1997 (to Sep)	1,953	167	3,600	83	5,803
Total	17,020	8,833	35,200	578	61,631

Source: Team estimates based on Uganda Revenue Authority data.

7. Again, the team made very conservative estimates to derive these figures. The numbers of gensets were estimated conservatively from URA data, and the sizes were estimated conservatively from interviews, surveys and past experience. Table E-3 shows that a minimum of 61 megawatts of capacity was imported between July 1993 and mid-September 1997. Therefore, there must surely be more capacity in the country, although it is difficult to estimate how much (government have estimated over 80 megawatts in their "Strategic Plan").

8. URA entries on value of imports are also very mixed. The value of imports are invariably underestimated, as are the taxes and import duties charged for those imports, for obvious reasons. Therefore, URA data cannot be relied upon to provide the value of imports. However, work carried out by the team over the years, both in Uganda and internationally, provide a good, conservative basis for estimating the value of those imports. Table E-4 shows those estimated values for 1993-1997:

Table E-4. Estimated Values for Gensets Imported into Uganda, 1993–1997 (US$/kW)

<75 kVA	*75-375 kVA*	*>375 kVA*	*Petrol*
$500	$400	$350	$700

9. As a rule of thumb, the larger the genset, the lower the cost per kilowatt, while petrol gensets are much more expensive per kilowatt then diesels. Again, these are conservative estimates: petrol gensets often average US$1000 per kilowatt. Therefore, if these are underestimates, then the estimated total import values shown in Table E-4 is underestimated, and the value of imported gensets between 1993 and 1997 is higher. Taking all the information and estimates shown in these tables, the following conservative estimate of the value of genset imports during the specified period is shown in Table E-5.

Table E-5. Estimated Total Capacity of Genset Imports, 1993 to 1997 (000 kVA)

Year \ Capacity (kVA)	*< 75 kVA*	*75-375 kVA*	*>375 kVA*	*Petrol*	*Total (US$)*
1993 (from Jul)	455	113	560	12.6	1,140,933
1994	2,103	787	2,753	57.8	5,701,083
1995	2,723	1,533	4,387	99.8	8,743,083
1996	2,252	1,033	3,360	176.4	6,821,400
1997 (to Sep)	977	67	1,260	57.8	2,361,083
Total	8,510.0	3,533.3	12,320.0	404.3	24,767,583

10. Table E-5 shows that at least USS24.8 million was spent on imports of gensets during 1993 to 1997, and most probably more. Additionally, these figures do not show imports prior to July 1993, nor imports after mid-September 1997. Therefore, these are underestimates, and foreign exchange expenditures on imported gensets, and local capital raised to finance those imports, was certainly higher than shown in Table E-5.

Additional Genset Expenditures

11. The team used interviews with suppliers and actual users, coupled with their own experience in Ugandan industry energy audits and information from UEB on electricity supplies, to estimate the load factors on these gensets, and the associated operational costs (e.g., fuel, operations and maintenance, spares). See Table E-6 for an overview of the findings. The team's surveys and interviews showed that most gensets serve UEB clients. They therefore serve, in principle, as back ups. However, given the fact that most areas where these generating sets are located suffer long periods without electricity, gensets often serve as base load.

12. A key factor to be noted in Table E-6 is that these generating set statistics only cover areas outside Kampala, Jinja and Entebbe. The significance of this is twofold. First, their operating load factors (i.e., hours of operation per day), are generally higher than those in the urban areas. Kampala, Jinja and Entebbe tend to have more reliable electricity, although that is not always the case (e.g., in Kampala's industrial area). The second important feature, tied to the first, is that their capacity utilization is relatively high, and is higher than those in Kampala, Jinja and Entebbe, again because of reliability of supply.

Table E-6. Genset Statistics from Field Surveys (33 interviews)

Location	*District*	*Installed kVA*	*Installed kW*	*Utilized kVA*	*Utilized kW*	*% Utilization*	*Hours operation*
Hoima	Hoima	114	91	70	56	61.5	4
St. Simon Peter Voc. T.C	Hoima	42	34	25	20	60.0	6
Nyakibale Hospital	Rukungiri	56	45	56	45	100.0	7
Mr. Philip Begumisa	Rukungiri	1.5	1.2	1.5	1.2	100.0	4
Rwerere Coffee Processing Factory	Rukungiri	65	52				12
Kasoroza Coffee Factory	Rukungiri	56	45				12
Jim's Residence, Katobo	Rukungiri	50	40	15	12	30.0	16
Diary Corp. Cooling Plant	Rukungiri	50	40	25	20	50.0	6
Maziba Mini Hydro Power	Kabale	350	280	350	280	100.0	4
Muko Saw mills	Kabale						10
Asam Products Grain Millers	Kabale	320	256	192	154	60.0	4
Hot loaf bakery - Kabale	Kabale	200	160	200	160	100.0	4
Capital Saw mill	Kabale	61	48	61	48	100.0	8
Rushere Hospital	Mbarara	20	16	20	16	100.0	6
Ndeija Coffee Factory	Mbarara	225	180	158	126	70.0	8
Rushere Diary Cooling Plant	Mbarara	58	46	29	23	50.0	12
Diary Corporation Mbarara	Mbarara	230	184	213	170	92.4	15
Kamukuzi	Mbarara	9.0	7.2	9	7.2	100.0	5
Banyankole Kweterana, Kakoba	Mbarara	203	162	152	122	75.0	
GBK Mbarara	Mbarara	610	488	225	180	36.9	4
BM Technical Services – Kakoba	Mbarara	58	46	52	42	89.9	4
Kagadi	Kibale	1.5	1.2	1.5	1.2	100.0	2
Kagadi	Kibale	3.5	2.8				4
Kagadi	Kibale	5.0	4.0				
Kagadi	Kibale	30	24	9	7.2	30.0	8
Kagadi hospital	Kibale	285	228	284.5	227.6	100.0	6
Mwera Tea Estate- Mityana	Mubende	370	296	370	296	100.0	6.5
NTC Mubende	Mubende	13	10	13	10.4	100.0	5
TAMTECO Mityana	Mubende	410	328	100	80	24.4	6
TILDA (U) Ltd – Kibimba	Bugiri – Mbale	188	150	188	150	100.0	5
Kasaku Tea Estates - Lugazi	Mukono	300	240	265	212	88.3	6
Sebei Elgon Coop. Union	Kapchorwa	843	674	422	337	50.0	12
World Vision Masaka	Masaksa	3.0	2.4	3	2.4	100.0	5
Total/average	33	5,229	4,183	3,508	2,806	77.4	7.0

Source: Field survey data.

13. That is, they have to rely more on their own generating resources than their counterparts in the urban centers, and therefore, even if their gensets are oversized when they first purchase them, they quickly bring on extra load to maximize the use of the gensets. This is supported

by the fact that smaller gensets operate at higher loads, as Table E-7 shows. As more of the gensets in the urban centers are for standby, they have a lower Utilization factor, and have considerable surplus capacity. This is important, because much of that "slack" capacity in urban centers could be utilized to help reduce UEB's load. It is also important because, unlike the team originally believed, there is not much excess capacity in the surveyed areas for sale to other consumers.

14. Having said that, there is considerable variation, as Tables E-6 and E-7 show. A relatively large number of sites surveyed utilize 50 percent of less of their capacity, and could therefore sell that to others. Just in the plants surveyed by the team, there is surplus capacity of over 1.2 megawatts. The team interviewed no more than 10 percent of the non-urban autonomous generators. Therefore, it is safe to say that there is at least 5 megawatts in small urban and trading center generating capacity available for other consumers. This is a compelling argument for government to encourage private sales to meet unmet demand, and to discourage imports of unnecessary genset capacity.

Table E-7. Size, Operations and Load Factors for Gensets Surveyed (33 interviews)

Size	*No Interviewed*	*Rated kW*	*Utilized kW*	*% Utilized*	*Hours/day*
>200 kVA	12	3,476	2,345	74.8	6.9
50-200 kVA	10	604	396	72.7	8.6
<50 kVA	11	103	66	86.3	5.5
Total/avg	33	4,183	2,807	77.4	7.0

15. Based upon the team's field surveys and interviews, profiles for use were developed. Two scenarios were developed to provide information on the operating and other recurrent costs of gensets, to obtain a more composite economic and financial picture for private gensets in Uganda.

16. Table E-8 shows a "medium load" case in which different sized gensets are utilized for different end uses (households, dairy and light industry). This provides a profile of their costs that shows what one would intuitively estimate; costs of operation based on a kilowatt hour basis, are higher for small gensets than for larger.

Table E-8. "Medium Load" Recurrent Cost Estimates for Four Different End Uses (US$/kWh)

Application	*Unit*	*Household*	*Household*	*Dairy*	*Light Industry*
Size	kVA	1.5	15	50	150
	kW	1.2	12	40	120
Lifetime	years	5	7	10	15
Depreciation	% per year	0.20	0.14	0.10	0.07
Operations	hours/day	2	4	6	6
	hours/year	730	1,460	1,716	1,716
	kWh/year	876	17,520	68,640	205,920
Capital cost (cif, duty, tax & installation)	US$ installed	1,000	7,500	17,500	48,750
	US$/year	200	1,071	1,750	3,250
	US$/kWh	0.23	0.06	0.03	0.02
Fuel consumption	l/hour	0.5	4	10	20
	l/kWh	0.42	0.33	0.25	0.17
	l/year	365	5,840	17,160	34,320
Fuel cost	US$/l	1.00	0.80	0.80	0.80
	US$/year	365	4,672	13,728	27,456
	US$/kWh	0.42	0.27	0.20	0.13
O&M, lubes & spares	US$/year	50	375	875	2,438
	US$/kWh	0.06	0.02	0.01	0.01
Annualized costs	US$/year	615	6,118	16,353	33,144
	US$/kWh	0.70	0.35	0.24	0.16

17. The team then estimated costs for gensets used as base load, and defined that as 4 hours per day for the small household, and over 8 hours per day for all other uses. As Table E-9 shows, and as one would expect, the cost per kilowatt hour goes down for the smaller gensets, and stays virtually the same for the larger. The reason for the latter is that so much of the cost per kilowatt hour for a large genset is embodied in its initial investment/capital cost. This provides another argument for why these gensets, particularly those in the urban centers that are used more on a standby basis, should be used to supplement UEB supplies.

18. Estimated costs per kilowatt hour for larger units are on the order of US$0.16 per kilowatt-hour, which is almost half the cost UEB and the World Bank estimate UEB spends per kilowatt hour in their remote diesel locations. This provides ample evidence that government should encourage use of surplus genset capacity to augment UEB supplies, and to provide owners with the licenses and the encouragement to sell their surplus to others. This recommendation is further supported by the fact that at least 75 percent of all gensets are used for economic activities. Therefore, the major demand is economic, and using their surplus output would promote economic growth and development.

Table E-9. "Base Load" Recurrent Cost Estimates for Four Different End Uses (US$/kWh)

Application	*Unit*	*Household*	*Household*	*Dairy*	*Light Industry*
Size	kVA	1.5	15	50	150
	kW	1.2	12	40	120
Lifetime	years	3	5	7	10
Depreciation	% per year	0.33	0.20	0.14	0.10
Operations	hours/day	4	8	8	8
	hours/year	1,460	2,920	2,288	2,288
	kWh/year	1,752	35,040	91,520	274,560
Capital cost (cif, duty, tax & installation)	US$ installed	1,000	7,500	17,500	48,750
	US$/year	333	1,500	2,500	4,875
	US$/kWh	0.19	0.04	0.03	0.02
Fuel consumption	l/hour	0.5	4	10	20
	l/kWh	0.42	0.33	0.25	0.17
	l/year	730	11,680	22,880	45,760
Fuel cost	US$/l	1.00	0.80	0.80	0.80
	US$/year	730	9,344	18,304	36,608
	US$/kWh	0.42	0.27	0.20	0.13
O&M, lubes & spares	US$/year	50	375	875	2,438
	US$/kWh	0.03	0.01	0.01	0.01
Annualized costs	US$/year	1,113	11,219	21,679	43,921
	US$/kWh	0.64	0.32	0.24	0.16

Annex F

Small Hydro Resource Data and Energy Potential

Summary

1. Very little reliable or centralized information on small hydropower is available in Uganda. A number of studies have been carried out over the past 25 years, each with a separate agenda, and none coordinated with the other. This makes small hydropower estimation very difficult in Uganda. Almost inevitably, wherever work has been undertaken to estimate potential, it has been from the point of view of estimating large hydropower potential. Those sites not satisfying the large-hydropower criteria, have had virtually no further work or studies carried out on them.

2. The current study aimed to obtain a clear picture of the availability and extent of use of hydro-power sites with a potential of about, or less than, 2-megawatt installed capacity. The main potential for small scale hydropower development exists in the following areas:

- Rivers draining Mt. Elgon in eastern Uganda;
- The extreme southwestern portion of Uganda;
- Rivers draining West Nile, near Arua (northwest); and,
- Rivers draining the Ruwenzori mountains in the west.

3. Although many potential schemes exist, preliminary studies have been carried out only on a few of them. It is, therefore, not possible to estimate reliably the potential installed capacity that could be realized from the development of small hydropower sites. Within the 2-megawatt range, available studies list the potential and developed capacities as shown in Table F-1. Table F-2 provides a very rough estimate of the potential of some of the most promising mini- and micro-hydropower sites in Uganda. Table F-3 provides fairly extensive information on the five operating small hydropower sites (and the Kikagati site that is not currently operational).

Developed Schemes

4. Interviews and fieldwork were carried out during the course of this study in order to obtain technical and economic/financial information pertaining to the development of small hydropower plants in Uganda. Sources included UEB, publications and the management of the power plants. In most cases, information was very scanty because either it was not well documented, or the responsible persons were not well informed about the technical and financial details of the equipment and other design parameters. During the study's field visits, three developed sites were visited: Maziba, Kisizi and Sipi.

5. Of the six known small (less than 2 megawatts) hydropower plants, two are connected to the grid while the four micro-hydropower plants are stand-alone plants (i.e., non-grid connected). The Kikagati plant, which was the first hydropower plant to be commissioned in Uganda, is connected by a 33-kilovolt line to the grid at Mbarara. However, it is not operational, having been damaged by floods in 1961 and 1964. It was finally closed in 1971.

Table F-1. Surveyed Small Hydropower Sites in Uganda with Estimated Costs of Development (1997)

Site	*District/Region*	*Estimated potential (MW)*	*Developed (MW)*	*Estimated Cost (US/mill.)*	*Status*
Rwizi	Mbarara	0.70		2.10	Estimate
Kakaka	Kabarole	1.50		4.20	Estimate
Nzongezi	Mbarara	2.00		5.40	Estimate
Nyamabuye	Kisoro	0.70		2.10	Estimate
Siti	Kapchorwa	1.00		1.75	Estimate
Sipi	Kapchorwa	2.00		2.54	Estimate
Anyu	Arua	0.30		1.50	Estimate
Heisesero	Kabale	0.30		1.30	Estimate
Kitumba	SW	0.20		0.70	Estimate
Mpanga	SW	0.40		1.40	Estimate
Nyakibale	Rukungiri	0.10		0.50	Estimate
Kisizi	Rukungiri	N/A	0.06	N/A	Developed
Moyo	Moyo	N/A		0.80	Estimate
Ora	Arua	0.90		N/A	Estimate
Nkussi	Mbarara	0.90		N/A	Estimate
Mitano	Kabale	2.00		N/A	Estimate
Maziba I	Kabale	1.00	1.00	N/A	Developed
Maziba II	Kabale	1.50		N/A	Estimate
Kikagati	Mbarara	1.25		N/A	Abandoned
Sezibwa	Mukono	0.50		N/A	Estimate
Mgiita		0.15	0.06	N/A	Estimate
Kagando	Kasese	N/A	0.12	N/A	Developed
Kuluva	Moyo	0.20		0.80	Developed
Total		17.6	1.24	25.09	

Source: UEB, various.

6. The Maziba plant is connected to the national grid at Kabale. While the two grid-connected plants are owned by UEB (Government), the four decentralized plants are privately owned. Three of the four are owned and operated by the Church of Uganda (COU) and one (Sipi) by a private individual. The COU developed these plants to provide electricity for its own requirements (e.g., hospitals, etc.).

Kikagati Hydro-Power Scheme

7. The Kikagati Hydro power plant is now a derelict scheme, commissioned in 1934 for the mining industry in its neighborhood. It was sold to UEB in 1959 with one 750-kilowatt unit. A 500-kilowatt unit was constructed in 1961. One generator was removed and the other burnt out but the turbines could be rehabilitated. The station was damaged by floods in 1961 and 1962 and part of the diversion weir was washed away. The station was closed in 1971. During its operational days, it had acute siltation problems. There is a 33-kilovolt line to Mbarara. However, the first 40 kilometers is abandoned and needs extensive rehabilitation.

Table F-2. Potential Sites for Micro- and Mini-Hydropower Development (1997)

Location numbers	*Stream*	*Location/ Region*	*Micro (0-100 kW)*	*Mini (100 kW- 1MW)*
81348	Nyakizumba	South West		✓
82312	Namafwa	East		✓
82313	Namatala	East	✓	
82317	Mpologoma	East	✓	
82318	Malaba	East	✓	
82321	Agu	East		✓
82323	Kapiri	East		✓
82325	Sezibwa	Central		✓
82331	Kelim	East		✓
82340	Sironko	East		✓
82341	Simu	East		✓
82342	Muyembe	East		✓
82344	Atari	East		✓
83313	Tochi II	North		✓
83313	Kafu	West		✓
84321	Rwimi	South West		✓
84324	Rukoki	West		✓
84327	Kyambura	South West	✓	
84328	Nyamugasani	South West	✓	
84367	Mitano	West		✓
85312	Nkusi	West		✓
85314	Wambabya	West		✓
85316	Waki I	West		✓
86312	Pager	North		✓
87301	Anyarwodo	North West	✓	
87305	Kochi	North West		✓
87307	Agugi	North West		✓
87312	Orci	North West		✓
87320	Aswa (Minor)			✓

Source: Sir Alexander Gibb, "Hydropower Development Master Plan" (Final Draft), 1994.

Table F-3. Information Available on Small Hydropower Sites Developed in Uganda

Power Station	*Year of commis-sioning*	*Ownership*	*Type of development scheme*	*Installed capacity (MW)*	*Average annual energy (GWh)*	*Catchment area (km^2)*	*Design head (m)*	*Design flow (m^3/s)*	*Hours of Utilization per day*	*Load factor*	*Grid connection*
Maziba	1963	UEB	Dam	1.00	8.5	800	90	2.8	4	0.53	Yes
Kikagati	1934	UEB	Diversion	1.25	N/A	N/A	6	200	N/A	N/A	Yes. But not in operation
Kisizi	1970	COU	Diversion	0.06	N/A	N/A	30	0.25	24	N/A	No. 43 km from UEB grid
Kagando	Mid-1990's	COU	N/A	0.06	N/A	N/A	N/A	N/A	N/A	N/A	No
Kuluva	1995	COU	N/A	0.12	N/A	N/A	N/A	N/A	N/A	N/A	No
Sipi	N/A	Dr. Chebrot	Diversion	0.0013	N/A	90	80	N/A	N/A	N/A	No

Note: COU = Church of Uganda.

8. Although previous studies have stated that Kikagati should not be rehabilitation, there has been renewed interest in it, most recently by the Egyptian Government and an independent power producer, Nortek. The Kagera river forms the boundary between Uganda and Tanzania at the point where Kikagati is located. Future rehabilitation of the plant must take this into account. There is another potential site on Kagera River 12-15 kilometers downstream of Kikagati at Nsongezi.

Maziba Hydropower Station

9. The Maziba Hydropower station was commissioned in 1963 with two generation units each of 250 kilowatts, it was built to supply power to the isolated fast growing district township of Kabale in South Western Uganda about 16 kilometers from the station. It was damaged by silt and was out of use for sometime. Following rehabilitation and uprating, the station now has an installed capacity of 1.0 megawatts.

10. This station was designed and is operated by UEB. Day-to-day maintenance and repair of the station are carried out by UEB staff. It is connected to the national grid throughout. The station operates mainly as a stand-by system, providing power to Kabale and Rwanda for an average period of 4 hours per day during load-shedding periods.

11. The major consumers of the power from the station are mainly of the domestic category, i.e. of the 2000 registered consumers, 1968 are domestic. The total consumption in a month is 3,400 kilowatt-hours locally and about 17,000 kilowatt-hours to Rwanda.

12. The major problem faced at the station is sedimentation which occurs during the rainy season. During this time the station can only generate 800 kilowatts. The capacity of this plant can be expanded if a reservoir is constructed.

Kisizi Hydropower Station

13. Kisizi micro-hydro power station is situated in Rukungiri district in South Western Uganda. It belongs to the Church of Uganda Diocese of North Kigezi. It serves Kisizi hospital, houses, a school and a grinding mill.

14. The station was commissioned in 1970 with a capacity of 10 kilowatts. In 1983 this was upgraded to 60 kilowatts. The head of the plant is about 30m and the flow rate is of the order of 0.25 cubic meters per second. There is adequate water in the rainy season although this reduces to a base minimum in the dry season. The plant is 43 kilometers from the UEB grid.

15. The installations, made by a British firm called GILKES, were funded by a British-based non-governmental organization TEAR FUND. However it was not possible to look at their generator set.

16. It was pointed out that the capacity of the plant is not enough to sustain the demand and load shedding is being carried out within the community. To limit the load, the management has advised people within the community to avoid the use of electric cookers.

17. There is interest to expand the capacity of the plant to about 150 kilowatts but funds are not yet available. Because there is a natural head due to a high waterfall (height not ascertained) it would be easy to increase the generation capacity. The Maziba plant is run by horizontal Francis turbines at a rated speed of 750 rpm with revolving field Matter and Platt Generators. The generator voltage and frequency are 415 volts and 50 hertz respectively.

18. Routine maintenance of the installations is done by the hospital electrician. Maintenance costs were estimated to about 1 million shillings per year, other costs were not established. The major problems being faced are, acquiring some of the spare parts like the belts and that of the limited capacity.

Hydropower Plant on Sipi Falls

19. This power plant is owned by an individual, Dr. Chebrot. It is a small domestic plant of about 1.5 kilovolt-amperes installed at the Sipi Falls in Kapchorwa District. Water is trapped using a concrete bin and directed to the hydro turbine through 4" pipes at a head of about 80m. The small installation was made by Juliet, an American friend of Dr. Chebrot. All machinery on ground are of the USA origin. The power generated is basically being used for lighting, refrigeration and television for one residential house.

20. During minor electrical and mechanical failures, a technician from Mbale is called upon to rectify the fault. During the time of the visit, the plant was not operational due to a broken pipe. This is the major failure that has been experienced so far since the time of installation.

21. The problem that has been faced time to time is that of silting during the rainy seasons. Plans are being made to bring a pipe of a larger diameter to increase the capacity so as to supply power to the neighbors. The plant cost US$9,300 to construct.

Trends in Small Hydro-power Development

22. Available records indicate that small scale hydropower development is still very slow. However, judging by the three micro-hydropower plants installed in the 1990s (Kagando, Kuluva and Sipi Falls), there is increased interest in small hydro. Because UEB has been the sole licensing authority for the supply of electricity, and since it does not have any records of licensees in recent times, one would think that it would have information on all new small hydropower sites. However, this does not seem to be the case, as the Kagando and Kuluva plants are operating without UEB's licenses.

23. Much of the development of potential small scale hydropower sites will depend on the location of load centers relative to the sites. Several undeveloped sites were visited during the survey to get a view of the potential demand in case they were developed. These sites are: Simu Falls and Nabiyongo Falls originating from Mt. Elgon, and Sezibwe Falls in Mukono District. It was observed that most of the sites are in areas with good hydrology which are, therefore, agriculturally productive. With the promotion of rural agricultural processing, the development of the sites to provide power for these processing industries can become a reality. The fact that the industry would settle its workers around the industry means that the site could be a nucleus for more resettlement, thus generating its own demand.

24. The Sezibwe site is located near the Kasaku Tea Estate. The management of the estate expressed enthusiasm about the possibility of developing a hydropower plant at Sezibwe. The industry is using a 300–kilovolt-ampere (240 kilowatts) diesel generator (output power of 212 kilowatts), operating six hours per day. Such a development, albeit on a large scale, is taking place on the Muzizi River where the Commonwealth Development Corporation (CDC) is going to construct a 10-megawatt hydropower plant targeting service specifically to the tea estates in that part of Western Uganda and selling the extra power to UEB.

Further Hydropower Notes

25. Twenty-two sites, each with potential of over 500 kilowatts, have been identified since the early-1980s. Another 71 "micro" and "mini" hydropower sites have been identified elsewhere. The following sources of information have been developed over the past ten years:

- **UNTCD:** UN Technical Cooperation Department carried out a study of small hydropower options in north-western and south-western Uganda. The study recommended that small hydro power, where the potential is available, can play a significant role for electrification of areas remote from the national grid. They went further to prioritise the following sites for implementation in respective order: Paidha in the Northwest, Ishasha and Nyamabuye in the Southwest (2-5 megawatts). Twenty-two sites with between 0.5 and 5 megawatt capacity were visited and evaluated.
- **World Bank & UNDP**: Reviewed the potential to rehabilitate the Kikigati mini-hydropower plant on the Kagera River in late-1980s. Funding was not available to carry out rehabilitation.
- **Rehabilitate Existing Power Plants:** The Governments of Sweden (SIDA), China, Federal Republic of Germany (KFW) financed a study to rehabilitate and develop small power stations to improve system reliability and to improve the distribution of power in the country at Maziba Power Station (for Kabale), for which rehabilitation is complete, and the development of electrogasification project in Ssese Islands, for which funding has not been secured.
- **Paidha-Nebbi District:** US Trade Development Agency and UN studied small hydropower options.
- **Paidha- Nyagak River:** Preliminary studies were carried out by the Koreans (PDRK) and Uganda on developing two sites (1- and 2-megawatt) on the River Nyagak. Preliminary engineering design for two sites (1- and 2-megawatt) undertaken and financing proposal developed for the 1-megawatt site.
- Ishasha: An Austrian team carried out a detailed feasibility study of developing the Ishasha small hydropower plant in Rukungiri District, south-western Uganda.
- **Paidha-Nebbi, Muzizi-Kibale & Nyamabuye-Kisoro:** Norconsult International, ABB Energy A.S., and Kvaerner Hydropower A.S. carried out pre-investment studies for hydropower development at Paidha in Nebbi district (North Uganda), Muzizi in Kabale District (Western Uganda) and Nyamabuye in Kisoro District (south-western Uganda). Potential at these sites ranged between 3 and 80 megawatts.
- Sipi, Mitano and Siti: The government of India carried out initial studies of small

hydropower sites in eastern and south-western Uganda. They recommended that Sipi (2-megawatt) in eastern Uganda, Mitano (9-megawatt) in south-western Uganda, and Siti (1-megawatt) in eastern Uganda should be implemented, with the highest priority on Sipi.

- **Biseruka and Nyamabuye**: The Government of Uganda has requested assistance from the Japanese Government to determine the financial, economic and technical; feasibility of hydropower development at Biseruka (10-megawatt) and Nyamabuye (3-5-megawatt).

Annex G

Sugar Factory Waste and Energy Potential

Large-Scale Sugar Plants

1. Uganda's sugar industry is currently recovering rapidly. As a by-product of sugar production, thousands of tons of bagasse is produced. Bagasse is currently being used for co-generation in Uganda's three large sugar industries, Kagira Sugar Works Ltd., Sugar Corporation of Uganda Ltd (Lugazi), and Kinyara Sugar Works Ltd. These factories generate 2.5 megawatts (installed capacity is 4.5-megawatt), 2 megawatts and 1.5 megawatts of electricity, respectively. See Table G-1 for details.

Table G-1. Existing Sugar Plant Electricity Generating Capacity

Site	*Current Capacity (MW)*	*Potential to Export (MW)*
Kagira	4.5	15-20
Lugazi	1.5	4-5
Kinyara	1.2	3-4
Total	**7.2**	**22-29**

Source: USTDA, private sugar companies.

2. The technologies employed are inefficient. The owners are now focussing on more efficient technologies for generating electricity to connect to the grid and to sell electricity to the national utility (UEB). Kagira has already completed a feasibility study, financed by the United States Trade Development Agency (USTDA). Government has also contacted USTDA to look into the possibility of financing a similar study for Lugazi and Kinyara.

3. The Kagira project aims at generating 15-20 megawatts at a total investment cost of approximately US$14 million. The investments into the project will include the following:

- provision of about 2 acres of land for the plant;
- procurement of a high efficiency boiler of 75 TPH, 64 kg/m^3, 510^{0}C with a micro-processor control system and an efficient pollution control equipment;

- an extraction-cum-condensing turbo alternator of 14.5-megawatt generating electricity at 11 kilovolts, 50 hertz;
- a transmission line of 11 or 33 kilovolts with a step-up transformer connected to the UEB main sub-station with an associated switch gear (10-kilometer line);
- a feed water system with a treatment plant for the new boiler;
- accessories for the turbo alternator comprising a condenser, a cooling tower, circulatory water pumps and a condensate extraction system.

4. An autonomous Energy Supply Company (ESCO) will be set up to manage the power generating plant. Revenues will comprise an average annual service payment of US$1.2 million to UEB; revenue of about US$3 million per annum from the sale of electricity to UEB and other industries; and the sale of high quality steam to Kagira Sugar Works.

5. The operating expenses will include rent for land and any other services provided by Kagira Sugar Works to the ESCO (estimated at US$0.2 million per annum), the cost of bagasse at a rate of US$10 per ton (for a total of approximately US$2.8 million per year), and operations and maintenance costs estimated at US$1.0 million per year. The payback period for this investment, on these terms, is estimated to be 2-3 years at an IRR of 25 percent.

Small-Scale Sugar Plants (Jaggeries)

6. There are at least 39 smaller-scale sugar "jaggeries" that produce between 15-20 percent of the sugar consumed in Uganda. They utilize wood almost exclusively to refine the cane to "jaggery" (a relatively inferior form of sugar, somewhat between molasses and unrefined caster sugar).

7. Most of these jaggeries are relatively small, and fall within the informal sector. They are generally situated far form the grid. Theoretically, they should offer good opportunities for off-grid electrification. However, the enterprises are poorly capitalized. Their boilers are very primitive, and could not be used to raise steam.

8. During the field surveys, one jaggery in Mukono District, Kiyanja Estate, was visited. The process heat for the jaggery is obtained from bagasse supplemented with firewood. It was estimated that 10 tons of cane produce about 1.2 tons of jaggery. One ton of cane also yields 100-300 kg of bagasse depending on the crushing efficiency.

9. A possible investment scenario for electricity production from a jaggery runs as follows:

> An average jaggery processes 6 tons of cane per day, yielding at least 600 kg of bagasse daily. Assuming an energy value of 12 MJ/kg for bagasse, and an operating period for the jaggery of 240 days a year, the equivalent electrical energy in the bagasse is approximately 168,000 kilowatt-hours per annum. If the jaggery is to generate electricity during an eight hour operation using the generated bagasse, a plant capacity of about 90 kilowatts will be installed. The cost of energy generated from such a plant is US$0.23 per kilowatt-hour. This

is a very high cost of electricity. The investment in electricity generation by a jaggery, therefore, does not look attractive.

10. It is unlikely that there would be either sufficient capital or the will to improve their technology base in such a manner as to generate electricity. The potential is there, as they produce an estimated 100,000 tons of bagasse per year, which is not currently utilized. However, the rehabilitation and investment costs would be prohibitive, even if the producers were interested in generating electricity. This is not a high priority option for off-grid electrification.

Annex H

Sawmill Wood Residues and Energy Potential

1. Uganda has a large number of sawmills and wood processing facilities. It is rich in forestry, both from a natural forestry point of view and from a forestry plantation point of view. As shown in Tables H-1 and H-2, there is great scope for sawmills to generate their own electricity in situ, as is done in many parts of the world.

Table H-1. Wood Waste Production from Natural Forests

Company	*Area of Operation*	*Estimated Installed Capacity Input (m3)*	*Average Capacity Utilization (%)*
Budongo Sawmill	BudongoMasindi	10,000	30.0
Amaply	BudongoMasindi	21,000	30.0
Nileply	Mabira, Mukono, West Mengo	20,000	30.0
Rwenzori Saw mill	Budongo, Masindi	7,500	30.0
Nkombe Sawmill	Kalinzu, Bushenyi	5,000	30.0
Bubwa saw mill	Budongo, Masindi	5,000	30.0
Kapkwata saw mill	Mt. Elgon, Kapchorwa	5,000	30.0
Tesekererwasaw mill	Sesse Islands, Kalangala	5,000	30.0
Jinja Construction and Joinery	Public and Private land	5,000	30.0
Total/avg		83,500	30.0

Source: Forest Department, team estimates from surveys.

2. The incentive for doing so would be much greater if wood were further processed (e.g., for fine timber, furniture, veneer, etc.). Such processing would require steam heat for processing. This would then justify the investment in plant for steam, and for co-generating electricity.

3. As it is now, wood processing is so dispersed and at such a low-level of technology, that there is little likelihood in the near future of any electricity generation from wood waste. The

high cost of capital, the distances from centers of demand, and the scale of the technology required will, as with sugar jaggeries, hinder this sector from providing electricity for a long time to come.

Table H-2. Wood Waste Produced from Plantations

Company	*Area of Operation*	*Installed capacity input (m3)*	*Average Capacity Utilization (%)*
Kanyankole & Sons Ltd.	Oruha Kabarole	2,000	30.0
Techna Saw mills (2)	Keyhara/kagora, Kabarole	8,400	30.0
Kwewayo Furniture & Timber Dealers	Kagorra, Kabarole		30.0
Western Patriotic Sawmill	Kikumiro, Kabarole		30.0
Rusekere Sawmill	Kikumiro, Kabarole	4,000	30.0
Muko Sawmills	Mafuga, Kabale		30.0
Ishasha Ban Dev. Scheme (2)	Mufuga & Muko, Kabale	8,400	30.0
Katugo Sawmill	Katugo, Luwero		30.0
Ndyagenda Sawmill	Katugo, Luwero		30.0
FMB Enterprises Sawmill	Katugo, Luwero		30.0
BESEPO Uganda Ltd (2)	Bugamba, Mbarara & Kibale NP, Kabarole		30.0
Capital Sawmill	Kiriima	5,000	30.0
Adaga Uganda Ltd (2)	Namafuma, Iganga	10,000 (?)	30.0
Kagera Sawmills Ltd.	Mafuga, Kabale	1,000	30.0
Casements (A) Ltd	Mafuga, Iganga	15,000	30.0
B.M. Technical Services	Bugamba, Mbarara	4,000	30.0
Uganda Wood Fabricators	Bugamba, Mbarara	8,000	30.0
Kapkwata Sawmills (2)	Lendu, Nebbi & Kapkwata, Kapchorwa	10,000	30.0
Sipi Sawmills Ltd.	Kapkwata, Kapchorwa	4,200	30.0
Bukenya and Sons Ltd.	Katugo, Luwero	3,000	30.0
Arbo Construction Ltd.	Wampanga	4,200	30.0
Cypress Sawmills Ltd	Kanyawara, Kabarole	4,200	30.0
Dissa Youth Group	Awang	4,200	30.0
Rugettee Overseas Ltd.	Usi	2,000	30.0
Forest Department (3)	Katugo, Luwero and Nyabyega, Masindi	12,600	30.0
Forest Research Institute	Katugo, Luwero	4,200	30.0
Total		**>114,400**	**30.0**

Source: Forest Department, team estimates from surveys.

Detailed Calculations

4. Logging and saw mills are very big sources of forest residues. In 1994, there were 37 saw mills in Uganda's forests, 11 of them in natural forests and 26 in plantation forests, as Tables H-1 and H-2 show. The saw mills operating in the natural forests have a total estimated installed capacity input of 83,500m^3 of logged wood.

5. The Utilization capacity of the saw mills in Uganda is about 30 percent. This means that the saw mills process approximately 25,000m^3 of logged wood annually. The team estimates that logging in natural forests results into residues of approximately 49,000m^3. This also means that the volume of the initial standing trees logged is about 71,000 m^3. The type of residues include branches and tops of the harvested trees, broken and defective logs, dead or injured standing trees, and small diameter trees. Some 65 percent of the volume of wood entering the mills ends up as residues. This implies that the mills produce residues of approximately 16,250m^3. Most of the mill residues are solid pieces and saw dust.

6. By the same token, the estimated 114,000 m^3 capacity of the saw mills in plantation forests, yield approximately 63,500 m^3 of logging residues and 22,680 m^3 of sawmill residues. Ultimately approximately 88 percent of the initial standing tree volume ends up as residues. Clearly, there is a lot of wastage of forest resources and, therefore, the need for intervention for waste recovery is obvious.

7. Currently, the major use of logging residues is for charcoal production. In areas where forest logging area is close to a population center, some of the residues are collected by the local people for fuel wood. The availability of the logging residues for use in a residues-fired electricity generation plant depends to a large extent on the these alternative (and competing) demands, the accessibility of the harvested forests, the adequacy of transportation networks, and the need for electrification in that particular area.

8. Field surveys were conducted on a number of sawmills operating in soft wood forests in order to assess the possibility of generating electricity to satisfy their own needs and that of load centers beyond. The sawmills visited were: Capital Sawmills and Uganda Associated Sawmills in Kabale, Ishasha Sawmills in Rukungiri, and BM Technical Services in Ishasha.

9. The sawmills are essentially small industries with one primary saw. The major source of power for these sawmills is diesel engines with capacities mainly in the range 60-85 Hp (80-114 kilowatts). One of the sawmills was using a 160 Hp (215 kilowatts) diesel engine. All the sawmills are situated quite some distance from the national grid. Both Capital Sawmills and Associated Sawmills are about 15 kilometers from the grid around Kabale town, while Ishasha Sawmills is about 40 kilometers from the grid. They are also located a good distance from potential customers, being deep into the forests. Therefore, the most likely possibility for electricity generation is only for the purposes of satisfying the requirements of the sawmill industry, and substituting for their diesel consumption, not for selling to anyone else.

10. Capital Sawmills in Kabale was selected by the team to determine the technical and economic viability of using wood residues for electricity generation. It has a capacity of 5,000 m^3 of log-wood, using a diesel engine of 65 Hp (86 kilowatts). Assuming a capacity Utilization of 30

percent it utilizes 100m^3 of log wood per annum. If 65 percent of the product is wood residues, this is equivalent to 975m^3 per year. Taking the basic density of air dry wood to be 600 kg/m^3 and the energy output of wood as 16 GJ/ton, the generated wastes have an energy value of approximately 7,810 megawatt-hours annually.

11. If a thermal power plant is installed at the site to utilize all the residues. assuming it is in operation 10 hours per day for 300 days a year, then the required installed capacity of the power plant would be on the order of approximately 2.6 megawatts. This is more than 30 times the required power needed to run the sawmill. Therefore, sawmills can generate much more power than their own needs. Theoretically, depending upon the proximity to settlements, industries or other load centers, sawmills are a potential source of electricity. Their capacity can be greatly increased by collecting much of the forest logging products.

12. The cost of electricity from such a plant would be, at best, on the order of US$0.15 per kilowatt hour. This cost compares reasonably with that of generation from coffee husks, although higher than the maximum UEB tariff. It is, therefore, much cheaper for the sawmill itself than running on a diesel engine. It is also a relatively good price for other isolated load centers in the neighborhood that may be using diesel engines or car batteries.

13. Work carried out with sawmill residues in Honduras found that sawmills producing more than 3,500m^3 annually could generate enough residues to be energy self-sufficient. Thus, theoretically, there are 25 sawmills in Uganda that could be energy self-sufficient. First, however, they would have to improve their capacity Utilization and saw more timber, thereby generating enough waste for raising steam for electricity generation. Second, the capital would have to be raised for such an investment. Most of the diesels driving the mills are very old. While it is inevitable they will have to be replaced, the cost of a boiler plant to generate electricity, and the organizational and management issues associated with such, will make this difficult. Nonetheless, this is an area government, donors and the private sector should examine much more closely.

Annex I

Coffee Husk Residues and Energy Potential

1. Because Uganda has very limited examples of biomass generated electricity (only limited cogeneration in the sugar industries), there is almost no basis for estimating the various costs of energy from biomass power plants. There is no data about importation of steam or gas fired turbines, gas combustion engines, or gasifiers. Therefore, estimations can only be made based mainly on inferred data from operating plants in other parts of the world.

2. In a district like Mukono, which produces one of the largest quantities of coffee husks and has relatively good infrastructure, it is possible to transport the coffee husks to one central place for generation of electricity, to either connect to the grid or serve large communities living far from the grid. Table I-1 shows the husk production by district; that Mukono District produces the most, with over 39,000 tons of husks annually. Table I-2 shows a list of all coffee hullers and their geographic distribution. If half of this amount is available for energy production and is collected at one point, about 30 GWh of electricity can be generated annually. Assuming that a peaking plant to supply electricity to the grid for 10 hours a day is installed and operates for 300 days a year, it would require an installed capacity of about 10 megawatts.

3. In order to calculate the levelized cost of electricity for such a plant, the following standard formula has been used:

$$\text{Cost of electricity (levelized)} = \frac{AC + (O \& M) + F}{E} \text{ (in \$/kWh)}$$

Where:

AC = Annualized capital cost ($/yr)
C = Total capital cost ($)
A = The annuity rate $= \frac{r(1+r)^n}{(1+r)^n - 1}$

where r is the discount rate and n = life of plant (years)
0 & M = Annual operating and maintenance cost ($/yr)
F = Annual fuel cost of plant ($/yr)
E = Number of kilowatt hours produced annually.

3. Table I-1 shows the derived cost of electricity from power plants for various biomass resources. A discount rate of 20 percent on the investment and a plant lifetime of 20 years has been assumed. Typical approximate values for the capital cost of US$2,000 per kilowatt of the plant and the O & M cost of US$0.01 per kilowatt-hour have also been assumed (refer to World Bank Technical Paper No. 240, Energy Series: Renewable Energy Technologies.

4. The cost of fuel (coffee husks) was derived from information provided by Uganda Clays Ltd, a ceramic industry that fires its kilns using coffee husks. The industry pays, on average, approximately US$23/ton for coffee husks, including transportation.

5. The assumed power plant generates electricity at a cost of approximately US$0.16 per kilowatt hour. Considering that the average consumer tariff in Uganda is approximately US$0.092 per kilowatt-hour, it is apparent that biomass plants in Uganda can not be competitive with grid electricity. The benefit/cost ratio for such a grid-connected plant would be less than one. However, because consumers not connected to the grid who use diesel generators are paying between twice and six times this price, decentralized biomass power plants (coffee husks, rice, wood wastes from sawmills) may offer an attractive prospect. If the industries produce power from their own residues, thereby eliminating the fuel costs (F=O), the cost of electricity goes down.

6. In order to demonstrate the aspect of power generation from a single factory using its own wastes, the case of the Kigulu coffee factory was considered. The factory generates 556 tons of coffee husks annually. Using the assumption that only half of the coffee husks are available for energy while half goes for soil conditioning, the energy produced by the plant is 4,448 GJ. A thermal generator operating at 35 percent efficiency would produce 443 megawatt-hours annually. Assuming that the plant operates for 10 hours per day, the period during which it is in normal production, for 300 days a year, an installed capacity of 144 kilowatts electricity generation could be installed.

7. For a small plant, an investment cost of US$1,575 per kilowatt has been assumed. The cost of generating electricity from this plant is approximately USS0.12 per kilowatt hour, which is about equal to the highest UEB tariff. This demonstrates that small plants generating electricity for their own use or having a little excess for selling to the neighboring community may be more cost-effective than larger plants.

Table I-1. Coffee Husk Resource and Energy Potential by District (1997)

District	Active factories	Active hullers	Est. annual husks (tons)	Avail. energy (GJ)	Elect. potential (MWh/yr)	Equiv. capacity (kW)	Equiv. capacity per factory (kW)
Bushenyi	19	35	9,730	77,840	7,566	518	27.3
Hoima	9	15	4,170	33,360	3,242	222	24.7
Iganga	18	38	10,564	84,512	8,214	563	31.3
Jinja	8	19	5,282	42,256	4,107	281	35.2
Kabarole	4	9	2,502	20,016	1,945	133	33.3
Kampala	5	10	2,780	22,240	2,162	148	29.6
Kamuli	8	12	3,336	26,688	2,594	178	22.2
Kasese	5	7	1,946	15,568	1,513	104	20.7
Kibale	4	11	3,058	24,464	2,378	163	40.7
Kiboga	8	16	4,448	35,584	3,459	237	29.6
Kigulu	1	2	556	4,448	432	30	29.6
Luwero	32	61	16,958	135,664	13,186	903	28.2
Masaka	62	116	32,248	257,984	25,075	1,717	27.7
Mbarara	9	16	4,448	35,584	3,459	237	26.3
Mpigi	52	96	26,688	213,504	20,752	1,421	27.3
Mubende	29	50	13,900	111,200	10,808	740	25.5
Mukono	78	141	39,198	313,584	30,479	2,088	26.8
Nebbi	1	4	1,112	8,896	865	59	59.2
Ntungamo	20	24	6,672	53,376	5,188	355	17.8
Rakai	18	34	9,452	75,616	7,349	503	28.0
Rukungiri	14	16	4,448	35,584	3,459	237	16.9
Total	404	732	203,496	1,627,968	158,230	10,838	26.8

Table I-2. Complete List of Coffee Factories, Locations, Districts and Number of Hullers in Uganda (1997)

No.	Factory Name	Location	District	No. Hullers
1	BWAMBA RUWENZORI*	BUNDIBUGYO	BUNDIBUGYO	2
2	A.B.A. LIMITED	NYAMUFUMURA	BUSHENYI	1
3	BANGA MULTI-PURPOSE COOP SOC.	ISHAKA	BUSHENYI	2
4	BANYANKOLE KWETERANA	BUSHENYI	BUSHENYI	4
5	BANYANKOLE KWETERANA	KABWEHE	BUSHENYI	2
6	BUKYENYE COFFE FACTORY	BUKYEKYE	BUSHENYI	1
7	BUSHENYI COFFEE ENTERPRISE	ISHAKA	BUSHENYI	2

No.	Factory Name	Location	District	No. Hullers
8	BUSHENYI COFFEE FACTORY	ISHAKA	BUSHENYI	2
9	BUSINGYE AND COMPANY LTD	RUTOTO	BUSHENYI	3
10	ISHAKA C.F. LTD	ISHAKA	BUSHENYI	1
11	KABIRA COFFEE FACTORY*	KABIRA	BUSHENYI	1
12	KALIRO COFFEE FACTORY	ISHAKA	BUSHENYI	2
13	KALIRO COFFEE FACTORY	KIZINDA-ISHAKA	BUSHENYI	3
14	KANENA COFFEE FACTORY*	ITENDERO	BUSHENYI	1
15	KWEKAMBA GRS. SOC.*	KITAGATA	BUSHENYI	1
16	KYABUGIMBI COFFEE FACTORY	RWENTUHA	BUSHENYI	1
17	KYANTAMBA MIXED FARM	ITENDERO	BUSHENYI	1
18	LEYA ENTERPRISES C.F.	RWENTUHA	BUSHENYI	1
19	MUKAMA TAREMWA ENTEPRISES LTD.	RUTOOKE	BUSHENYI	1
20	MURENGA C.F	KITAGATA	BUSHENYI	1
21	MWERU INVESTMENTS (U) LTD	ISHAKA	BUSHENYI	3
22	NYAKIHANGA FARMERS COOP. SOC.	BURARO	BUSHENYI	2
23	ST. JUDE COFFEE FACTORY	ISHAKA	BUSHENYI	2
24	BUNYORO GROWERS COOP UNION	HOIMA	HOIMA	2
25	BUGAHYA COFFEE FACTORY	KITOBA	HOIMA	2
26	HOIMA FARMERS C. F	KIRYATETE	HOIMA	1
27	KAIZER COFFEE FACTORY	KITYATETE	HOIMA	1
28	KAKE HONEST COFFEE FACTORY	KIRYATETE	HOIMA	1
29	KIRYATETE COFFEE FACTORY	KIRYATETE	HOIMA	2
30	KITOBA COFFEE FACTORY LTD	BUTEMA	HOIMA	2
31	MODERN COFFEE FACTORY	KITYATETE	HOIMA	2
32	TINANA COFFEE FACTORY CO. LTD	KITYATETE	HOIMA	1
33	ASSOCIATED COFFEE DEALERS	MUSITA	IGANGA	2
34	BUBOGO	BUBOGO	IGANGA	1
35	BUKONKO COFFEE FACTORY	BUKAYE	IGANGA	2
36	BULANGA FELLOWSHIP C. F.	BULANGA	IGANGA	1
37	BUNYA COFFEE FACTORY	BUNYA	IGANGA	1
38	BUSIKI COFFEE FACTORY	NAKAWUNZO	IGANGA	1
39	BUWONGO COFFEE FACTORY	KIGULU	IGANGA	1
40	KALIRO PRO. & PROD. LTD*	NABITENDE	IGANGA	1
41	KASOLO PRO. & PROD. LTD	KASOLO	IGANGA	2
42	KIYUNGA COFFEE FACTORY	KIYUNGA	IGANGA	4
43	LUUKA COFFEE FACTORY	BUSIIRO	IGANGA	2

No.	Factory Name	Location	District	No. Hullers
44	MAWUNDO BISUSA COFFEE FACTORY	KASOLO	IGANGA	1
45	MUSITA MODERN C. F	MUSITA	IGANGA	1
46	MWERU INVESTMENTS (U) LTD	KIYUNGA	IGANGA	1
47	NABUYANDA COFFEE FACTORY	NAMASOGA	IGANGA	2
48	NAKALAMA COFFEE FACTORY*	NAKALAMA	IGANGA	2
49	NAKISIGE COFFEE FACTORY	BUKAYE	IGANGA	1
50	NAWANYAGO COFFEE FACTORY*	BUSOLWA	IGANGA	2
51	NGAYAAMA C. F	KASOLO	IGANGA	1
52	WABULUNGU MULTI-PURPOSE	WABULUNGU	IGANGA	1
53	WILCO (UGANDA) LTD	MUSITA	IGANGA	1
54	ALIKOBA COFFEE ENTERPRISES	MAGAMAGA	JINJA	1
55	BUSOGA GRS NAMULESA C.F	NAMULESA	JINJA	6
56	BWAVU MPOLOGOMA C.F*	BUWENGE	JINJA	2
57	KANTONO COFFEE FACTORY	BUGEMBE	JINJA	4
58	KYERINDA COFFEE FACTORY	BUWENGE	JINJA	1
59	LWINHYO COFFEE FACTORY	KIKO	JINJA	1
60	MUTASAAGA HOLDINGS	BUWENGE	JINJA	1
61	TULIRABA ESTATES LTD	MUGULUKA	JINJA	2
62	WANAANCHI (U) LTD	BUWENGE	JINJA	1
63	BUKUMBI COFFEE GRS & PROCESSORS	BUKUKU	KABALORE	2
64	KABALORE COOP. UNION LTD	KITUMBA	KABALORE	3
65	MWENGE COFFEE FACTORY LTD	KIGUNGA	KABALORE	2
66	NYAKATONZI GRS. COOP. UNION	KICHECHE	KABALORE	2
67	NSAMBA COFFEE WORKS	KAWEMPE	KAMPALA	1
68	ORIENT COFFEE FACTORY	BWAISE	KAMPALA	1
69	SAYANA INTRA SALES (U) LTD	KAWEMPE	KAMPALA	2
70	VICTORIAL FARMERS	KAWEMPE	KAMPALA	2
71	WEST MENGO GRS COOP. UNION	KAWEMPA	KAMPALA	4
72	ERIMIYA KABAALE & SONS C.F	BUTABAALA	KAMULI	1
73	KALITUWA MILLERS (U) LTD	KALIRO	KAMULI	1
74	KEERA COFFEE FACTORY	KAMULI	KAMULI	1
75	LUZINGA COFFEE ESTATE	LUZINGA	KAMULI	3
76	MBULAMUTI COFFEE FACTORY	MBULAMUTI	KAMULI	2
77	MISSISSIPPI C.F	KAMULI	KAMULI	1
78	NEW KIYIRA COFFEE FACTORY	BUWAGI	KAMULI	2

No.	Factory Name	Location	District	No. Hullers
79	NSAMBA COFFEE WORKS LTD	KASAMBIRA	KAMULI	1
80	UGANDA AGRO INDUSTRIES*	KAMULI	KAMULI	2
81	BAKWANYE TRADING CO. LTD	RUKOKI	KASESE	1
82	NYAKATONZI COFFEE CO.	RUIMI	KASESE	2
83	RWENZORI COFFEE CO.	KASESE	KASESE	2
84	RWENZORI STD IND FARMERS CHOICE	KASESE	KASESE	1
85	SMRAD & BCCM COMPANY	KASESE	KASESE	1
86	BUYAGA FARMERS	ISUNGA	KIBALE	2
87	KAGADI COFFEE WORKS	KAGADI	KIBALE	3
88	KAKUMIRO GRS. COOP UNION	KAKUMIRO	KIBALE	4
89	KAKUMIRO GRS COOP UNION*	KAGADI	KIBALE	3
90	MAGOMA COOP SOC. LTD	KISOSOLYA	KIBALE	2
91	JOHN LUGENDO & CO. LTD	BUKOMERO	KIBOGA	1
92	KIKONYOGO C.F	KIBOGA	KIBOGA	1
93	KYANKWANZI C.F	LWAMATA	KIBOGA	1
94	LWAMATA C.F A/C KAHUMIRO FRS	LWAMATA	KIBOGA	2
95	MATULUBE COFFEE PROCESSORS	KAMPIRI	KIBOGA	2
96	WAMALA GROWERS COOP UNION	MASODDE	KIBOGA	3
97	WAMALA GROWERS COOP UNION	KATEERA	KIBOGA	3
98	WAMALA GROWERS COOP UNION	MASODDE	KIBOGA	3
99	KASOLO PROCESSORS & PROD LTD	KASOLO	KIGULU	2
100	A.G.B GROUP LTD	LUWERO	LUWERO	5
101	BANGA MULI-PURPOSE	LUMPEWE	LUWERO	2
102	BOMBO KWEKAMBA C. HULLERIES*	BBOWA	LUWERO	1
103	B.B DELTA MACHINERY SERVICES	ZIROBWE	LUWERO	2
104	EAST MENGO GRS. COOP UNION	BOMBO	LUWERO	2
105	EYALI AKUMANYI GEN MILLERS LTD	WOBULENZI	LUWERO	2
106	KALULE COFFEE ENTERPRISES	KALULE	LUWERO	1
107	KALULE COTTON GINNERY LTD	KALULE	LUWERO	1
108	KARA COFFEE LTD	NAKASEKE	LUWERO	2
109	KASANA KADDU COFFEE FACTORY LTD	KASANA	LUWERO	3
110	KATWE DYNAMO & COFFEE WORKS LTD	KIKOMA	LUWERO	2
111	KIMALIRIDDE C.F.	KASANA	LUWERO	3
112	KYATEREKERA TRANSPORT AGENCY	LUWERO	LUWERO	2
113	LUBE COFFEE GRS	LUWUBE	LUWERO	2

No.	Factory Name	Location	District	No. Hullers
114	LUSUKU DEVELOPMENTS LTD C.F	KIGULU	LUWERO	1
115	LUWERO COFFEE MILLERS	KASANA	LUWERO	2
116	MAGERUKI CO. LTD	KIKYUSA	LUWERO	1
117	MBOGO COFFEE FACTORY	LUWERO	LUWERO	1
118	MBUGA MULTI-PURPOSE SOC. LTD	BUTO	LUWERO	2
119	MIGEERA COFFEE FACTORY	KIZITO	LUWERO	1
120	MPANGATI MULTI-PURPOSE LTD	BUKASA	LUWERO	2
121	MUTAGISA C.F	SEMUTO	LUWERO	1
122	NAKALEMBE COFFEE FACTORY	KASANA	LUWERO	2
123	NAYASA COFFEE FACTORY	BAMUNANIKA	LUWERO	2
124	NSAMBA COFFEE WORKS	LWEMEWEDDE	LUWERO	2
125	NSAMABA COFFEE WORKS	WAKATAYI	LUWERO	2
126	QUICKONES COMMERCIAL AGENCIES	KIKYUSA	LUWERO	1
127	SEGIKAYO COFFEE WORKS	BBAALE	LUWERO	1
128	SEMUTO FARMERS A/C BUSIRO	SEMUTO	LUWERO	2
129	SIKIROJJA COFFEE GROWERS LTD	NAKASEKE	LUWERO	2
130	WAKATAYI COFFEE FACTORY	WAKATAYI	LUWERO	2
131	WOBULENZI AGR.FARM & C PROD LTD	KIKOMA	LUWERO	2
132	ZINUNULA COFFEE FACTORY	WOBULENZI	LUWERO	2
133	ASANANSIO SAJJABI PROPERTIES LTD	BIKAALI	MASAKA	1
134	AZZIZ COFFEE WORKS LTD	LUKAYA	MASAKA	1
135	A.G.B GROUP LTD	KIMWANYI	MASAKA	3
136	BADDU COFFEE WORKS	KAYIRIKITI	MASAKA	1
137	BAMAGEZI II GROUP LTD	KYABAKUZA	MASAKA	1
138	BUGONZI CURING CO. LTD	BUGONZI	MASAKA	2
139	BULAYI FARM (B) LTD	SAMALIYA	MASAKA	2
140	BULEMAUIRE FARMERS CO. LTD	KIRIMYA	MASAKA	1
141	BWOGI DAVID KALANZI & SONS	KINONI	MASAKA	1
142	B.B.J COFFEE FACTORY	MBIRIZI	MASAKA	1
143	CENTRAL MASAKA CO.*	KITOVU	MASAKA	2
144	CMBL – KAWOKO C.F.	KAWOKO	MASAKA	4
145	COFFEE PROCESSORS BUTENGA*	BUTENGA	MASAKA	2
146	EQUATOR GROWERS	KABONERA	MASAKA	3
147	GERALD BALUTI KIZIBA C.F	KABONERA	MASAKA	2
148	HAJJI JAMIL KAYIRA & SONS LTD	KABOYO	MASAKA	1
149	HAJJI SULAYIT B. MAYANJA B.B.J C.F	MBIRIZI	MASAKA	1

No.	Factory Name	Location	District	No. Hullers
150	HAJJI MUHAMUD ZZIWA	MISANVU	MASAKA	1
151	KABATEX CURERS CO. LTD	KYAMBOGO	MASAKA	2
152	KABOGERE COFFEE FACTORY	KABOYO	MASAKA	2
153	KABUKOLWA COFFEE FACTORY	KABUKOLWA	MASAKA	2
154	KAMUTUZA MBIRIZI C. F. LTD	MBIRIZI	MASAKA	2
155	BAKIJJULULA FRS C.F.	LUKAYA	MASAKA	1
156	KASASA COFFEE FACTORY	KASASA	MASAKA	2
157	KASUJJA COFFEE FACTORY	MISANVU	MASAKA	1
158	KAYANJA COFFEE FAC. A/C BWANIKA	BUKALASA	MASAKA	1
159	KAYIRIRA C.F.	MBIRIZI	MASAKA	1
160	KIGGUNDU & SONS	KYALUBU	MASAKA	3
161	KIKALALA C.F.	KYAMUYIMBWA	MASAKA	1
162	KIKUMA DDUNGU GRS COOP.	KIZIBA	MASAKA	2
163	KIMALIRIDDE COFFEE FACTORY	LUKAYA	MASAKA	4
164	KIRIMYA COFFEE FACTORY	KIRIMYA	MASAKA	1
165	KIRUMBA GROWERS (MIRAMBI) C.F	MIRAMBI	MASAKA	3
166	KISIITA ESTATES LTD	BUTENGA	MASAKA	1
167	KISOJJO COFFEE FACTORY LTD*	MUTEMULA	MASAKA	2
168	KUULA COFFEE FACTORY	MISANVU	MASAKA	1
169	KYABIRI C.F	KYABIRI	MASAKA	2
170	KYAKATEBE COFFEE FACTORY	BUKALASA	MASAKA	2
171	KYAMBOGO COFFEE CURING WKS LTD	KYAMBOGO	MASAKA	2
172	KYANGOMA ESTATES*	KYANGOMA	MASAKA	2
173	KYAZANGA COFFEE FACTORY	KYAZANGA	MASAKA	1
174	KYEBONGOTOKO C.F. LTD	MBIRIZI	MASAKA	1
175	KYOOKO COFFEE FACTORY LTD	KYOOKO	MASAKA	2
176	LWANYAGA COFFEE FACTORY	KISAAWE	MASAKA	3
177	LWANYAGA COFFEE FACTORY LTD	LUVULE	MASAKA	1
178	LWAZI-ZIZINGA C.F	BUTENGA	MASAKA	2
179	MAGALA COFFEE FACTORY LTD	KABOYO	MASAKA	2
180	MAKONDO COFFEE FACTORY	BUKOTO	MASAKA	1
181	MASAKA COOP. UNION LTD	KYABAKUZA	MASAKA	3
182	MASAKA COOP UNION LTD	MASAKA	MASAKA	3
183	MASAKA COOP UNION LTD	SENYANGE	MASAKA	3
184	MASAKA COOP. UNION LTD**	VILLA MARIA	MASAKA	2
185	MATETE COOFFEE WORKS LTD	MATETE	MASAKA	1

No.	Factory Name	Location	District	No. Hullers
186	MISANSALA COFFEE CO. LTD	MISANSALA	MASAKA	2
187	MPAKA GROUP OF COMPANIES	MBIRIZI	MASAKA	1
188	MUHIGIRA (1953) LTD	MASAKA	MASAKA	1
189	MUKISA MPEWO TRADING CO. C.F	KIRINYA	MASAKA	2
190	M/S NSUBUGA GODFREY C.F	NAKAIBA	MASAKA	1
191	NABAJJUZI FARMERS	KYABAKUZA	MASAKA	3
192	NAKAIBA GRS CO. LITD*	LUZINGA	MASAKA	2
193	NDAGWE COFFEE FACTORY	KYAZANGA	MASAKA	1
194	NKOMA FARMERS C. F. LTD	KYAZANGA	MASAKA	2
195	NTALE COFFEE FACTORY	LUKAYA	MASAKA	4
196	P.S.K. INDUSTRIAL GROUP LTD	MASAKA IND.	MASAKA	1
197	SAMALIYA ESTATES LTD	BULAYI	MASAKA	3
198	SOUTH EQUATORIAL CO.	KAYIRIKITI	MASAKA	2
199	SSENTONGO PRODUCE & C.F.	KISENYI	MASAKA	3
200	S.A.S COFFEE WORKS LTD	KINONI	MASAKA	1
201	TEBUKOZZA(OBWAVU) GRS COOP SOC	LUKAYA	MASAKA	2
202	VICTORIA COFFEE FACTORY	BUGONZI	MASAKA	1
203	BANYANKOLE KWETERANA	NDAIJA	MBARARA	2
204	BANYANKOLE KWETERANA	NYABIKURUNGU	MBARARA	3
205	GAMBA OKORE CONSUMER C.F	KAKIGANI	MBARARA	2
206	IBANDA COFFEE FACTORY	IBANDA	MBARARA	1
207	IBANDA FARMERS	ISHONGORORO	MBARARA	2
208	KAAR INDUSTRIES LTD	NYEIHANGA	MBARARA	1
209	KATENGA FARM ESTATES & C.F LTD	KAKIGANI	MBARARA	2
210	NSAMBA COFFEE WORKS	KASENYI	MBARARA	2
211	TAGA INVESTMENTS (U) LTD	NYAMITANGA	MBARARA	1
212	ABESIGWA GRS COOP. UNION*	SEETA	MPIGI	1
213	AKWATEMPOLE FARMERS LTD.	BUGOYE	MPIGI	1
214	ALLIED COFFEE WORKS	KAKIRI	MPIGI	2
215	BAGOLOBA FARMERS LTD	JJEZA	MPIGI	2
216	BENSU GENERAL AGENCIES	LUBANGA	MPIGI	2
217	BUGAGGA MANYI GROWERS LTD	SEETA	MPIGI	2
218	BUKANDULA COFFEE FACTORY*	BUKANDULA	MPIGI	2
219	BULENGA C.F. LTD	BULENGA	MPIGI	2
220	BULIGI MULTI-PURPOSE COOP SOC.*	KAMENGO	MPIGI	4

No.	Factory Name	Location	District	No. Hullers
221	BULWADDA COFFEE FACTORY	BULWADDA	MPIGI	1
222	BUSEGA NATETE FARMING COOP SOC.	BUSEGA	MPIGI	2
223	BUTAMBALA UNITED GRS LTD	KASOSO	MPIGI	2
224	BUWASA COFFEE FACTORY	NAMAYUMBA	MPIGI	2
225	BUYE ABAYITA ABABIRI COOP. SOC.	KANONI	MPIGI	1
226	CITY COFFEE FACTORY	LUGOBA	MPIGI	2
227	CMBL	BUDDE	MPIGI	3
228	GOMBA RANCHERS	KANONI	MPIGI	2
229	GWALIMUTALA ESTATES (U) LTD	MAIRYE	MPIGI	3
230	HARUNA MWANJE & SONS-KIWENDA CTLKIWENDA		MPIGI	1
231	JAGUAR COMMERCIAL COMPLEX*	LUWAMI	MPIGI	2
232	KABULASOKE COFFEE FACTORY*	KABULASOKE	MPIGI	1
233	KAKIRI COFFEE HULLING FACTORY	KAKIRI	MPIGI	1
234	KAMI COFFEE FACTORY LTD	KIWENDA	MPIGI	2
235	KAMULI INDUSTRIES ESTATES LTD	KASANGE	MPIGI	2
236	KANONI COFFEE FACTORY	KANONI	MPIGI	1
237	KATONGA C. MILLS*	KAYABWE	MPIGI	2
238	KAWANDA NKUMBI GRS COOP SOCIETY	KWANDA	MPIGI	1
239	KIRIRI FARMERS C.F.	KIRIRI	MPIGI	2
240	KYABWE COFFEE FACTORY	KYABADAZA	MPIGI	2
241	KYADDONDO FARMERS	GOMBE	MPIGI	1
242	KYAKUWA C.F.	LUTETE	MPIGI	1
243	LAXMI COFFEE CO.	KIRIRI	MPIGI	3
244	MACHINERIES E.A. LTD	MPIGI	MPIGI	4
245	MAGANJO COFFEE FACTORY	TITULA	MPIGI	2
246	MAGOMA GRS. LTD	BUJUUKO	MPIGI	2
247	MATUGGA COFFEE FACTORY*	MATUGGA	MPIGI	3
248	MAYA COFFEE FACTORY*	MAYA	MPIGI	2
249	MPUMUDDE ESTATES*	BULOBA	MPIGI	4
250	MUGERWA MUSIGIRE CO. LTD	KATINANGABO	MPIGI	1
251	MUYOBOZI GRS COOP SOC. LTD	JJEZA	MPIGI	1
252	M.M.L COFFEE TRADERS	BUKANDULA	MPIGI	1
253	M/S MWAVU SAUL COFFEE FACTORY	KASANGATI	MPIGI	1
254	NAKANA COFFEE FACTORY	BUWAMA	MPIGI	3
255	NAKATOOKE EXRESS COFFEE	NAKATOOKE	MPIGI	2

No.	Factory Name	Location	District	No. Hullers
	FACTORY			
256	NAKITOKOLO BUSIRO COF. FARMERS	NSANGI	MPIGI	1
257	NAKIYANJA COFFEE FACTORY	NAMUGONGO	MPIGI	2
258	NAMALIRI MULTI-PURPOSE FACTORY	NAKAWUKA	MPIGI	1
259	NSAMBA COFFEE WORKS LTD	BULO	MPIGI	2
260	NYANZI & SONS	KATEREKE	MPIGI	1
261	PAULINA LTD	KAKIRI	MPIGI	2
262	PEARL MECHANTILE LTD	NABUSANKE	MPIGI	3
263	PENETRAL GENERAL AGENCIES LTD	JJALAMBA	MPIGI	1
264	SAFARI INDUSTRIES LTD	KINAAWA	MPIGI	2
265	SANYU BALIMI MULTI-PURPOSE	KABOGA	MPIGI	2
266	SERUGOTI ESTATES	LUTEETE	MPIGI	1
267	UGANDA PROFIT DISTRIB. C.F LTD	NAMASAWO	MPIGI	2
268	WAGUMBULIZI MULTI-PURPOSE	KIRIRI	MPIGI	1
269	WALUDDE & PARTNERS	KASANGATI	MPIGI	2
270	WEST MENGO GRS. COOP UNION	KIBIBI	MPIGI	4
271	WEST NEBGI GRS, COOP UNION	KIDUMULE	MPIGI	3
272	Y.K. & M. COFFEE CO. LTD	KITUNGWA	MPIGI	3
273	BUJJUBI GRS COOP SOC.	MANYI	MUBENDE	1
274	BUSUNJU FARMERS COFFEE FACTORY	BUSUNJU	MUBENDE	2
275	HASAYA COFFEE FACTORY	KASSANDA	MUBENDE	2
276	KALANGALO COFFEE GRS LTD*	KYESINGIRO	MUBENDE	2
277	KAMPALA JELLITON SUPPLIERS	BBUYE/MITYANA	MUBENDE	1
278	KAMUSENENE GRS. COOP. SOC.	KISEKENDE	MUBENDE	2
279	KAWAMA AGENCIES*	KAKINDU	MUBENDE	4
280	KIRYABIROKWA ESTATE LTD	NAMBALE	MUBENDE	1
281	KISEMBO C.F	KISEKENDE	MUBENDE	2
282	KITEKO GENERAL TRADERS & FRS LTD	NAWANGIRI	MUBENDE	2
283	KITONGO GRS*	KITONGO	MUBENDE	1
284	KIWEEBYA COFFEE FACTORY	KIWEBYA	MUBENDE	2
285	K. KIZITO COFFEE FACTORY	KASIBA	MUBENDE	1
286	MAKONZI ESTATE C. F	MAKONZI	MUBENDE	2
287	MOLES ENTERPRISES C. F	KISEKENDE	MUBENDE	1
288	MUBENDE COFFEE FACTORY	KAMULI	MUBENDE	2
289	MUNAKU KAAMA SINGO GRS LTD	SSEKANYONYI	MUBENDE	2
290	MUYIZZI TASUBWA COFFEE FACTORY	NAMUKOZI	MUBENDE	1

No.	Factory Name	Location	District	No. Hullers
291	M/S SAMWIRI KASAANVU C.F.	KATAKALA	MUBENDE	2
292	NAAMA COFFEE WORKS	NAAMA	MUBENDE	2
293	NAKINSIGE MILLING PLANT	NAMUKOZI	MUBENDE	1
294	NAMAGEMBE FARM KABALUNGI LTD	KYANKOWE	MUBENDE	2
295	NAMBALE C.F.	NAMBALE	MUBENDE	1
296	NAMUKOZI COFFEE FACTORY	NAMUKOZI	MUBENDE	2
297	O.S.U COFFEE FACTORY LTD	DAVULA	MUBENDE	1
298	QUICKLINES COMMERCIAL AGENCIES	BAMUNANIKA	MUBENDE	1
299	WAGGWA EKKU COFFEE ASS. LTD	TTAMU	MUBENDE	1
300	WAMALA GROWERS COOP UNION	KASENYI	MUBENDE	3
301	WAMALA GROWERS COOP UNION	KATEERA	MUBENDE	3
302	WAMALA GROWERS COOP UNION	MITYANA	MUBENDE	4
303	ZIGOTI COOP SOC. LTD	ZIGOTI	MUBENDE	3
304	AFRO TRADERS & FARMERS (U) LTD	NABUGANYI	MUBENDE	2
305	ANDREW KAGGWA BUKERERE C.F*	BUKERERE	MUKONO	4
306	BANGA MULTI-PURPOSE	NTENJERU	MUKONO	2
307	BEVERAGES & SPICES	KYAGGWE-MUKISA	MUKONO	2
308	BUGERERE FARMERS & TRADERS	GANGAMA	MUKONO	1
309	BUGUNGU C.F. LTD*	BUGUNGU	MUKONO	1
310	BUIKWE C.F.	BUIKWE	MUKONO	2
311	BUKAYA COFFEE FACTORY	BUKAYA	MUKONO	4
312	BUKUNJA KATEREKERA GRS COOP SOC	NAGOJJE	MUKONO	2
313	BUKYAMA COFFEE GRS LTD	KIBOWA	MUKONO	1
314	BUSABAGA COFFEE ESTATES	SSEZIBWA/BUSABAGA	MUKONO	1
315	BUSIRO FARMERS	NGOGWE	MUKONO	1
316	BUTIKO COFFEE FACTORY	KISOGA	MUKONO	1
317	BUWETA COFFEE ESTATES LTD	BULUMAGI	MUKONO	2
318	BWEYINDA TRANSPORT & PRODUCE	WAKISU	MUKONO	2
319	CMBL – KIIRA C.F	NJERU	MUKONO	2
320	DAMJI PLANTATIONS	KINAJJUZA	MUKONO	4
321	DANIEL KIMBUGWE & CO KITIGOMA C.F	KITIGOMA	MUKONO	1
322	DIKUH (U) LTD	BUKAYA	MUKONO	2
323	EAST MENGO GRS COOP UNION LTD	BUIKWE	MUKONO	2
324	EAST MENGO GRS COOP UNION LTD	KAYUNGA	MUKONO	2
325	EAST MENGO GRS COOP UNION LTD	MULONDO	MUKONO	2
326	EAST MENGO GRS COOP UNION LTD	NAMAIBA	MUKONO	1

No.	Factory Name	Location	District	No. Hullers
327	EAST MENGO GRS COOP UNION LTD	NAZIGO	MUKONO	2
328	EAST MENGO GRS COOP UNION LTD	NDESE	MUKONO	4
329	EDWARD KIWANUKA & SONS	KASAWO	MUKONO	2
330	GWALIMUTALA ESTATES LTD	WABIKOKOOMA	MUKONO	3
331	HABARI INDUSTRIES C.F	KAYUNGA	MUKONO	2
332	INDEPENDENCE COFFEE FACTORY*	KASAWO	MUKONO	2
333	INDUSTRIAL COFFEE GRS A/C BUSIRO	NAMAKOMAGO	MUKONO	4
334	J.M.S COFFEE FACTORY	NYENGA	MUKONO	2
335	KABIMBIRI FARMERS	KABIMBIRI	MUKONO	2
336	KAGANDA COFFEE MILLERS	NAMINYA	MUKONO	1
337	KALIRO C.F	KISOGA	MUKONO	2
338	KAMBE COFFEE FACTORY LTD	KAWUKU	MUKONO	1
339	KANGULUMIRA COFFEE GRS & CURERS	NAKATUNDU	MUKONO	2
340	KANGULUMIRA FARMERS	KANGULUMIRA	MUKONO	1
341	KARA COFFEE LTD	LWEJALI	MUKONO	3
342	KASAWO COFFEE FACTORY	GGAVU	MUKONO	2
343	KASUBI-KAGGWE C.F.	GGAVU	MUKONO	2
344	KIGUNGA COFFEE PROCESSORS	KIGUNGA	MUKONO	2
345	KIKATI MULTI-PURPOSE COOP SOC.	KIKATI	MUKONO	2
346	KIMBUGUMA COFFEE GRS	WALUSUBI	MUKONO	2
347	KIMOTE COFFEE FACTORY*	KATETE	MUKONO	4
348	KISAABA C.F	KAYUNGA	MUKONO	1
349	KIWANGA COOP SOC.	KIWANGA	MUKONO	2
350	KOTWE COFFEE FACTORY	KOTWE	MUKONO	1
351	KULANEMA C.F.	NYENGA	MUKONO	2
352	KYAGALANYI COFFEE LTD	KYAMBOGO	MUKONO	2
353	KYAGALANYI COFFEE LTD	NAKANYONYI	MUKONO	3
354	MAGONGA BAGALA AYAZE	BUSENYA	MUKONO	2
355	MALUNGU COFFEE FACTORY	MALONGWE	MUKONO	1
356	MASAGAZI COFFEE FACTORY	BUNYIRI	MUKONO	1
357	MIGEERA COFFEE FACTORY	NAKAZZI	MUKONO	1
358	MIREMBE NGALO MULTI-PURPOSE	DDUNGI	MUKONO	2
359	MUGABI & FAMILY C.F.	MALINI	MUKONO	1
360	MUGANZI COFFEE FACTORY	KISOGA	MUKONO	1
361	MUJJAJJASI COFFEE FACTORY	NAZIGO	MUKONO	1

No.	Factory Name	Location	District	No. Hullers
362	MUKONO ESTATES LTD	KIREREMA	MUKONO	1
363	MUKONO MILLERS & FARMERS	MUKONO	MUKONO	1
364	MULIMI GEN. MERCHANDISE CO. LTD	KALAGALA	MUKONO	2
365	MULIMIRA NYONYI C.F.	NTOOKE	MUKONO	3
366	MUSOKE SEMANDA COFFEE FACTORY	NAGOJJE	MUKONO	2
367	M/S BEVERAGES & SPICES LTD	NAMAIBA	MUKONO	2
368	M/S LAKE KUTEA MILLERS	LUKUMBI	MUKONO	2
369	NABUTITTI C.F	NAMUMIRA	MUKONO	1
370	NAKABAGO GRS COOP SOC. LTD	NAKABAGO	MUKONO	1
371	NAKAYAGA GRS COOP SOC.	BANDA	MUKONO	1
372	NAMALIRI MIXED GROWERS	NAMALIRI	MUKONO	2
373	NAMATOGONYA COFFEE FACTORY	NAZIGO	MUKONO	1
374	NEKOYEDDE MULTI-PURPOSE	NAMYOYA	MUKONO	2
375	NGEYE COFFEE FACTORY LTD	NDEEBA	MUKONO	2
376	NSAMBA COFFEE WORKS	MBALALA	MUKONO	2
377	NSAMBA COFFEE WORKS	NAKIFUMA	MUKONO	1
378	PAULO KALULE & SONS	BUKOLOTO	MUKONO	3
379	SEKIMU C.F.	BUKOLOTO	MUKONO	2
380	SEMPALA COFFEE ESTATES	NAMATABA	MUKONO	3
381	SSEZIBWA COFFEE CURING WORKS	BUKOLOTO	MUKONO	2
382	SSEZIBWA UNITED FARMERS	SEETA	MUKONO	1
383	S.S. FARM PROCESSING	SSENYANGE	MUKONO	2
384	TRADERS AND ENTERPRISES	MONIKO	MUKONO	2
385	ZIN ENTERPRISES C.F.	SEETA	MUKONO	1
386	ZIRIDDAMU C.F. LTD	NKOKONJERU	MUKONO	1
387	OKORO COFFEE GRS COOP UNION LTD	AYUDA	NEBBI	4
388	BANYANKOLE KWETERANA COOP	BWONGYERA	NTUNGAMO	2
389	BIRUGA OMUTUTU KWETERANA GRS	NTUNGAMO	NTUNGAMO	2
390	BUSHINGYE COF. HULLERS COOP SOC	RWASHAMAIRE	NTUNGAMO	1
391	BUTARE PROD. BUYERS COOP SOC	KAHUNGA	NTUNGAMO	1
392	BYUSUF & SONS ENTERPRISES C.F	RWASHAMAIRE	NTUNGAMO	1
393	HAJI AHAMADA RWOMUSHANA C.F.	NTUNGAMO	NTUNGAMO	1
394	J.M.K ENTERPRISES	NYAMUNUKA	NTUNGAMO	1
395	KAGARAMA FARMERS	KAGARAMA	NTUNGAMO	1
396	KASINGA AGENCIES	RWASHAMAIRE	NTUNGAMO	1
397	KATE COFFEE FACTORY A/C A.B.A LTD	NTUNGAMO	NTUNGAMO	1

No.	Factory Name	Location	District	No. Hullers
398	KINENA COFFEE FARMERS	RWASHAMAIRE	NTUNGAMO	1
399	MANDE & KISENYI CO.	NYAMUNUKA	NTUNGAMO	1
400	M/S BARUGA MPOLA C.F.	RWASHAMAIRE	NTUNGAMO	1
401	N & B KAHENGYE C.F	KAHENGYE	NTUNGAMO	1
402	NYAKASSALALA C.F.	NYAKASSALALA	NTUNGAMO	1
403	ORIGINAL HULLERS LTD	KITONGO	NTUNGAMO	1
404	RWASHAMAIRE COFFEE FACTORY	RWASHAMAIRE	NTUNGAMO	2
405	RWASHAMAIRE GRS COOP SOC.	RWASHAMAIRE	NTUNGAMO	2
406	THE 'K' ENTERPRISES LTD	RWASHAMAIRE	NTUNGAMO	1
407	YORAM KASYATA C.F. LTD	RWAMABONDO	NTUNGAMO	1
408	ALIBA AZEWA GRS COOP SOC.	NSAMBYA	RAKAI	2
409	AVE MARIA COFFEE FACTORY	KIKONDO	RAKAI	1
410	BULINDA GRS. COOP SOC.	MATALE	RAKAI	2
411	BYANSI C.F. LTD	KALWANGA	RAKAI	2
412	INDUSCO LTD	KAKONDO	RAKAI	4
413	KALISIZO COFFEE WORKS	MANYAMA	RAKAI	2
414	KASULE MEGERA COFFEE FACTORY	KAKONDO	RAKAI	2
415	KIGENYA COFFEE FACTORY LTD	KIGENYA	RAKAI	1
416	KIKONDO KYATEREKERA GRS COOP	KAKONDO	RAKAI	1
417	KITWALANYE GRS COOP SOC.	KITWALANYE	RAKAI	1
418	KOOKI COFFEE FARMERS	LUMBUGU	RAKAI	2
419	KYOTERA COFFEE GROWERS LTD	KYOTERA	RAKAI	3
420	KYOTERA ESTATES HIDES & SKINS CO.	KYOTERA	RAKAI	2
421	MASAKA COOP UNION LTD	NSAMBYA	RAKAI	2
422	MUBEJJA COOFFEE FACTORY	KALONGO	RAKAI	1
423	MUGERWA LUGWANA & CO.	JJONGOZA	RAKAI	2
424	NDIBAREKERA MITTI C. F	MITTI	RAKAI	2
425	NSAMVA COFFEE WORKS	LWAMAGGWA	RAKAI	2
426	BUGYERA GRS. COOP. SOC.	BUGYERA	RAKAI	2
427	BUYANZA C.F.	BUYANZA	RUKUNGIRI	1
428	KAKINGA FARMERS TRADING CO.	KEBISONI	RUKUNGIRI	1
429	KASOROOZA FARMERS COOP SOC LTD	RWERERE	RUKUNGIRI	1
430	KIGEZI DISTRICT GRS COOP UNION*	RUKUNGIRI	RUKUNGIRI	4
431	KIGIRO MILLERS COFFEE FACTORY	KIGIRO	RUKUNGIRI	1
432	KINKIZI C.F.	KAYONZA	RUKUNGIRI	1

No.	Factory Name	Location	District	No. Hullers
433	NYAKATUNGA FRS & PROC. COOP SOC	KEBISONI	RUKUNGIRI	2
434	RUBABO COFFEE FACTORY (U) LTD	RUBABO	RUKUNGIRI	1
435	RUKUNGIRI COFFEE FACTORY	BWOMA	RUKUNGIRI	1
436	RUGEYO GRS COOP SOC.	RUGYEYO	RUKUNGIRI	2
437	RWABIGANGURA COFFEE FACTORY	RWABIGANGURA	RUKUNGIRI	1
438	RWERERE GRS & COFFEE CURING	RWERERE	RUKUNGIRI	1
439	STANLEY RWAKAZAIRE C.F.	RWERERE	RUKUNGIRI	1
440	UGANDA DAY & NIGHT C.F.	RUKUNGIRI	RUKUNGIRI	1
	Total			792

* Not operating in 1997.
Source: Uganda Coffee Development Authority (UCDA).

Annex J

Table Illustrating Solar Resource Distribution and Potential

Table J-1. Solar Resource Distribution and Potential

Station	*Zone*	*Temperature (^{0}C)*	*Sunshine (hours)*	*Cloud cover (oktas)*	*Insulation (langleys)*
Wandelai		25.4	7.9	N/A	445
Kabale	S.E	16.6	5	6.7	N/A
Kasese	West	23.1	6.4	6.6	444
Gulu	North	23.1	7.9	5.6	421
Atumatak	N.E	21.8	8.6	N/A	540
Entebbe	South	21.2	6.5	5.9	438
Kibanda		20.2	5.9	N/A	377
Bugusege		21	5.8	N/A	374

Source: Meteorological Department.

Annex K

Tables Showing Wind Measurements in Key Locations in Uganda

Table K-1: Wind Measurements at 0600 (at 10m above ground)

Month	*Arua*	*Entebbe*	*Masaka*	*Fort Portal*	*Gulu*	*Jinja*	*Kabale*	*Kampala*	*Kasese*	*Kitgum*	*Lira*	*Masindi*	*Mbale*	*Mbarara*	*Moroto*	*Mubende*	*Soroti*	*Tororo*
Jan.	3.0	3.0	2.0	1.5	3.5	2.5	1.5	3.5	1.0	1.5	2.5	2.0	3.0	1.5	1.5	5.5	3.5	2.5
Feb.	3.0	2.0	2.5	1.5	3.5	2.0	1.0	3.0	1.5	2.5	2.0	1.5	3.0	1.5	1.0	6.0	3.0	3.5
Mar.	3.0	2.5	1.5	2.5	3.5	2.5	1.0	3.5	1.5	2.5	2.0	2.0	2.0	2.0	1.0	6.0	2.5	2.5
Apr.	3.5	3.0	1.5	2.0	4.0	2.5	1.0	3.5	1.5	2.5	1.5	2.0	3.0	1.5	1.0	6.5	2.5	2.0
May	2.5	3.5	1.5	2.5	3.5	2.5	1.5	3.5	2.0	3.5	1.5	2.0	3.0	2.0	1.0	6.5	2.5	2.0
Jun.	2.5	3.0	2.0	2.0	3.0	2.5	1.0	3.5	1.0	3.5	1.5	1.5	3.0	2.0	1.0	6.5	2.5	2.0
Jul.	2.5	3.0	2.5	2.0	3.0	2.0	1.5	4.0	1.0	2.5	1.5	1.5	3.5	2.0	1.0	6.0	2.5	2.0
Aug.	2.5	2.5	2.5	2.0	3.0	2.0	2.5	4.0	1.0	2.5	1.5	1.5	3.5	2.0	1.0	6.0	2.5	2.0
Sept.	2.5	3.0	2.5	2.0	3.0	2.0	1.5	4 0.	1.0	2.5	1.5	1.5	3.5	2.0	1.0	6.0	2.5	1.5
Oct.	2.5	2.5	2.0	2.0	3.5	2.5	1.5	3.5	1.0	2.5	2.0	1.5	3.5	2.0	1.0	6.0	2.5	1.5
Nov.	2.5	2.0	2.0	2.0	3.5	2.5	1.5	3.0	1.5	3.0	2.0	2.0	3.5	1.5	1.0	5.0	3.0	2.0
Dec.	2.5	2.0	2.0	2.0	3.5	2.5	1.5	3.5	1.0	3.0	1.5	2.0	3.5	1.5	1.5	5.5	3.0	2.0
Avg	**2.5**	**2.5**	**2.0**	**2.0**	**3.5**	**2.5**	**1.5**	**3.5**	**1.0**	**2.5**	**2.0**	**1.5**	**3.5**	**2.0**	**1.0**	**6.0**	**2.5**	**2.0**

Source: Meteorological Department.

Table K-2: Wind Measurements at 1200 (at 10m above ground)

Month	*Arua*	*Entebbe*	*Masaka*	*Fort Portal*	*Gulu*	*Jinja*	*Kabale*	*Kampala*	*Kasese*	*Kitgum*	*Lira*	*Masindi*	*Mbale*	*Mbarara*	*Moroto*	*Mubende*	*Soroti*	*Tororo*
Jan.	4.5	5.0	3.5	4.0	5.0	5.0	3.5	6.0	3.5	5.5	6.0	3.0	4.5	3.5	3.0	6.5	4.0	3.5
Feb.	4.5	6.0	3.5	3.5	5.0	5.0	3.5	6.5	3.5	5.5	6.0	3.0	4.5	3.5	3.0	6.5	3.5	3.5
Mar.	4.0	5.5	3.5	3.5	4.5	5.0	3.5	6.0	3.0	5.5	6.0	3.6	4.5	3.5	3.0	7.0	3.5	3.5
Apr.	4.0	5.0	3.0	3.5	4.0	4.5	3.5	5.5	2.5	5.0	4.5	3.0	4.5	3.5	2.5	6.5	3.0	3.0
May	3.5	3.0	3.0	3.5	4.0	4.5	3.5	6.0	2.5	4.5	4.0	2.5	4.5	3.5	2.0	6.5	3.0	2.5
Jun.	3.5	5.5	3.0	3.5	3.5	4.5	3.5	6.5	2.5	4.0	3.5	3.5	4.0	4.0	1.0	7.5	3.0	3.0
Jul.	3.5	5.0	3.0	3.5	3.5	4.5	3.5	6.0	2.5	4.0	3.5	2.5	4.5	4.0	3.5	7.0	3.0	3.5
Aug.	3.5	5.0	3.0	3.5	3.5	4.5	4.0	5.5	2.5	4.5	4.0	2.5	4.5	4.0	2.0	6.0	3.0	3.0
Sept.	4.0	5.0	3.0	3.5	4.0	4.5	4.0	5.5	3.5	4.5	4.5	2.5	4.5	4.0	2.0	6.5	3.0	3.5
Oct.	4.0	5.0	3.0	3.5	4.0	4.0	4.0	5.0	3.0	5.0	4.5	2.5	4.0	3.5	2.5	6.0	3.0	3.5
Nov.	4.0	5.0	3.0	3.5	4.0	4.5	4.0	5.0	3.0	5.5	5.5	2.5	4.0	3.0	2.5	6.0	3.5	3.5
Dec.	4.0	4.5	3.0	3.5	4.0	4.0	3.5	5.5	3.0	5.0	6.0	2.5	4.5	3.0	2.5	6.0	4.0	3.5
Avg.	**4.0**	**5.0**	**3.0**	**35.0**	**4.0**	**4.5**	**3.5**	**5.5**	**3.0**	**5.0**	**5.0**	**2.5**	**4.5**	**3.5**	**2.5**	**6.5**	**3.5**	**3.5**

Source: Meteorological Department.

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Joint UNDP/World Bank

ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

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
	Commercialization of Marginal Gas Fields (English)	12/97	201/97
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
Ethiopia	Energy Assessment (English)	07/84	4741-ET

Region/Country	***Activity/Report Title***	***Date***	***Number***
Ethiopia	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
Mauritius	Bagasse Power Potential (English)	10/87	077/87
	Energy Sector Review (English)	12/94	3643-MAS
Mozambique	Energy Assessment (English)	01/87	6128-MOZ

Region/Country	***Activity/Report Title***	***Date***	***Number***
Mozambique	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
Tanzania	Power Loss Reduction Volume 1: Transmission and Distribution SystemTechnical Loss Reduction and Network Development (English)	06/98	204A/98
	Power Loss Reduction Volume 2: Reduction of Non-Technical Losses (English)	06/98	204B/98

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
	Rural Electrification Strategy Study	09/99	221/99
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

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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
	Institutional Development for Off-Grid Electrification	06/99	215/99
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	--

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India	Opportunities for Commercialization of Nonconventional Energy Systems (English)	11/88	091/88
	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
	Environmental Issues in the Power Sector (English)	06/98	205/98
	Environmental Issues in the Power Sector: Manual for Environmental Decision Making (English)	06/99	213/99
	Household Energy Strategies for Urban India: The Case of Hyderabad	06/99	214/99
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	Natural Gas Investment Study, Volumes 1, 2 & 3	12/97	199/97
Kazakhstan & Kyrgyzstan	Opportunities for Renewable Energy Development	11/97	16855-KAZ
Poland	Energy Sector Restructuring Program Vols. I-V (English)	01/93	153/93
	Natural Gas Upstream Policy (English and Polish)	08/98	206/98
	Energy Sector Restructuring Program: Establishing the Energy Regulation Authority	10/98	208/98
Portugal	Energy Assessment (English)	04/84	4824-PO
Romania	Natural Gas Development Strategy (English)	12/96	192/96
Slovenia	Workshop on Private Participation in the Power Sector (English)	02/99	211/99
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

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Arab Republic of Egypt	Energy Assessment (English and French)	03/84	4157-MOR
	Status Report (English and French)	01/86	048/86
Morocco	Energy Sector Institutional Development Study (English and French)	07/95	173/95
	Natural Gas Pricing Study (French)	10/98	209/98
	Gas Development Plan Phase II (French)	02/99	210/99
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
Syria	Energy Efficiency Improvement in the Fertilizer Sector (English)	06/90	115/90
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
	Renewable Energy Strategy Study, Volume I (French)	11/96	190A/96
	Renewable Energy Strategy Study, Volume II (French)	11/96	190B/96
Yemen	Energy Assessment (English)	12/84	4892-YAR
	Energy Investment Priorities (English)	02/87	6376-YAR
	Household Energy Strategy Study Phase I (English)	03/91	126/91

LATIN AMERICA AND THE CARIBBEAN (LAC)

LAC Regional	Regional Seminar on Electric Power System Loss Reduction in the Caribbean (English)	07/89	--
	Elimination of Lead in Gasoline in Latin America and the Caribbean (English and Spanish)	04/97	194/97
	Elimination of Lead in Gasoline in Latin America and the Caribbean - Status Report (English and Spanish)	12/97	200/97
	Harmonization of Fuels Specifications in Latin America and the Caribbean (English and Spanish)	06/98	203/98
Bolivia	Energy Assessment (English)	04/83	4213-BO
	National Energy Plan (English)	12/87	--
	La Paz Private Power Technical Assistance (English)	11/90	111/90
	Prefeasibility Evaluation Rural Electrification and Demand Assessment (English and Spanish)	04/91	129/91
	National Energy Plan (Spanish)	08/91	131/91
	Private Power Generation and Transmission (English)	01/92	137/91
	Natural Gas Distribution: Economics and Regulation (English)	03/92	125/92
	Natural Gas Sector Policies and Issues (English and Spanish)	12/93	164/93
	Household Rural Energy Strategy (English and Spanish)	01/94	162/94
	Preparation of Capitalization of the Hydrocarbon Sector	12/96	191/96
Brazil	Energy Efficiency & Conservation: Strategic Partnership for Energy Efficiency in Brazil (English)	01/95	170/95
	Hydro and Thermal Power Sector Study	09/97	197/97
Chile	Energy Sector Review (English)	08/88	7129-CH
Colombia	Energy Strategy Paper (English)	12/86	--
	Power Sector Restructuring (English)	11/94	169/94
	Energy Efficiency Report for the Commercial and Public Sector (English)	06/96	184/96
Costa Rica	Energy Assessment (English and Spanish)	01/84	4655-CR
	Recommended Technical Assistance Projects (English)	11/84	027/84

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Costa Rica	Forest Residues Utilization Study (English and Spanish)	02/90	108/90
Dominican Republic	Energy Assessment (English)	05/91	8234-DO
Ecuador	Energy Assessment (Spanish)	12/85	5865-EC
	Energy Strategy Phase I (Spanish)	07/88	--
	Energy Strategy (English)	04/91	--
	Private Minihydropower Development Study (English)	11/92	--
	Energy Pricing Subsidies and Interfuel Substitution (English)	08/94	11798-EC
	Energy Pricing, Poverty and Social Mitigation (English)	08/94	12831-EC
Guatemala	Issues and Options in the Energy Sector (English)	09/93	12160-GU
Haiti	Energy Assessment (English and French)	06/82	3672-HA
	Status Report (English and French)	08/85	041/85
	Household Energy Strategy (English and French)	12/91	143/91
Honduras	Energy Assessment (English)	08/87	6476-HO
	Petroleum Supply Management (English)	03/91	128/91
Jamaica	Energy Assessment (English)	04/85	5466-JM
	Petroleum Procurement, Refining, and Distribution Study (English)	11/86	061/86
	Energy Efficiency Building Code Phase I (English)	03/88	--
	Energy Efficiency Standards and Labels Phase I (English)	03/88	--
	Management Information System Phase I (English)	03/88	--
	Charcoal Production Project (English)	09/88	090/88
	FIDCO Sawmill Residues Utilization Study (English)	09/88	088/88
	Energy Sector Strategy and Investment Planning Study (English)	07/92	135/92
Mexico	Improved Charcoal Production Within Forest Management for the State of Veracruz (English and Spanish)	08/91	138/91
	Energy Efficiency Management Technical Assistance to the Comision Nacional para el Ahorro de Energia (CONAE) (English)	04/96	180/96
Panama	Power System Efficiency Study (English)	06/83	004/83
Paraguay	Energy Assessment (English)	10/84	5145-PA
	Recommended Technical Assistance Projects (English)	09/85	--
	Status Report (English and Spanish)	09/85	043/85
Peru	Energy Assessment (English)	01/84	4677-PE
	Status Report (English)	08/85	040/85
	Proposal for a Stove Dissemination Program in the Sierra (English and Spanish)	02/87	064/87
	Energy Strategy (English and Spanish)	12/90	--
	Study of Energy Taxation and Liberalization of the Hydrocarbons Sector (English and Spanish)	120/93	159/93
	Reform and Privatization in the Hydrocarbon Sector (English and Spanish)	07/99	216/99
Saint Lucia	Energy Assessment (English)	09/84	5111-SLU
St. Vincent and the Grenadines	Energy Assessment (English)	09/84	5103-STV
Sub Andean	Environmental and Social Regulation of Oil and Gas Operations in Sensitive Areas of the Sub-Andean Basin (English and Spanish)	07/99	217/99
Trinidad and Tobago	Energy Assessment (English)	12/85	5930-TR

Region/Country	*Activity/Report Title*	*Date*	*Number*
	GLOBAL		
	Energy End Use Efficiency: Research and Strategy (English)	11/89	--
	Women and Energy--A Resource Guide The International Network: Policies and Experience (English)	04/90	--
	Guidelines for Utility Customer Management and Metering (English and Spanish)	07/91	--
	Assessment of Personal Computer Models for Energy Planning in Developing Countries (English)	10/91	--
	Long-Term Gas Contracts Principles and Applications (English)	02/93	152/93
	Comparative Behavior of Firms Under Public and Private Ownership (English)	05/93	155/93
	Development of Regional Electric Power Networks (English)	10/94	--
	Roundtable on Energy Efficiency (English)	02/95	171/95
	Assessing Pollution Abatement Policies with a Case Study of Ankara (English)	11/95	177/95
	A Synopsis of the Third Annual Roundtable on Independent Power Projects: Rhetoric and Reality (English)	08/96	187/96
	Rural Energy and Development Roundtable (English)	05/98	202/98
	A Synopsis of the Second Roundtable on Energy Efficiency: Institutional and Financial Delivery Mechanisms (English)	09/98	207/98
	The Effect of a Shadow Price on Carbon Emission in the Energy Portfolio of the World Bank: A Carbon Backcasting Exercise (English)	02/99	212/99
	Increasing the Efficiency of Gas Distribution Phase 1: Case Studies and Thematic Data Sheets	07/99	218/99
	Global Energy Sector Reform in Developing Countries: A Scorecard	07/99	219/99
	Global Lighting Services for the Poor Phase II: Text Marketing of Small "Solar" Batteries for Rural Electrification Purposes	08/99	220/99

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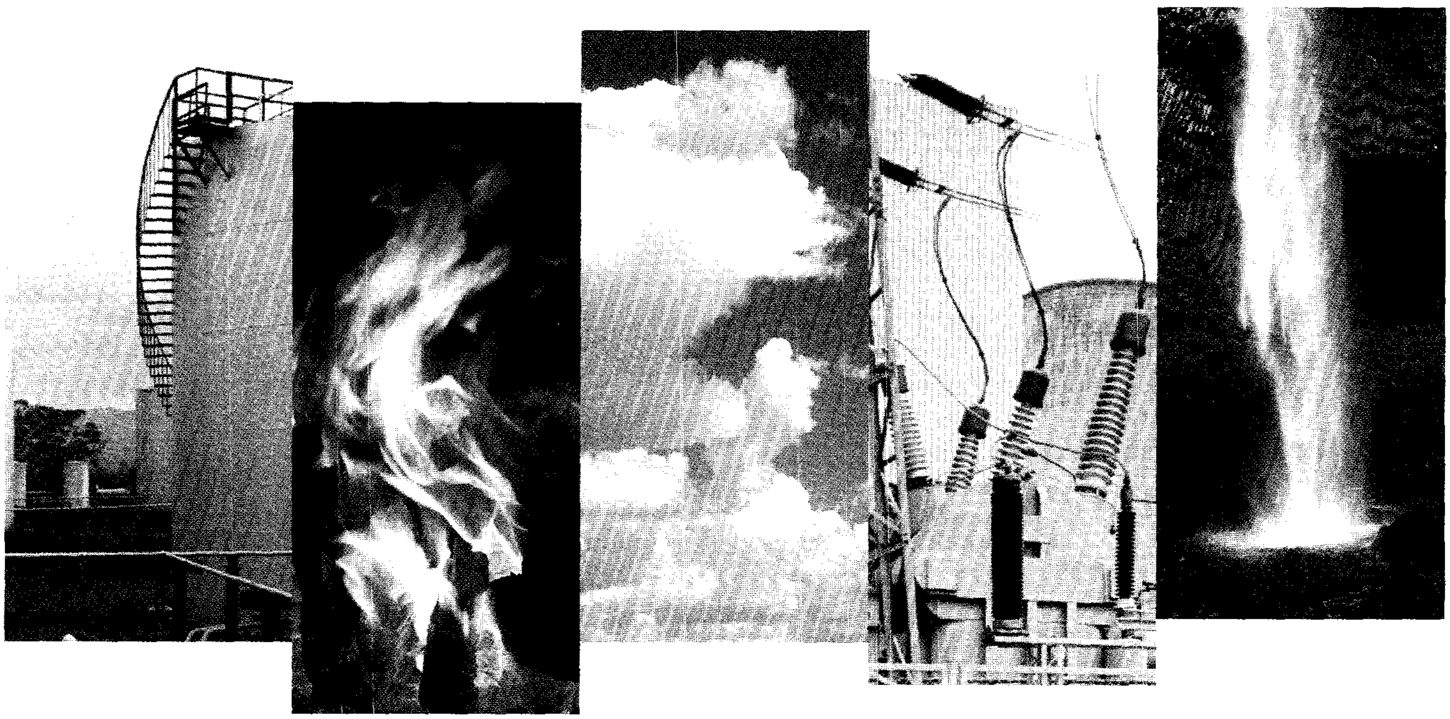

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