CHAPTER 7 SOLAR POWER GENERATION PLANNING

Chapter 7 Solar Power Generation Planning

The electrification method based on the extension of distribution lines is known as on-grid electrification, while the method that utilizes photovoltaic solar power is known as off-grid electrification.

In this chapter, results of the survey on the status of electrification by photovoltaic solar power in Malawi and the state of implementation of photovoltaic power projects funded by foreign countries are discussed.

7.1 The state of Solar Power in Malawi

At present photovoltaic energy systems are used in Malawi in many rural sites far from the distribution line. PV residential systems are mostly owned by tobacco farmers, and PV systems for public facilities can be found at many hospitals, post offices, telephone exchange offices, etc. Photovoltaic energy in Malawi has enough potential for development with regard to environmental issues and also reflects a satisfactory degree of established technology.

If the problem of the expense of photovoltaic could be solved, it is expected that this technology would spread throughout Malawi and contribute to overall electrification. Some specific knowledge is required to maintain PV systems although not as much as other systems. Furthermore, PV systems can generate electricity whenever solar irradiation is available.

Most PV systems in Malawi are Solar Home Systems (SHS) as stand-alone type, being installed in areas far from the grid and where electricity generation by other methods (for example mini hydro) is not possible. There are also systems that are only installed temporarily until other electrification methods become available.

The main components of a SHS are the Solar Panel, Battery and Battery Charge Controller (Fig. 7-1). The capacity of the most popular system is 50W (the actual equipment used in Malawi is depicted in the photograph).

Fig. 7-1 SHS system equipment

(Left) Solar Panel (KYOCERA)

(Middle) Battery Charge Controller (KYOCERA)

(Right) Battery (WILLARD)

(1) Solar Irradiation Data

Solar irradiation data was made available by DANIDA and PV companies in Malawi. According to the collected data, monthly solar irradiation was identified at between 5.0 and 6.9kWh/m^2/day (refer to Fig. 7-1-1), with the average of each geographical region being between 5.0 and 6.2kWh/m^2/day (refer to Fig. 7-1-2). The annual average of the solar irradiation was identified as 5.8kWh/m^2/day.

Fig. 7-1-1 monthly solar irradiation

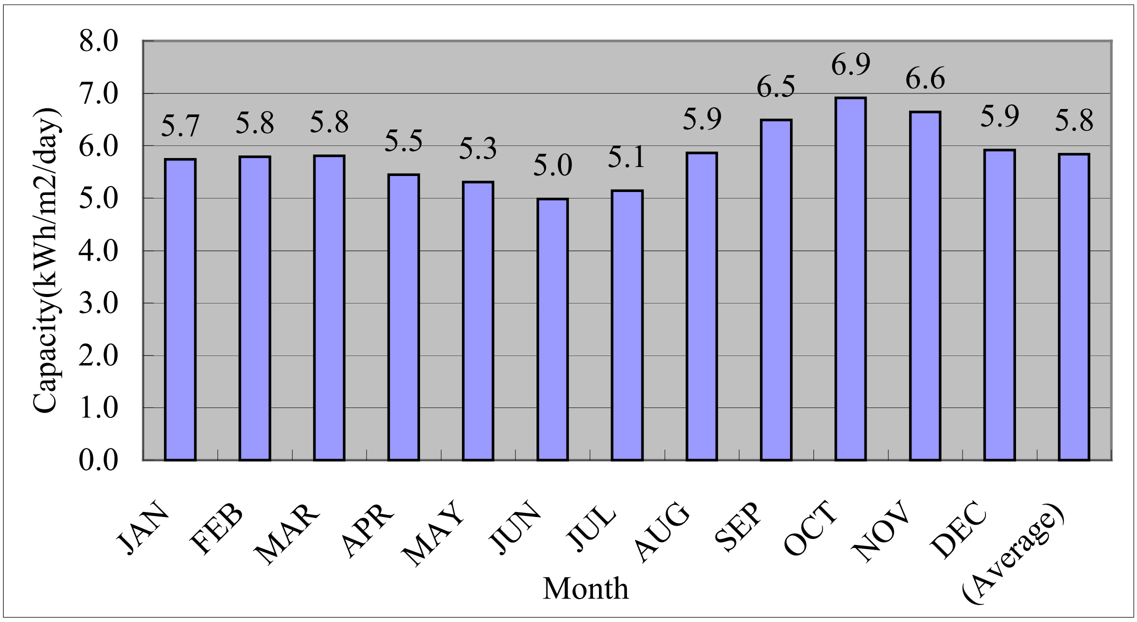
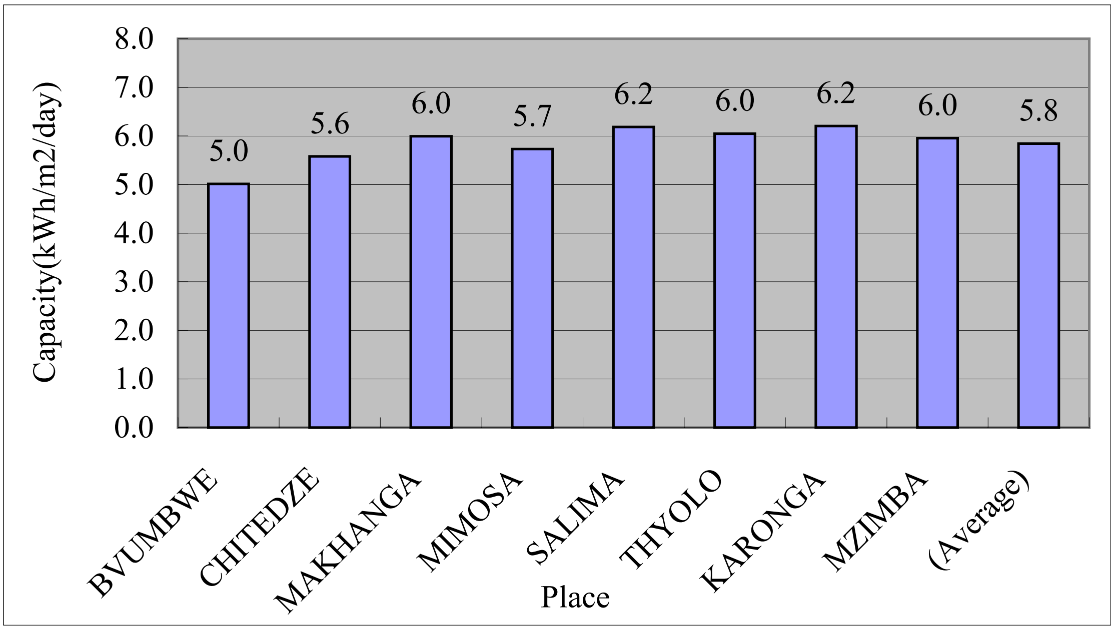


Fig. 7-1-2 each geographical region's solar irradiation data



Solar irradiation data used by DANIDA is as shown in Table 7-1-1. The solar irradiation figures used by PV companies are larger than that used by DANIDA. It can be concluded from this data that it is possible to rely on high solar irradiation levels everywhere in Malawi (by comparison, the solar irradiation annual average for Japan is 3.8kWh/m^2/day).

Table 7-1-1 Solar irradiation data used by DANIDA

AREA	Capacity
North	5.2kWh/m^3
Central	5.1kWh/m^3
South	5.0kWh/m^3

(2) Existing PV Systems

Systems installed in the areas where field surveys were carried out in Malawi were Solar Home System (SHS). Almost all equipment (solar panel, battery, charge controller, etc.) was imported from Europe, America and South Africa, with the majority coming from the USA, United Kingdom, Germany and Spain. The typical capacity of these Solar Home Systems was between 30W and 100W, the main purpose being for domestic use such as lighting and radio, and TV in some cases. With regard to systems for public facilities, most applications were for lighting, wireless communication and refrigerators.

7.2 Field Surveys and evaluation of existing PV systems

In the field survey in Malawi, several rural areas (North, Central and South) were visited in order to inspect and evaluate existent photovoltaic systems (Fig. 7-2-1). Health Centres were examined since it became apparent that many of these public facilities were equipped with PV systems. Surveys were also conducted to inspect several houses that had installed private PV systems. In some cases it was difficult to find the solar panel for these houses because they were very large so that the solar panel couldn't be seen from the outside.

Fig. 7-2-1 Field surveys

North Area (Mbalachanda in Mzimba District)

The PV system at the Health Centre was found to be in good condition. The capacity of the solar panel was about 40W. Health Center staff indicated that the PV system failed once because the battery was overloaded, but subsequent to this, there were no more problems. The main purpose was electric lighting and wireless communication for the Health Centre, and lighting, radio and TV (Fig. 7-2-3) for Stuff House (Fig. 7-2-2).

Fig. 7-2-2 Stuff House

Fig. 7-2-3 (Left) Wireless Communication in Health Centre
(Middle, Right) Radio, TV, and Electric bulb in Stuff House

Central Area (Chatoloma in Kasungu District, Mkaika in Nkhotakota District)

1. Chatoloma

A PV system for wireless communication was installed in 1998 at the Health Centre. This system proved to have a limited capacity and was unable to handle the load. This was because the communication system was required to function all day. Maintenance must be done once per month. The maintenance is limited to measure the electrolyte density and to add water to the battery. This maintenance is being conducted once a month.

2. Mkaika

A house that had installed private PV systems was identified and inspected. The system was installed on October 2001 to provide lighting (9W x 12 pieces, Fig. 7-2-4), TV and radio. The price was MK84, 000 (without insurance). There have been no failures since installation. However since the battery is the major risk component for breakdowns, one more battery was added to boost storage capacity. (Fig. 7-2-4)

Fig. 7-2-4 (Top) Electric Bulb
(Under) Battery

South Area (Khombedza in Salima District)

The system installed at the Health Centre is primarily used for refrigeration and lighting. The survey indicated that electricity consumption from the refrigerator was very large, being supplied by a total PV capacity of about 420W (Fig. 7-2-5).

An existent SHS owned by a staff member of the Health Centre was surveyed as well. This system has a capacity of about 50W and is used to power a light (9W), radio (3.6W) and TV (14W), and was implemented by the Ministry of Health. Technicians from the company that installed the system are responsible for maintenance.

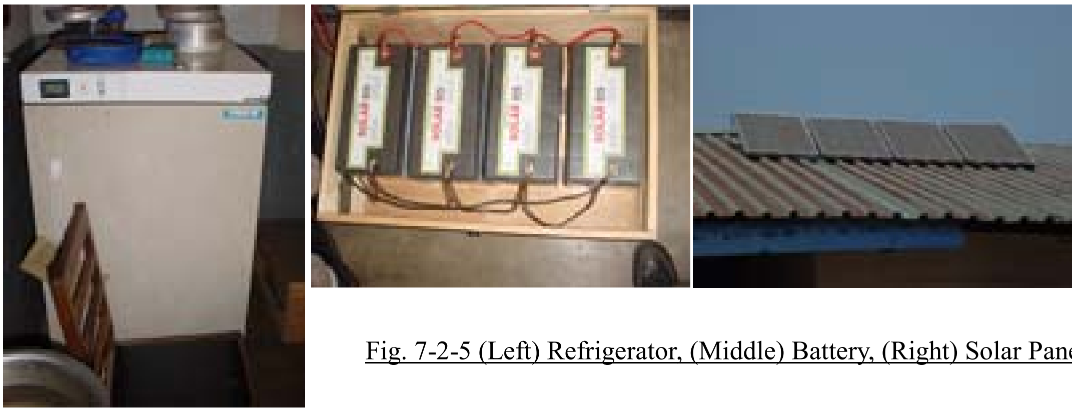


Fig. 7-2-5 (Left) Refrigerator, (Middle) Battery, (Right) Solar Panel

7.3 Design and Specification of PV systems in Malawi

PV companies were visited in order to obtain information about their business activities, details of SHS equipment, methods of installation and construction costs. The battery shop was also inspected. Pertinent information from two companies and a battery shop is summarized as follows. Fig. 7-3-1 shows the house belonging to the PV Company and inside of it.

Fig. 7-3-1 (Right)PV Company (Middle, Left) inside the company

Battery shop in Blantyre

In this battery shop, there is a variety of equipment and accessories, including for example water for batteries and hydrometers. The owner indicated that some people purchase the tools and maintain batteries by themselves.

Fig. 7-3-2 (Left) Battery (Right) Battery's tools and parts

International Power Control System (IPCS) in Blantyre

This company was established in 1996 (trading under a different name from 1998). The company specializes in SHS, their main business area being Namwera (Mangochi), Blantyre, Mchinji, Mponela (Dowa) and Lilongwe. The company staff is comprised of 20 members (with some workers having attained the Photovoltaic Technician qualification implemented by DOE). The majority of clients are wealthy tobacco farmers, but businessmen, fishers and teachers also purchase systems.

Solar irradiation data used by DANIDA The main uses of SHS are for lighting, radio and TV, the capacity being between 40W and 70W. The most popular type is the 50W system priced at US$950. This company sells SHS and provides installation and maintenance services. Equipment warranty is included in the price of SHS (the term of insurance being one year). Equipment sold by IPCS is imported from Germany, USA, South Africa and the United Kingdom. Detail of SHS equipment is as per in Table 7-3-1. Most SHS are used for three hours per day, from 18 to 21 hrs.

Table 7-3-1 The company name of SHS equipment

Material	COMPANY
Solar Panel	KYOCERA
Charge Controller	SOLARTEK
Battery	WILLARD

Briethel Solar Company in Zomba

Briethel Solar Company was established in 1995. This company specializes in solar power equipment, including SHS. The main business area encompasses Zomba, Kasungu, Dowa, Ntchisi, Nkhotakota and Salima. The company staff consists of 13 members. The majority of clients are wealthy tobacco farmers who live far from distribution lines. This year, SHS were also installed in the Kasungu District as well.

The main purpose of SHS from this company, with capacities between 50 and 100W, is for lighting, radio and TV. This company sells SHS, also providing installation and maintenance services. Systems are similar to IPCS, and are comparatively priced. In addition to SHS, they also deal in Solar Thermal Systems. Details of SHS equipment are as per Table 7-3-2. Equipment sold by this company is imported from the United Kingdom, South

Table 7-3-2 The company name of SHS equipment

Material	COMPANY
Solar Panel	BP、Kyocera
Charge Controller	Siemens
Battery	Willard
Solar Light	Labcraft

Africa and Spain. Installation is carried out by photovoltaic technicians who had attained the Photovoltaic Technician qualification implemented by DOE. (This company filed bankruptcy soon after being surveyed. It is considered the necessity to survey and analyze in detail the background of bankruptcy in the SHS industry.) Details of SHS, including panels, batteries, lights, charge controllers, socket for radios and TVs and prices, are as per Table 7-3-3. Table 7-3-4 indicates the usage hours per day of different appliances.

Table 7-3-3 SHS price list

MATERIALS	3 Light System	4 Light System	5 Light System	6 Light System
Kyocera 40Watt Panel	○			
Kyocera 50Watt Panel		○	○	
Kyocera 70Watt Panel				○
6Watt Lights	○	○	○	○
Battery 100Ah	○			
Battery 120Ah		○	○	○
ChargeController 5Amps	○			
Charge Controller 10Amps		○	○	○
Socket for Radio	○	○	○	○
Socket for TV	○	○	○	○
Full Installation	○	○	○	○
Price (US$)	756.36	919.38	946.00	1055.12

Table 7-3-4 Usage hour per day

MATERIALS	3 Light System	4 Light System	5 Light System	6 Light System
TV	3h	3h	3h	3h
Radio	9h	10h	9h	9h
Light (Bedrooms)	1h	1h	1h	1h
Light (lounge)	3h	3h	3h	3h
Light (Corridor)			2h	1h
Light (Kitchen)		3h	2h	2h

7.4 Procedure for the Cost Estimation of Photovoltaic Power System

The procedure to estimate the photovoltaic power system cost is explained in this section. A basic system of 70W is used to develop the cost estimation

1. Collection and analysis of related data

The following conditions are thoroughly investigated and data collection is conducted in order to decide the scale of the photovoltaic power generation equipment to be installed.

1.1 Geographical conditions (solar irradiation)

Solar irradiation data for the main cities in Malawi is made available. The amount of daily electricity generation per square meter of photovoltaic module is calculated from this data. In Malawi, the daily solar irradiation is approximately 5.8kWh/m2/day (refer to section 7.2 Solar Irradiation Data).

1.2 Installation conditions

Photovoltaic electricity generation is available as long as the modules are exposed to the solar irradiation. However, analyses are conducted in order to determine the orientation and tilt angles of the modules in order to maximize the electricity generation. Shades caused by foreign obstacles are taken into consideration.

In Malawi, it is recommended to install the photovoltaic modules facing north with a tilt angle of approximately 15 degrees.

1.3 Construction costing information

In this master plan, the price of photovoltaic equipment has been determined by adopting the results of former projects in Malawi. Pricing information (including construction and maintenance costs) obtained from photovoltaic system shops has been taken into consideration as a reference. The price structure must be updated regularly.

From results of this survey, the price of PV systems (equipment only) is estimated to be 12.18US$/W.

2. Assessment of system configuration

The relation between the amount of solar irradiation per day and the capacity of the system is analyzed. The suitability of the electricity generation levels (W and Wh) is confirmed. The relation between the size of module, capacity of battery and amount of solar irradiation is formulated.

Comparison analyses were conducted against solar irradiation and system capacity used in other PV projects (project data: 70W(117Wh) of system capacity and approx. 4.5kWh/m2/day of solar irradiation). It was found that it is possible to consume approximately 145Wh/day of electricity (TV for 3 hours, radio for 9 hours and two lights for 6 hours).

3. Calculation of maintenance costs

Annual maintenance expenses including costs of replacement parts are projected for 20 years. These costs are then converted to present values.

At this time, the inspection fee is estimated for the case when all systems in a TC are inspected during a single visit. The operation life of batteries and charge controllers are supposed to be 4 and 8 years, respectively. The prices of batteries and battery charge controllers are assumed to be 110US$ and 50US$ per unit, respectively.

4. Calculation of costs for electrification of TCs

Costs are determined by multiplying the electricity demand (W and Wh) of TCs by the unitary costs per W and Wh.

5. Addition of distribution line costs
   Distribution costs (capital and maintenance costs) are added to the photovoltaic power generation equipment cost to obtain the total cost of the photovoltaic system.

   The costs of photovoltaic power systems for each TC are estimated following this procedure.

7.5. State of PV Projects implemented with foreign funds

The development and spread of renewable energy projects in Malawi was originated by the NSREP (National Sustainable and Renewable Energy Programme) supported by UNDP (United Nations Development Organization) in 1997. At present, PV systems are installed not only by independent users but also by support programs such as DANIDA (Danish International Development Agency) and JICA (Grass Root Grant Project). DANIDA had assisted DOE (Department of Energy Affairs) from October 1999 to December 2001. DANIDA planned to continue the support after December 2001 but government issues made this not possible.

PV systems should be installed in areas far from the existing distribution lines and where the electricity demand is not very large.

The JICA project provides assistance for the installation of systems in the Central Area (Detza, Ntcheu). These programs must be taken into consideration, as well as results of social surveys, in order to select target areas for electrification and determine suitable sites for the installation of photovoltaic power systems.

The DANIDA project has two main objectives. One is the construction of systems for development and spread of renewable energy technology and the other is the Capacity Development, Market Priming and Renewable Energy Technology standards for development and spread of renewable energy technology.

The DANIDA project is aimed to implement the installation of 14 SHS in Health Centres and households and the maintenance of existing SHS.

Other role of DANIDA was to assist medical facilities in using efficiently the renewable energy (mainly photovoltaic energy). However, the extent of this project is limited because of the large number of unelectrified clinics that exist in Malawi. A number of remaining issues from this project in relation to the installation and maintenance of SHS must be solved.

The Grass Root Grant Project was implemented in order to expand the results of DANIDA's demonstration project. JICA started the planning stage of this project in January 2001. SHS (for lighting, wireless communication, refrigerator) were installed in 2002 in 5 Health Centres (managed by CHAM), and their construction will continue in 2003.

It can be noted that both projects have similar administrative structure. With the exception of 10% of the cost (allocated for installation), both projects are able to supply the remaining finances.

The following topics, addressed official programs in relation to enabling equipment and loan system, were suggested at a NSREP workshop in order to boost the implementation of SHS.

Equipment authorizing program

① Growth of the industry and establishment of an institute for equipment certification

② Regulation of the sale of authorized equipment with the provision of a warranty.

Loan system

① Financial assessment to be conducted by the shop

② Direct cash flow from the bank to the shop

③ Collection of loan repayment monies to be conducted by the bank

④ Seizure of the equipment and resale for unpaid accounts (creation of a fund to cover the balance of unpaid accounts)

Parallel to the implementation of the above, it was recommended also to address capacity building, public relations, spread of activity, promotion of ESCO (Electricity Supply Company) based on PV, and to conduct an evaluation of results.

7.6 Photovoltaic Power Generation and Environmental Issues

Photovoltaic power generation is a supply of clean electric power because the energy source is solar light, meaning this that this technology has a huge environmental impact on the greenhouse effect (by reduction of CO2) and acid rain (by reduction of SO2).

Photovoltaic power generation systems consist of solar panels, batteries, charge controllers, etc. Solar panels and charge controllers have a long life and large portion of them can be reused. However, repair of batteries is very difficult once performance has decreased and replacement is necessary. Disposal method of used batteries is an important issue that must be resolved in Malawi.

7.7 Model for the promotion of PV projects supported by foreign countries

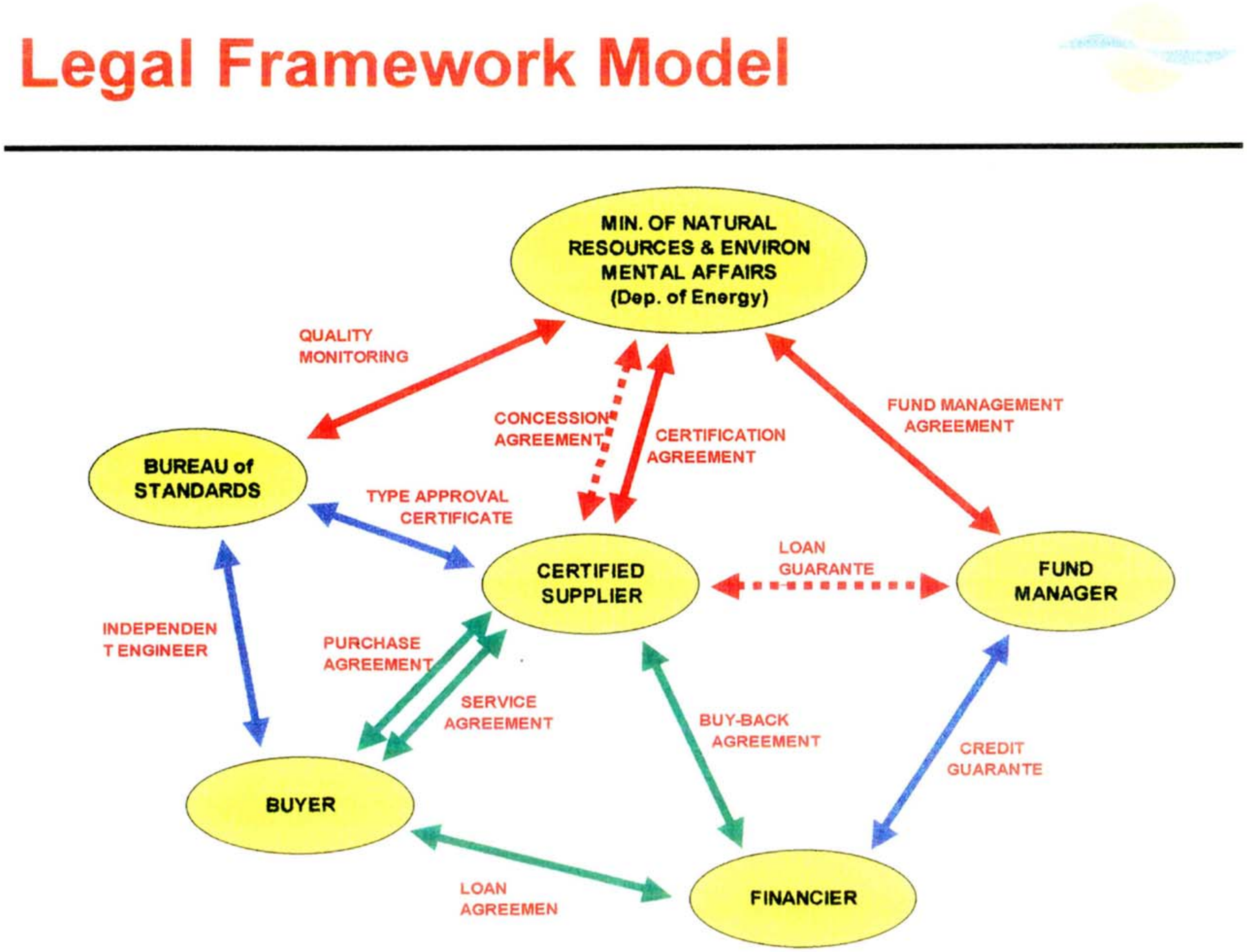
At a first stage, UNDP was planning to support NSREP, but the scheme was delayed because of financing problems. Then DANIDA was implemented to follow up the NSREP project by promoting PV systems, mainly SHS. Refer to Fig. 7-7-1.

This project proposed an administrative structure between the Ministry of Natural Resources & Environmental Affairs (Department of Energy Affairs), the organization for fund management, the bureau for standard management of PV equipment, funding organizations and authorized suppliers of PV systems.

The Department of Energy Affairs issues a loan contract to the fund management organization, and also overviews the management of PV equipment standards in order to secure the quality of equipment. The Department of Energy Affairs also regulates the certification of suppliers for the authorized sell of PV systems. In case that a PV system user cannot repay the loan, the equipment is removed and a guarantee is arranged for the difference between the rest of the loan and the value of the equipment that was removed.

It is not clear whether this system is complete or not, but taking over DANIDA, DOE started the implementation in June 2002. The reevaluation of the DANIDA system should be considered.

The process to formulate the electrification by using PV systems was discussed at the first stage of this master plan. However, since the electrification by PV system under UNDP, DANIDA and other projects was promoted already, we decided to change this concept and only surveyed the status of these projects.



(Source: NSREP)

Fig. 7-7-1 DANIDA's Legal Framework Model of PV System

CHAPTER 8 RURAL SOCIETY

Chapter 8 Rural Society

8.1 Functions of Trading Centers and Local Communities

Villages in Malawi tend to be scattered along roads. A typical rural village consists of clustered houses and in many cases does not include core facilities, such as churches, schools, clinics, etc. The style of these villages is considered to be a reflection of cultural factors such as a strong sense of individualism and little desire to settle permanently. Rural localities with a high concentration of residential settlement are called Trading Centers (TCs), which are the center of rural economic activity. At the TCs, people not only in the TC but also in the catchment area (CA, influence area of the TC) sell their products such as crops and handicrafts, purchase daily necessities and use public services (refer to Fig. 8-1-1).

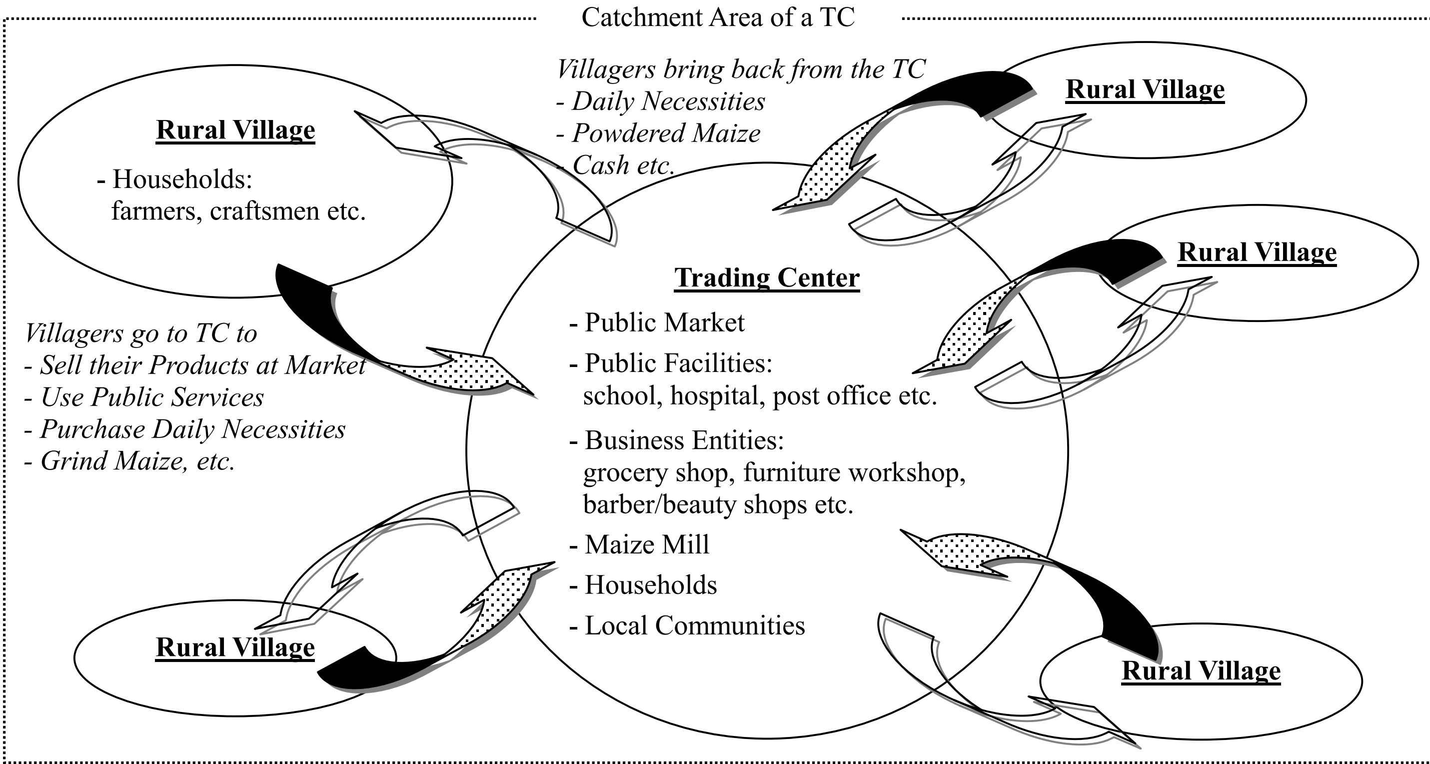


Fig. 8-1-1 Summary of Trading Center's Functions

In addition to various grocery shops selling miscellaneous goods, electrified maize mills are also present in the TC, which are used to grind corn to flour for the Malawian staple food "Nsima". As the TC becomes larger, barbers, furniture shops, tinsmithing, restaurants, bars and so on can also be found. Each TC has a public market, and residents in neighboring villages sell their crops and products there by paying a market fee to the district assembly local office. Since the residents can purchase miscellaneous goods and/or receive services at shops, the TC functions as a center of daily life and activities in rural areas. Public facilities, such as hospitals, clinics, schools, police units, post offices and so on, also tend to be located or established in

Trading Centers. As a consequence, public workers, such as doctors, nurses, teachers, police officers, etc., are also counted as residents of the TC. Local community groups are established and operate based at public places such as community halls and recreation centers in the TC. Some local community groups are established as local branches of nation wide organizations, such as agricultural cooperatives, coffee product cooperatives, the Tobacco Association of Malawi (TAMA), etc., and function as economically active organizations by providing materials, machinery and technical guidance, market products, etc.

There are also local community groups that contribute to the development of infrastructure and public facilities, acting as recipient organizations of funds from the religious organization CHAM, NGOs such as Concern Universal (an international organization) and World Vision International, and international donors such as the World Bank, European Union, NORAD and DANIDA.

In order to receive a funding from the Malawi Social Action Fund (MASAF) established by the World Bank, for example, a committee for each project, such as for the construction of a school, clinic, borehole, road or bridge, needs to be established by beneficiaries living in the neighboring villages, who form what is called the MASAF Project Management Committee. While receiving expensive construction materials from MASAF, the committee provides construction labor through villager participation, as well as any relatively cheap materials. Although maintenance of the constructed facility is basically the responsibility of the committee, a support system from the Malawi government has been established to include the dispatch of salaried doctors for newly constructed clinics and teachers for newly constructed schools.

In one instance, local residents established a Road Construction Cooperative without receiving funds from donor agencies, and constructed a local road in order to improve the transportation of agricultural products and fertilizers, completing all the labor by themselves. In this project, 7 kilometers of road was constructed in one month by four working days per week with 75 participants each day. This shows that it is possible to execute rural electrification projects successfully by establishing local cooperatives for particular projects and entrusting the cooperative with the operation and maintenance works of electric facilities and/or tariff collection.

8.2 Economic Activity in Rural Areas and Expected Effects after Electrification

In relation with economic activities in rural areas, residents in neighboring villages cash their crops and products at the public market by paying a market fee, purchase miscellaneous goods at grocery shops, or have their corn ground at electrified maize mills in the TC. In unelectrified TCs, electricity demand for refrigeration in grocery shops, additional maize mills, etc. is expected after the electrification. Although paraffin is utilized as fuel for refrigerators in unelectrified TCs, a typical refrigerator in grocery shops with a capacity of 200 bottles consumes a daily amount of paraffin equivalent to approximately MK75. Thus, if stable electricity is supplied at reasonable cost, there is a strong possibility that paraffin refrigerator users will shift to electric refrigerators. In unelectrified TCs, maize mills with capacity of approximately 25kW are driven by privately owned diesel generators, and the owner of the mill collects MK 25 to 35 as fee for grinding 50 kg of corn. Additional maize mill businesses are expected to appear if electricity is supplied by distribution line extension at reasonable cost. Price reduction of milling fees, as a result of price competition, shall occur by the introduction of new mill owners, and this is expected to have other secondary impacts.

8.3 Rural Electrification and Energy Consumption

Rural electrification has been executed in four phases since 1984: Phase-I for District Centers' electrification, Phase-II for hydropower development in the Northern region, Phase-III for distribution line extension for major TCs near the capital city Lilongwe, and the present Phase-IV for the extension of distribution lines along roads nationwide.

As shown in Table 8-3-1, the electrification rate for dwelling units is 3.5 percent in Malawi. Of the 85 percent of the population that live in rural areas, only 0.8 percent currently has access to electricity. At a regional level, electrification rates in descending order are 4.1 percent in the Southern, 3.0 percent in the Central, and 2.4 percent in the Northern region. In urban areas of the Southern region, the electrification rate of dwelling units has reached 25 percent.

90 percent of the dwelling units are using paraffin lamps for lighting. From the interview of several residents in rural unelectrified TCs, it was found that the monthly fuel cost for a paraffin lamp is about MK300. By contrast, the monthly electricity tariff is about MK200 for lighting at average dwelling units in electrified TC. Thus, paraffin lamp users are likely to be able to pay the electricity tariff for an alternative energy source. In order to receive transmitted electricity, however, initial costs consist of a connection fee and also an in-house wiring cost is charged: these being MK200 and MK 12,000 respectively. The in-house wiring cost is especially high, since necessary materials are imported from countries such as South Africa. These expensive initial costs are one of the limitations in the promotion of rural electrification.

In fact, there is one particular household which started receiving transmitted electricity 20 years after the TC was electrified by ESCOM, since savings to pay initial costs took time: the household was connected to the ESCOM distribution line in the 1990s at Dedza TC which was electrified by ESCOM in the 1970s. This household was using a car battery as a power source for television and radio before receiving transmitted electricity from ESCOM. Fluorescent lights (60W×9 units), refrigerator (200W), cooking hot plate (1,800W), Iron (1,000W), CD player (700W), micro fan (20W) were purchased when the household started receiving electricity. Five years later, a microwave oven and VCR (77W) were also purchased. Thus, it seems that the amount of electricity consumption has steadily increased in that household. Recent monthly electricity payments were between MK600 to MK 800.

The majority of Malawians (94 percent) use firewood and only 1.5 percent use electricity as their main source of energy for cooking (refer to Table 8-3-2).).

Table 8-3-1 Number of Dwelling Units by Main Source of Energy for Lighting

		Firewood	Electricity	Paraffin	Gas	Candles	Grass	None	Total
Malawi	Urban	3,323	81,476	260,791	376	10,141	1,999	1,313	359,419
		0.9%	22.7%	72.6%	0.1%	2.8%	0.6%	0.4%	100.0%
	Rural	53,659	20,540	2,384,017	2,118	4,116	74,666	20,876	2,559,992
		2.1%	0.8%	93.1%	0.1%	0.2%	2.9%	0.8%	100.0%
	Total	56,982	102,016	2,644,808	2,494	14,257	76,665	22,189	2,919,411
		2.0%	3.5%	90.6%	0.1%	0.5%	2.6%	0.8%	100.0%
Northern	Urban	300	6,209	31,089	161	492	44	98	38,393
		0.8%	16.2%	81.0%	0.4%	1.3%	0.1%	0.3%	100.0%
	Rural	6,191	1,823	272,518	184	325	8,709	2,050	291,800
		2.1%	0.6%	93.4%	0.1%	0.1%	3.0%	0.7%	100.0%
	Total	6,491	8,032	303,607	345	817	8,753	2,148	330,193
		2.0%	2.4%	91.9%	0.1%	0.2%	2.7%	0.7%	100.0%
Central	Urban	1,209	29,977	100,973	71	5,259	1,440	503	139,432
		0.9%	21.5%	72.4%	0.1%	3.8%	1.0%	0.4%	100.0%
	Rural	16,363	6,191	967,462	1,159	1,894	50,813	9,459	1,053,341
		1.6%	0.6%	91.8%	0.1%	0.2%	4.8%	0.9%	100.0%
	Total	17,572	36,168	1,068,435	1,230	7,153	52,253	9,962	1,192,773
		1.5%	3.0%	89.6%	0.1%	0.6%	4.4%	0.8%	100.0%
Southern	Urban	1,814	45,290	128,729	144	4,390	515	712	181,594
		1.0%	24.9%	70.9%	0.1%	2.4%	0.3%	0.4%	100.0%
	Rural	31,105	12,526	1,144,037	775	1,897	15,144	9,367	1,214,851
		2.6%	1.0%	94.2%	0.1%	0.2%	1.2%	0.8%	100.0%
	Total	32,919	57,816	1,272,766	919	6,287	15,659	10,079	1,396,445
		2.4%	4.1%	91.1%	0.1%	0.5%	1.1%	0.7%	100.0%

Source: 1998 Malawi Population and Housing Census Report
(National Statistical Office, December 2000)

Table 8-3-2 Number of Dwelling Units by Main Source of Energy for Cooking

		Firewood	Charcoal	Electricity	Paraffin	Gas	Dung	Grass	None	Total
Malawi	Urban	252,811	55,951	38,049	8,285	267	134	264	3,658	359,419
		70.3%	15.6%	10.6%	2.3%	0.1%	0.04%	0.1%	1.0%	100.0%
	Rural	2,490,072	8,338	6,541	5,411	280	136	11,817	37,397	2,559,992
		97.3%	0.3%	0.3%	0.2%	0.01%	0.01%	0.5%	1.5%	100.0%
	Total	2,742,883	64,289	44,590	13,696	547	270	12,081	41,055	2,919,411
		94.0%	2.2%	1.5%	0.5%	0.02%	0.01%	0.4%	1.4%	100.0%
Northern	Urban	33,784	1,802	2,250	362	14	2	3	176	38,393
		88.0%	4.7%	5.9%	0.9%	0.0%	0.01%	0.01%	0.5%	100.0%
	Rural	287,615	373	458	363	21	10	36	2,924	291,800
		98.6%	0.1%	0.2%	0.1%	0.01%	0.003%	0.01%	1.0%	100.0%
	Total	321,399	2,175	2,708	725	35	12	39	3,100	330,193
		97.3%	0.7%	0.8%	0.2%	0.01%	0.004%	0.01%	0.9%	100.0%
Central	Urban	111,968	4,140	15,822	5,090	111	18	202	2,081	139,432
		80.3%	3.0%	11.3%	3.7%	0.1%	0.01%	0.1%	1.5%	100.0%
	Rural	1,028,546	1,623	2,304	2,319	81	71	2,230	16,167	1,053,341
		97.6%	0.2%	0.2%	0.2%	0.01%	0.01%	0.2%	1.5%	100.0%
	Total	1,140,514	5,763	18,126	7,409	192	89	2,432	18,248	1,192,773
		95.6%	0.5%	1.5%	0.6%	0.02%	0.01%	0.2%	1.5%	100.0%
Southern	Urban	107,059	50,009	19,977	2,833	142	114	59	1,401	181,594
		59.0%	27.5%	11.0%	1.6%	0.1%	0.1%	0.03%	0.8%	100.0%
	Rural	1,173,911	6,342	3,779	2,729	178	55	9,551	18,306	1,214,851
		96.6%	0.5%	0.3%	0.2%	0.01%	0.005%	0.8%	1.5%	100.0%
	Total	1,280,970	56,351	23,756	5,562	320	169	9,610	19,707	1,396,445
		91.7%	4.0%	1.7%	0.4%	0.02%	0.01%	0.7%	1.4%	100.0%

Source: 1998 Malawi Population and Housing Census Report
(National Statistical Office, December 2000)

8.4 Rural Development Plan

The Ministry of Local Government (MLG) has drafted a rural development plan, and Rural Growth Centers and major TCs were identified based on this plan about 10 years ago. Transitions of these developed Centers, however, have not been monitored by MLG, and recent rural development plans tend to be drafted by each District based on the decentralization policy found in the Local Government Act. Thus, all information regarding rural development plans is not centralized at the MLG. The MLG does not possess basic information such as number and names of TCs in each District, number of public facilities in each TC, etc. In addition, although improvement of schools and hospitals/clinics has been planned by the Ministry of Education, Science & Technology and the Ministry of Health and Population (linked with the Poverty Reduction Strategy which prioritizes the social sector development), there is no organization that centralizes all information regarding rural development plans, because so little information is shared among ministries, including the MLG. In addition, share of information regarding rural electrification and arrangements between ESCOM and the Ministry of Natural Resources and Environmental Affairs (MONREA) has not been carried out satisfactorily. Thus, the electrification status of each TC is uncertain, and selection of target TCs for electrification is easily affected by politics and sometimes criticized as being unfair.

8.5 Selection of Electrification Target

The electrification rate in rural areas in Malawi is significantly low (less than 1%). Even TCs, the centers for rural economic activities where public facilities such as schools and clinics are in place, have not been electrified. The electrification of a TC contributes to the growth of the public market and improves the quality of public services such as education and health care to which the Malawi government gives priority. As a result, the TC's electrification will benefit residents not only in the TC but also in its CA. In addition to this, business entities whose incomes are generally high will pay a connection fee and a continued monthly tariff for electrification, resulting in a boost to the local economy. Therefore, according to an agreement with governmental organizations in Malawi, TCs are selected as the electrification target for the rural electrification master plan, which has been established in this study.

From the points of view of maintaining transparency of the electrification targets selection, to provide equal opportunity of electrification for the whole country, to be consistent with national policies, and to exclude political motives, three basic strategies are defined below for the rural electrification master plan subject of this study.

(1) Selection and prioritization of target TCs based on the expected benefits from electrification evaluated numerically.
(2) Electrification target TCs are selected from all Districts equally.
(3) Focus of electrification is on public facilities in selected TCs.

In order to make the selection of target TCs possible, utilizing the three basic strategies mentioned above, it was essential to collect data with respect to all of the existing unelectrified TCs in each of the 27 Districts. As stated in the previous section, even the MLG does not have basic information such as the number and names of TCs in each District, number of public facilities in each TC and electrification status of each TC (electrified or unelectrified). Therefore, collection of basic data for both electrified and unelectrified TCs in each District was conducted at a District Commissioners Conference (which is held once a year with the participation of all District Commissioners assigned to each District Assembly Office under the jurisdiction of MLG). At this conference, the questionnaire shown in Table 8-5-1 was distributed to each District Commissioner requesting to list the existing TCs in their districts and to provide figures regarding several topics of each TC. These included electrification status, numbers of public facilities and business entities, total monthly market fees (fees paid by a person who want to sell crops and products at a public market in a TC) collected at the local office of the District Assembly, etc. Based on the collected information, criteria for selecting the priority of each unelectrified TC in accordance with the three basic strategies for the implementation of the master plan is established (refer to "[Stage 1] Preliminary Data Collection" in Fig. 8-6-1).

In October 2001, about a month after the distribution of the questionnaire at the District Commissioners Conference, the results of the questionnaire were collected from each District Assembly Office. As a result, data for 246 unelectrified TCs were listed at that time (refer to [Stage 2] in Fig. 8-6-1). In September 2002, data of nine additional TCs was collected and thus the total number of listed unelectrified TCs became 255. By analyzing the collected data, it was determined that even the District Assembly Offices do not have accurate records of the existing public facilities and business entities in each TC. However, it was noted that District Assembly Offices have relatively accurate records regarding the total Market Fee collected monthly at each TC, being this information conveyed to the MLG once a month. These issues were confirmed by a Preliminary Investigation (refer to [Stage 3] in Fig. 8-6-1), which was conducted by visiting a District Assembly Office and an unelectrified TC in one District selected from each one of the three areas[1]: Northern, Central and Southern.

Even though the unit price of the Market Fee differs in each TC, it was concluded that the higher the fees are, the more prioritized the TCs ought to be for electrification, since the unit prices reflect importance and/or market value of the TCs in any particular District. Therefore, Market Fees were selected as the first criteria for prioritization of TCs in each District (refer to [Stage 4] in Fig. 8-6-1). The total data collected from 255 unelectrified TCs were listed by the annual market fees collected in every District, as shown in Table 8-5-2.

[1] From Northern, Central, and Southern areas, Mzimba, Dowa, and Balaka Districts were selected respectively. The District Assembly Office and one unelectrified TC in each District - Mbalachanda TC in Mzimba, Nambuma TC in Dowa, and Kwitanda TC in Balaka - were investigated by JICA Study Team and DOE Staff to decide the specifications of the consignment contract with a local consultant to undertake the Socio-economic Survey.

Table 8-5-1 Data Collection Sheet for Unelectrified Trading Centers

NAME OF DISTRICT:

PRIORITY FOR ELECTRIFICATION	1	2	3	4	5
1. Name of Trading Center					
2. Traditional Aauthority					
3. Distance from the Existing Distribution Line (km)					
4. Market Fee					
a) Monthly Market Fee per Person (MK/month)					
b) Total Collected Annual Market Fee in TC (MK/year)					
5. a) Number of Beneficiaries in TC					
b) Number of Beneficiaries in Catchment Area (CA) [inc. the TC]					
6. a) Population in TC					
b) Population in CA [inc. the TC]					
7. a) Number of Households in TC					
b) Number of Households in CA [inc. the TC]					
8. Number of Existing Public Facilities					
a) Secondary School					
b) Primary School					
c) Hospital					
d) Health Center					
e) Under Five Clinic					
f) Maternity					
g) Orphanage					
h) Police Station					
i) Police Unit					
j) Immigration Office/ Border Post					
k) Post Office/Post Agency					
l) Radio Station					
m) Church					
n) Mosque					
o) Community Halls/Recreation Center					
p) Court					
q) Government Offices					
r) Local Community/Cooperative Offices					
s) Non-Government Organization Offices					
t) Other (specify:)					
Total					
9. Number of Existing Business Entities					
a) Markets					
b) Retail Shops-Grocery					
c) Retails-Others					
d) Wholesale Shops					
e) Maize Mills					
f) Furniture Workshops					
g) Tinsmiths					
h) Restaurants					
i) Rest Houses					
j) Bottle Stores/ Bars					
k) Workshops for Car Repairs/ Garages					
l) Battery Charge Stations					
m) Barber Shops/ Beauty Shops					
n) Banks					
o) Other (specify:)					
Total					
10. Existence of Local Community/organization/cooperative and NGO					

1st Prioritized Unelectrified TC: ____________________

2nd Prioritized Unelectrified TC: ____________________

Table 8-5-2 Unelectrified Trading Centers with Annual Market Fee in Each District (Northern)

Northern Region

	Chitipa		Karonga		Rumphi	
	TC Name	Market Fee	TC Name	Market Fee	TC Name	Market Fee
1	**Nthalire**	**75,000**	*Songwe*	*248,085*	**Katowo**	**35,539**
2	**Lupita**	**72,000**	**Kiwe**	**144,000**	**Chitimba**	**23,400**
3	Wenya	49,000	**Pusi**	**140,620**	Lara	5,005
4	Kameme	45,000	Iponga	53,915	Muhuju	3,961
5	Chsenan	35,000	Miyombo	30,010	Mwasisi	1,203
6	Kapoka	35,000	Mlare	21,680	Nchenachena	-
7	Chisenga	-	Chihepasha	18,048	Nkhozo	-
8	Mwenemulembe	-	Mwenitete	350	Ng'onga	-
9			Tilora	350	Kamphenda	-
10			Hara		Mphompha	-
11			Lupembe			

	Nkhata Bay		Mzimba		Likoma	
	TC Name	Market Fee	TC Name	Market Fee	TC Name	Market Fee
1	**Mpamba**	**164,808**	**Edingeni**	**372,000**	**Likoma**	**240,000**
2	**Kavuzi**	**131,844**	**Euthini**	**362,496**	**Chizumulu**	**14,400**
3	Khondowe	100,000	Mpherembe	312,000		
4	Sanga	58,845	Jenda	255,500		
5	Usisya	58,842	Manyamula	216,000		
6	Nthungwa	50,247	Eswazini	144,000		
7	Ruarwe	17,137	Luwelezi	60,000		
8	Chituka	14,500	Emfeni	60,000		
9	Maula	14,282	Engutwini	48,000		
10	Lwazi	12,000				

Bolded : Surveyed in Detail (January 2002)
Italic : Data Obtained after the Survey (Sept. 2002)
[shaded] : Targeted in Phase IV

Table 8-5-2 Unelectrified Trading Centers with Annual Market Fee in Each District (Central)

Central Region

	Kasungu		Nkhotakota		Ntchisi	
	TC Name	Market Fee	TC Name	Market Fee	TC Name	Market Fee
1	**Chamama**	**324,000**	**Mkaika**	**350,000**	**Nthesa**	**22,800**
2	Chulu	120,000	**Dwambadzi**	**200,000**	**Khuwi**	**20,000**
3	Mpepa	116,141	Msenjere	60,000	Kamsonga	11,400
4	Matenje	30,000	Kasitu	40,000	Chinguluwe	9,600
5	Simlemba	20,000			Bumphula	6,300
6	Kamboni	17,000			Malambo	6,000
7	Kapheni	8,000			Ng'ombe	5,400
8					Kasakula	4,200
9					Mzandu	3,600
10					Nthondo	2,400
11					Kayoyo	2,400

	Dowa		Salima		Lilongwe	
	TC Name	Market Fee	TC Name	Market Fee	TC Name	Market Fee
1	**Thambwe**	**245,760**	**Kandulu**	**57,450**	**Chilobwe**	**432,000**
2	**Nambuma**	**88,920**	**Chilambula**	**57,450**	**Nyanja**	**414,000**
3	Bowe	88,920	Kambiri Sch.	57,450	Kasiya	360,000
4	Chiseflo	72,000	Khwidzi	51,450	Chawantha	360,000
5	Bibanzi	72,000	Thavite	23,200	Malembo	300,000
6	Msalanyama	56,160	Makioni	23,200	Nsaru	180,000
7	Kachigamba	52,560	Michulu	23,200	Kabudula	72,000
8	Chinkhwiri	52,560	Chikombe	14,477	Hiunjiza	60,000
9	Lipri	50,040	Mnema	14,417	Phirilanjuli	48,000
10	Kasuntha	50,040	Chitala	14,417	Kachale	48,000
11	Chankhunga	47,520	Chinguluwe	14,417	Chimbalanga	48,000
12	Nalunga	47,520	Siyasiya	14,417	Mtema	30,000
13	Dzoole	28,800	Matenje	14,417	Bisai	28,800
14	Kalonga	36,000	Chagunda	3,600	Mbng'ombe	24,000
15	Kalumbu	-	Pemba	3,600	Sinumbe	12,000
16	Mkukula	-	Mphinzi	3,600	Kang'oma	3,000
17	Chakadza	-			Chiwamba	1,500
18	Chimungu	-			Chadza	1,500
19	Thonje	-			Kalumbu	800
20	Kayembe	-			Kalima	750
21	Simbi	-				
22	Bweya	-				
23	Ntiti	-				

	Mchinji		Dedza		Ntcheu	
	TC Name	Market Fee	TC Name	Market Fee	TC Name	Market Fee
1	**Mkanda**	**551,000**	**Kabwazi**	**275,400**	*Ntonda*	*384,000*
2	**Chiosya**	**414,000**	**Golomoti**	**192,000**	*Kasinje*	*289,126*
3	Mikundi	165,000	Chimoto	143,000	*Kadzakalowa*	*250,000*
4	Nkhwazi	50,000	Chiluzi	130,000	**Kandeu**	**210,000**
5	Gumba	50,000	Mphati	100,000	**Sharpvalle**	**180,000**
6	Kazyozyo	45,000	Magomelo	78,000	Bilila	110,000
7	Gumulira	40,000			Pengapenga	110,000
8	Kabzyala	12,000			Kaloga	58,900
9	Kalulu	10,800			Masasa	-

Bolded : Surveyed in Detail (January 2002)
Italic : Data Obtained after the Survey (Sept. 2002)
(shaded) : Targeted in Phase IV

Table 8-5-2 Unelectrified Trading Centers with Annual Market Fee in Each District (Southern)

Southern Region

	Mangochi		Machinga		Balaka	
	TC Name	Market Fee	TC Name	Market Fee	TC Name	Market Fee
1	**Makanjira**	**360,000**	**Chikwewu**	**249,455**	**Chendausiku**	**80,000**
2	**Chilipa**	**240,000**	**Nampeya**	**204,000**	**Kwitanda**	**40,000**
3	Chiponde	130,000	Ngokwe	158,705	Phimbi	18,000
4	Majuni	100,000	Mposa	142,938		
5	Mvumba	94,158	Nayuchi	136,297		
6	Katuli	80,000	Msosa	116,617		
7	Mkumba	38,788	Ngwepele	114,578		
8	Katema	38,630	Mangamba	92,108		
9	Lungwena	20,000	Likhonyowa	81,077		
10	Kwisimba	-	Malundani	24,066		
11			Nanyumbu	-		
12			Molipa	-		

	Zomba		Chiradzulu		Blantyre	
	TC Name	Market Fee	TC Name	Market Fee	TC Name	Market Fee
1	**Jenale**	**268,800**	*Kanje*	*610,833*	**Chikuli**	**384,000**
2	**Sunuzi**	**248,600**	**Milepa**	**462,187**	**Mombo**	**174,000**
3	Zaone	192,000	*Chimwawa*	*206,782*	Dziwe	80,000
4	Muwa	192,000	**Ndunde**	**107,151**	Mudi	58,842
5	Mpyupyu	144,000			Mlenje	48,000
6	Masaula	115,200			Domwe	35,000
7	Nachuma	96,000			Chigwaja	-
8	Khonjeni	96,000			Linjidzi	-
9	Kachulu	94,000				
10	Sakata	57,600				
11	Makina	48,000				
12	Ngwelero	44,800				
13	Chisunzi	38,000				
14	Ngondole	24,000				

	Mwanza		Thyolo		Mulanje	
	TC Name	Market Fee	TC Name	Market Fee	TC Name	Market Fee
1	*Chikonde*	*176,826*	**Nansadi**	**288,000**	**Chinyama**	**360,000**
2	**Thambani**	**126,000**	**Fifite**	**168,000**	*Nkando*	*260,000*
3	**Lisungwi**	**108,000**	Lalakani	15,000	**Nanthombozi**	**216,000**
4	Ligowe	72,077	Thomasi	12,000	Chambe	208,000
5	Kam'mwamba	32,606	Makapwa	12,000	Mathambi	130,000
6	Matope	15,108	Sandama	12,000	Chinakanaka	119,600
7	Magaleta	10,555	Chipho	9,000	Msikawanjala	52,000
8	Kanenekude	-			Namphundo	41,600
9	Tulonkhondo	-			Kambenje	15,600
10	Kasuza	-			Kamwendo	7,800

	Phalombe		Chikwawa		Nsanje	
	TC Name	Market Fee	TC Name	Market Fee	TC Name	Market Fee
1	**Chilinga**	**260,000**	*Mitondo*	*280,000*	**Tengani**	**576,000**
2	**Mlomba**	**208,000**	**Chapananga**	**201,600**	**Mankhokwe**	**300,000**
3	Phaloni	208,000	**Linvunzu**	**200,000**	Mtowe	294,288
4	Chitekesa	156,000	Kakoma	41,000	Mbenje	115,200
5	Mpasa	41,600	Tomali	28,458	Masenjere	15,120
6	Nambazo	10,400	Ndakwera	28,000	Kampata	13,824
7			Kanyinda	15,000	Lulwe	-
8					Chididi	-
9					Sankhulani	-

Bolded : Surveyed in Detail (January 2002)
Italic : Data Obtained after the Survey (Sept. 2002)
(shaded) : Targeted in Phase IV

8.6 Socio-economic Survey

8.6.1 Purposes of socio-economic survey

In order to establish a Master Plan of Rural Electrification, it is essential to identify the potential electricity demand in each target TC to be electrified, which is regarded as the basic data required to determine the electrification method and to calculate the necessary budget. In addition to the identification of such a potential demand in each electrification target TC, clarification of the obstacles to the electrification progress from a socioeconomic point of view, and validation of the electrification project in an unelectrified TC from the project sustainability point of view – such as the uninterrupted payment of monthly tariffs by would-be beneficiaries – are required. Therefore, the socio-economic survey was conducted to serve the following purposes: 1) technical aspects evaluation (forecast of potential demand) and 2) social aspects evaluation (setup of judgment criteria for electrification project sustainability).

8.6.2 Process for the socio-economic survey and technical/social aspects evaluation

[Survey Process]

The survey process covering from the selection of target TCs to the evaluation of technical/social aspects is shown in Fig. 8-6-1. Among the 255 unelectrified TCs included in Table 8-5-2, listed according to their annual market fee in each district, the two top-ranking TCs (54 TCs in total = 2 TCs/District × 27 Districts) were selected as electrification targets (refer to [Stage 4] in Fig. 8-6-1). This was done by following two out of the three basic strategies defined for the rural electrification master plan: adoption of numerical data and offering equal opportunities for all Districts. Compared to the number of target TCs in the Rural Electrification Program Phase IV, 40 TCs, the number of target TCs in Phase V (implemented by the application of results from this Master Plan Study) was decided to be 54, based on the discussion between JICA Study Team and DOE: the number of targets in Phase V should be equivalent to that in Phase IV. In evaluating the technical aspects – demand forecast for the TCs that are currently unelectrified –, it was decided that a demand prediction model developed by statistical analysis using electricity consumption data in electrified TCs will be used. Thus, any variables relating to the formulation of this demand forecast model are collected by surveying the electrified TCs. Therefore, in addition to the 54 unelectrified TCs, 18 electrified TCs in various areas, scales, and with different years after electrification were also surveyed. As a result, the total number of TCs, both electrified and unelectrified, investigated in the survey became 72 (refer to [Stage 5] Socio-economic Survey in Fig. 8-6-1).

[Data Collection Method]

To implement the technical aspects of the evaluation, variables relating to the formulation of a demand prediction model need to be collected during the survey. Such variables include population, numbers of households, public facilities, business entities and maize mills, amount of alternative energy consumption for each type of consumer, number of electrical appliances in each household and power consumption and usage of each appliance. With respect to the population and number of households in every TC, relatively reliable data obtained from the national census, carried out every 10 years by the National Statistics Office (NSO)[2], was used. With respect to the number of public facilities, business entities and maize mills, amount of alternative energy consumption for each type of consumer, and power consumption and usage of each appliance, this data was collected during the socio-economic survey, as there was no organization that had reliable data about them.

To implement the social aspects evaluation, actual records of connection fees, indoor/house wiring costs, and monthly fees were collected by interviewing ESCOM users in the electrified TCs, while the willingness/ability to pay for these costs and fees was collected by interviewing potential users in unelectrified TCs.

[Data Analysis Method]

Basic statistical analysis methods[3] were applied to both the technical and social aspects evaluation. Concerning the technical aspects evaluation, a linear regression model was developed with electricity consumption records obtained in electrified TCs (refer to [Stage 6] Development of Peak Demand Forecast Model in Fig. 8-6-1), and then the potential demand for an unelectrified TC was forecasted by substituting into the model data collected in unelectrified TCs (refer to [Stage 7] Technical Aspects Evaluation in Fig. 8-6-1).

With respect to the social aspects evaluation, data obtained from ESCOM users and from potential consumers were compared using hypothesis tests. This data was used as criteria for the assessment of the rural electrification projects' sustainability and to establish objective policy recommendations (refer to [Stage 8] Social Aspects Evaluation in Fig. 8-6-1).

[2] As for population and number of households in a TC, we searched the NSO's census data file for a village with the same name as the TC. When a TC consists of several villages, the total data of all these villages was used as data of that TC.

[3] By assuming readers of this report have knowledge of basic statistics to undergraduate school level, detailed description and explanation of basic terms, equations, and solving methods are not included in this report. Reference books for probability and statistics are listed at the end of this chapter instead.

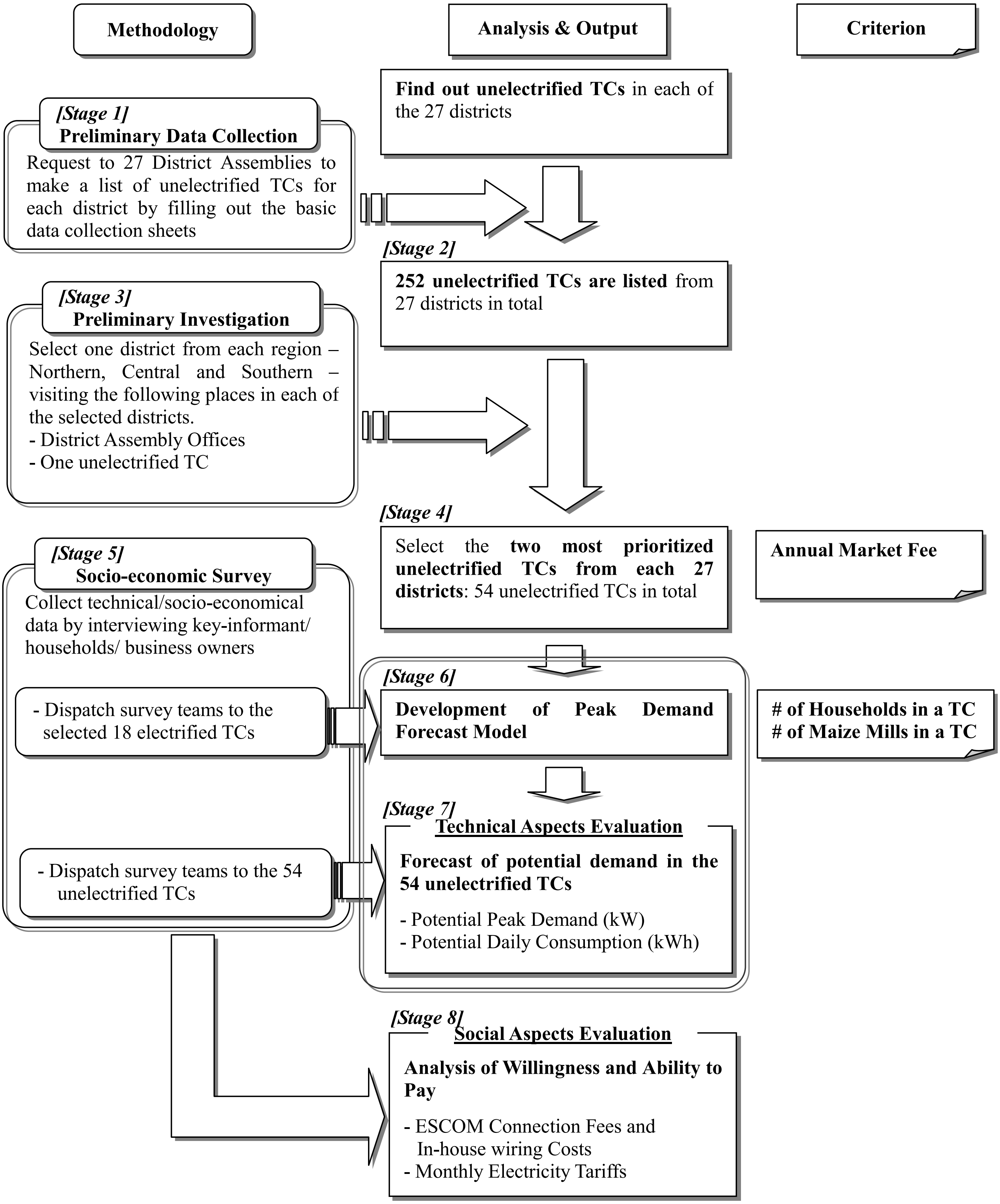


Fig. 8-6-1 Process of Target TCs Selection for Electrification and Technical/Social Aspects Evaluation

8.6.3 Surveyed items

In order to carry out evaluation of both technical and social aspects, data was collected as follows:

1) Size and quantification figures for each of the electrified and unelectrified TCs
2) Electricity consumption records and demand growth of electrified TCs in each of the consumer sectors such as public facilities, households and commercial – business entities
3) Potential demand of unelectrified TCs in each of the consumer sectors such as public facilities, households and commercial
4) Financial capability for continued electricity usage

These data were collected during the socio-economic survey by interviewing four different types of consumers: household representatives, business owners, representatives of each public facility, and key-informants of each TC. Table 8-6-1 summarizes the main survey items in each data category, type of interviewees, and expected demand from each category. The latest census data (1998) was also acquired from the National Statistical Office (NSO) in order to collect demographic data about each TC.

Table 8-6-1 Main Survey Items in Socio-economic Survey

Data Categories	Main Survey Items	Elec. TCs	Unelec. TCs	Interviewees/Data Sources
1) Numerical scales of each TC in both Electrified and Unelectrified	Scale of TCs			
	- Populations	○	○	Census data from NSO
	- Number of households	○	○	Census data from NSO
	- Number of public facilities	○	○	Interview for Key-Informant
	- Number of business entities	○	○	Interview for Key-Informant
	- Number of maize mills	○	○	Interview for Key-Informant
	Location (longitude/latitude)	○	○	Measured data by GPS
	Distance from existing ESCOM lines	○	○	ESCOM District Office
	Year of electrification of each TC	○	—	Interview for Key-Informant
	Electrification rate	○	—	Interview for Key-Informant
	[Expected Outputs] ➢ Numerical scales of each TC ➢ Growth rates of population/number of households in each TC (both electrified and unelectrified) ➢ Average electrification rate and its chronological transition in electrified TCs			
2) Characteristics of public facilities, households, and business entities in Electrified TCs	Demographic characteristics			Interviews for
	- Number of families	○	—	- Household Representatives
	- Number of rooms	○	—	- Business Owners
	Energy Sources	○	—	- Representatives of Public Facilities
	Possessed Electric Appliances	○	—	
	Capacities of Each Appliance	○	—	
	Usage Time Tables of Each Appliance	○	—	
	Effects of electrification	○	—	
	[Expected Outputs] ➢ Daily demand tables/curves in each of household, business entity and public facility ➢ Daily demand tables/curves and peak Demand in each electrified TC ➢ Demand growth rate after electrification ➢ Potential Demand Forecast Model			
3) Characteristics of public facilities, households, and business entities in Unelectrified TCs	Demographic characteristics			Interviews for
	- Number of families	—	○	- Household Representatives
	- Number of rooms	—	○	- Business Owners
	Willingness to Connect ESCOM	—	○	- Representatives of Public Facilities
	[Expected Outputs] ➢ Potential demand in each unelectrified TC - Peak Demand and Daily Consumption (in kW and kWh respectively) - Expected Peak Demand and Daily Consumption (in year of 2021)			
4) Financial capability to sustain electricity usage	Income and expenditure (monthly)	○	○	Interviews for
	Actual payment records to ESCOM			- Household Representatives
	- Capital contribution	○	—	- Business Owners
	- Connection fee	○	—	
	- Indoor/house wiring cost	○	—	
	Electricity fee (monthly)	○	—	
	Alternative energy costs (monthly)	—	○	
	Maximum amount of willing payment			
	- Capital contribution	—	○	
	- Connection fee	—	○	
	- Indoor/house wiring cost	—	○	
	- Electricity fee (monthly)	—	○	
	[Expected Outputs] ➢ Difference of financial conditions between households and business owners ➢ Difference of financial conditions between residents in electrified TCs and in unelectrified TCs ➢ Significance of difference between electrification costs actually paid by residents in electrified TCs and these willing to pay by unelectrified TCs			

8.6.4 Surveyed target Trading Centers

The annual market fee statistics were used to select a total of 54 unelectrified TCs[4] (the two top-ranking TCs in each of the 27 Districts), which were the subject of the socio-economic surveys conducted in this study (refer to the TCs indicated in bold typeface in Table 8-5-1). At these 54 TCs, detailed economic data, which enable to identify potential demand, ability and willingness to pay electricity, conditions preventing promotion of rural electrification, etc., will be collected by a local consulting firm contracted to carry out the socio-economic survey.

18 electrified TCs were also added for surveying, in order to collect the necessary data for establishing demand forecast models. Thus, a total of 72 TCs, including both electrified and unelectrified, were selected as survey targets. Table 8-6-2 and 8-6-3 summarize the TCs investigated in this survey.

Table 8-6-2 Electrified Trading Centers Investigated in Socioeconomic Survey

Location & Scale of TC		Year(s) after the Electrification			Total
		1 to 5 years	6 to 10 years	10 years <	
Northern	Medium	Embangweni [Mzimba]	Enukweni [Mzimba]	Chikangawa [Mzimba]	3 TCs
	Small	Uliwa [Karonga]	Phwezi [Rumphi]	Mbwengu [Mzimba]	3 TCs
Central	Medium	Lizulu [Ntcheu]	Masasa [Ntcheu]	Mponela [Dowa]	3 TCs
	Small	Linthipe [Dedza]	Lobi [Dedza]	Chikuse [Dowa]	3 TCs
Southern	Medium	Nselema [Machinga]	Ntaja [Machinga]	Namwera [Mangochi]	3 TCs
	Small	Ndeka [Blantyre]	Nsanama [Machinga]	Sorjin [Nsanje]	3 TCs
Total		6 TCs	6 TCs	6 TCs	18 TCs

4 The two top-ranking TCs in each of the 27 Districts were selected, based on the annual market fee data obtained by October 2001. Since additional data with respect to unelectrified TCs was obtained after the socio-economic survey (September 2002) for 6 Districts - Karonga, Ntcheu, Chiradzulu, Mwanza, Mulanje, Chikwawa, TCs for which the annual market fee is outside of the two top-ranking were surveyed for these Districts. In addition to this, 6 unelectrified TCs in 5 Districts - Likomma, Kasungu, Dowa, Mwanza, Chikwawa - which are targeted in the Rural Electrification Plan (REP) Phase IV established by DOE were mistakenly selected for the socio-economic survey of target TCs. However, for our master plan, these TCs involved in the REP Phase IV were counted out and re-prioritized based on the latest information taking the additional unelectrified TCs data into account as well (refer to Chapter 10).

Table 8-6-3 Unelectrified Trading Centers Investigated in Socioeconomic Survey

Location	District	1st Prioritized TC	2nd Prioritized TC	Total Number
Northern	Chitipa	Nthalire	Lupita	2 TCs
	Karonga	Kiwe	Pusi	2 TCs
	Rumphi	Katowo	Chitimba	2 TCs
	Nkhata Bay	Mpamba	Kavuzi	2 TCs
	Mzimba	Edingeni	Euthini	2 TCs
	Likoma	Likoma	Chizumulu	2 TCs
Central	Kasungu	Chamama	Chulu	2 TCs
	Nkhotakota	Mkaika	Dwambadzi	2 TCs
	Ntchisi	Nthesa	Nkhuwi	2 TCs
	Dowa	Thambwe	Nambuma	2 TCs
	Salima	Kandulu	Chilambula	2 TCs
	Lilongwe	Chilobwe	Nyanja	2 TCs
	Mchinji	Mkanda	Chiosya	2 TCs
	Dedze	Kabauzi	Golomoti	2 TCs
	Ntcheu	Kandeu	Sharpvalle	2 TCs
Southern	Mangochi	Makanjira	Chilipa	2 TCs
	Machinga	Chikweo	Nampeya	2 TCs
	Balaka	Chendausiku	Kwitanda	2 TCs
	Zomba	Jenale	Sunuzi	2 TCs
	Chiradzulu	Milepa	Ndunde	2 TCs
	Blantyre	Chikuli	Mombo	2 TCs
	Mwanza	Thambani	Lisungwi	2 TCs
	Thyolo	Nansadi	Fifite	2 TCs
	Mulanje	Chinyama	Nanthombozi	2 TCs
	Phalombe	Chilinga	Mulomba	2 TCs
	Chikwawa	Chapananga	Livunzu	2 TCs
	Nsanje	Tengani	Mankhokwe	2 TCs
Grand Total		27 TCs	27 TCs	54 TCs

8.6.5 Number of samplings in the socio-economic survey

In the socio-economic survey, data necessary for both the technical and social aspects of the 72 TCs – 54 unelectrified and 18 electrified – were collected from four different types of interviewees: 1) household representatives, 2) business owners, 3) representatives of each public facility, and 4) key-informants of each TC. The basic assumptions and conditions in relation to the sampling process, which are based on the results of the Preliminary Investigation (refer to [Stage 3] in Fig. 8-6-1) conducted prior to the socio-economic survey, are as follows:

a) TCs to be surveyed are categorized into two sizes – medium and small. It is assumed that a medium size TC has an average of 250 households and 25 businesses, while a small size TC has 125 and 12, respectively.
b) Among the 18 electrified TCs, half of them must be medium size and half must be small size.
c) Among the 54 unelectrified TCs, again, half of them must be medium size and half small size.

The estimated number of households and business entities in each category of electrified TC and unelectrified TC, are calculated the from above assumptions and conditions, and are summarized in Table 8-6-4. A total of 3,375 households and 333 business entities are assumed to exist in the 18 electrified TCs investigated in the survey. In the 54 unelectrified TCs, the expected totals of existing households and business entities were 10,125 and 999, respectively. Thus, the estimated overall totals of households and business entities in the 72 TCs are 13,500 and 1,322, respectively.

In order to process data to a 95% of significance level (5% of target perception (ε)) during the statistical analysis stage, the minimum number of samples required for the survey was calculated by using Equation 8-1, the results being as shown in the “Necessary Sample Sizes” column of Table 8-6-5. To satisfy these minimum requirements, the actual number of samples was selected as shown in the “Selected Sample Sizes in the Survey” sample of Table 8-6-5.

The total number of samples to be taken during the survey broken down into categories and interviewees/data sources summarized as in Table 8-6-6. The socio-economic survey took place from December 26, 2001 to January 30, 2002. Data was collected from 518 households, 423 business entities, 303 public facilities and 70 key-informants. The colleted sample sizes for the socio-economic survey are summarized in Table 8-6-7. As a result of the survey, it was found that the number of households in a TC was less than the expected number, while the number of business entities was more than expected. Although the total number of samples collected in the survey was slightly less than the target numbers, the number of samples was enough to process the data to a 95% of significance level in the tail test, because of the difference between the actual and the assumed number of households and business entities.

Table 8-6-4 Estimated Populations of Households and Business Entities in Socio-economic Survey

Electrification Status	Size of TC	Number of TCs	Population	
			Households	Business Entities
Electrified	Medium	9	2,250 (250×9 TCs)	225 (25×9 TCs)
	Small	9	1,125 (125×9 TCs)	108 (12×9 TCs)
	Sub Total	**18**	**3,375**	**333**
Unelectrified	Medium	27	6,750 (250×27 TCs)	675 (25×27 TCs)
	Small	27	3,375 (125×27 TCs)	324 (12×27 TCs)
	Sub Total	**54**	**10,125**	**999**
Grand Total		**72**	**13,500**	**1,332**

$$n = \left[\frac{N}{\left(\frac{\varepsilon}{1.96}\right)^2 \times \frac{N-1}{\pi(1-\pi)} + 1} \right] + 1 \qquad \text{(Equation 8-1)}$$

Necessary sample size: n

Population: N

Target precision: $\varepsilon = 0.05$ (5%)

Sample proportions $\pi = 0.5$

Table 8-6-5 Necessary Sample Sizes and Selected Sample Sizes in Socio-economic Survey

Electrification Status	Number of TCs	Population		Necessary Sample Sizes		**Selected Sample Sizes in the Survey**	
		House holds	Business Entities	House holds	Business Entities	**Households**	**Business Entities**
Electrified	18 TCs	3,375	333	345	179	**360** (20×18 TCs)	**180** (10×18 TCs)
Unelectrified	54 TCs	10,125	999	371	278	**378** (7×54 TCs)	**324** (6×54TCs)
Grand Total	72 TCs	13,500	1,332	374	299	**738**	**504**

Table 8-6-6 Detail Sample Sizes for Socio-economic Survey

Data Categories	Type of Interviewees /Data Sources	Sample Sizes		
		Electrified TCs	Unelectrified TCs	Total
1) Numerical scales of each TC in both Electrified and Unelectrified	Key-Informant	54	18	72
	ESCOM District Office	54	18	72
	Census Data from NSO	54	18	72
2) Characteristics of public facilities, households, and business entities in Electrified TCs	Representatives of Public Facilities	All	–	All
	ESCOM Connected - Household Representatives - Business Owners	 252 (=14×18TCs) 108 (= 6×18TCs)	 – –	 252 108
	Not Connected to ESCOM (not electrified) - Household Representatives - Business Owners	 108 (= 6×18TCs) 72 (= 4×18TCs)	 – –	 108 72
3) Characteristics of public facilities, households, and business entities in Unelectrified TCs	Representatives of Public Facilities	–	All	All
	Household Representatives	–	378 (=7×54TCs)	378
	Business Owners	–	324 (=6×54TCs)	324
4) Financial capability to sustain electricity usage	Household Representatives	360 (=[14+6]×18TCs)	378 (=7×54TCs)	738
	Business Owners	180 (=[6+4]×18TCs)	324 (=6×54TCs)	504

Table 8-6-7 Collected Sample Sizes in Socio-economic Survey

Electrification Status	Number of TCs	Actual Population		Necessary Sample Sizes		**Collected in the Survey**	
		House-holds	Business Entities	House-holds	Business Entities	**Households**	**Business Entities**
Electrified	18 TCs	1,769	869	92	88	**159**	**121**
Unelectrified	54 TCs	8,008	2,576	96	94	**359**	**302**
Grand Total	72 TCs	9,777	3,445	96	95	**518**	**423**

8.7 Technical Aspects Evaluation: Demand Forecast for Unelectrified Trading Centers

8.7.1 Purposes of technical aspects evaluation and data analysis flow

The purpose of technical aspects evaluation is to forecast unelectrified TCs' potential electricity demand by based on already electrified TCs' electricity consumption tendencies. A flow chart of data analysis for the technical aspects evaluation is shown in Figure 8-7-1. The first step of the analysis consisted of estimation of an average Daily Load Curve per unit of facility for each of the following four different types of consumers in electrified TCs: 1) public facilities, 2) business entities, 3) maize mills and 4) households. By multiplying the unitary average daily load curve by the number of existing facilities in a TC for each type and then adding them all together, the daily load curves and daily peak demands were estimated for all electrified TCs participating in this survey. The second step of the analysis was the development of a "Peak Demand Forecast Model". A linear regression model to estimate the daily peak demand in electrified TCs was derived from the relationship between the number of households and the estimated peak demands in electrified TCs (calculated in the first step). The third step of the analysis was to forecast the potential demand for unelectrified trading centers. Unelectrified TCs' potential daily peak demands were calculated by introducing the number of households in each TC into the peak demand forecast model. Details of each step are explained in the following sections.

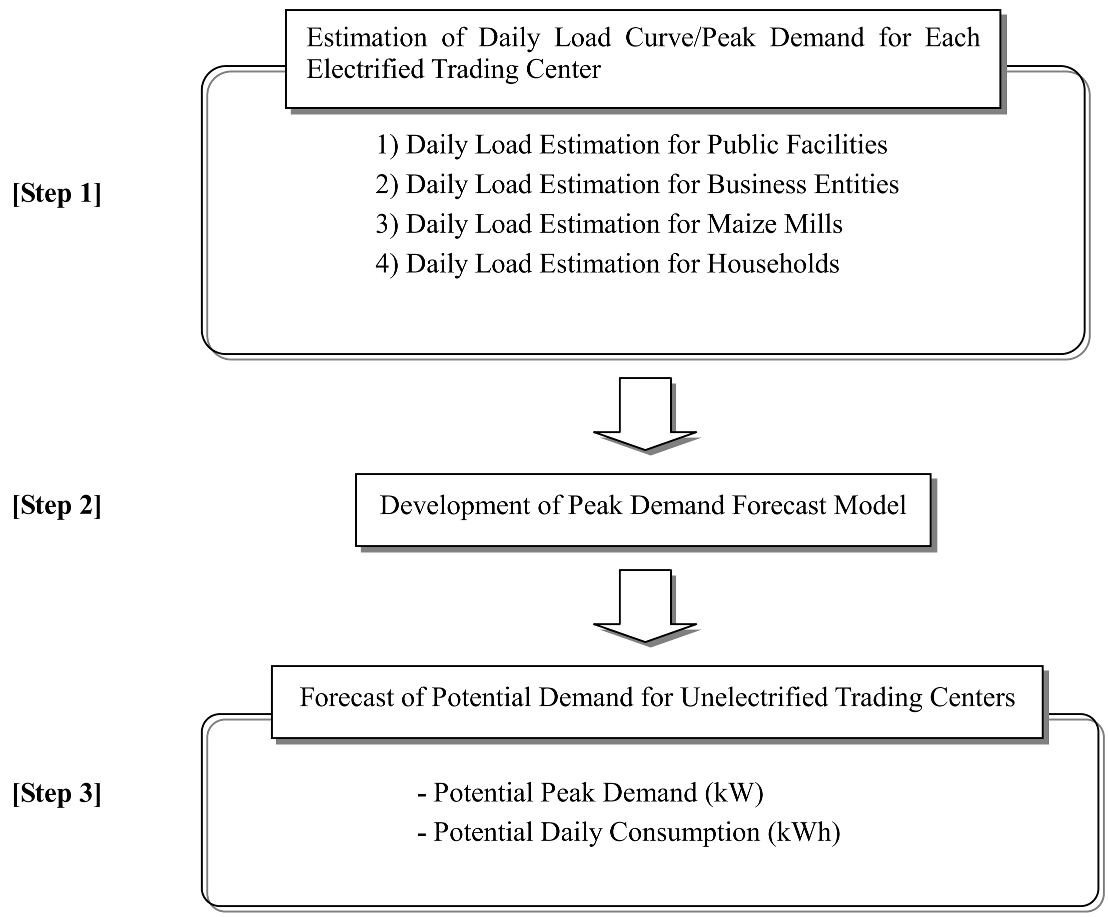


Fig. 8-7-1 Flow Chart of Data Analysis for Technical Aspects Evaluation

8.7.2 Estimation of Daily Load Curve/Peak Demand for Each Electrified Trading Center [Step 1]

From the survey results and the national census data, statistics regarding the number of existing facilities and the number of these facilities already electrified were obtained for each electrified TC and for each type of consumer (public facilities, business entities, maize mills and households), as shown in Table 8-7-2-1. Firstly, an average daily load curve per unit for each type of customer was obtained. Then, the total daily demand of electrified TCs studied in this survey was found by multiplying the curve data by the existing number of each type of facility in a TC and adding them altogether.

8.7.2.1 Estimation of Daily Demand for Public Facilities

The socio-economic survey results showed that there are 258 public facilities in the 18 electrified TCs considered in this survey. Of a total of 258 facilities, 103 receive electricity from ESCOM. Data collected from 53 electrified public facilities was significant to the creation of electricity demand curves. Table 8-7-2-2 summarizes the results of the investigation regarding public facilities.

On the data collection sheet used in the survey, public facilities were categorized in 20 types as indicated from a) to t) in Table 8-7-2-2. Significant data was collected from the following 14 types of public facilities: secondary school, primary school, hospital, health center, under five clinic, police station, police unit, post office/post agency, church, mosque, governmental offices, community/cooperative offices, non-government organizations and telephone exchange offices. Two types of public facilities expected to exist – immigration offices and radio stations – were not found in the electrified TCs surveyed. Additionally, data from four other types of public facilities – maternity, orphanage, community halls/recreation centers, and court – could not be collected, although there is no doubt that these facilities existed in the electrified TCs. Therefore a daily load curve per unit was created for each of the 14 specific types of public facilities. And the average daily demand of these 14 types was applied to the four public facility types from which no data could be collected. Figure 8-7-2-1 shows the daily load curve for each of the 14 public facility types as well as an average curve representative for all these facility types.

The daily load curve data per unit multiplied by the number of electrified units for each type in a TC (shown in Table 8-7-2-3) resulted in the daily load curves of public facilities for electrified TCs, as shown in Figure 8-7-2-2. Curves for 3 TCs – Mponela, Chikuse, and Ndeka – could not be calculated since the number of electrified public facilities in these TCs could not be verified as part of the survey.

Table 8-7-2-1 Summaries of Surveyed Electrified Trading Centers

TC Name	Region	Public Facility			Business Entity			Maize Mill			Household		
		Existing in TC	Electrified	Elec. Rate	Existing in TC	Electrified	Elec. Rate	Existing in TC	Electrified	Elec. Rate	Existing in TC	Electrified	Elec. Rate
Uliwa	Northern	16	2	12.5%	69	36	52.2%	3	3	100%	100	15	15.0%
Phwesi	Northern	7	5	71.4%	22	11	50.0%	1	1	100%	142	104	73.2%
Bwengu	Northern	16	1	6.3%	27	21	77.8%	2	2	100%	18	9	50.0%
Enukweni	Northern	11	6	54.5%	47	23	48.9%	3	3	100%	20	6	30.2%
Embangweni	Northern	22	5	22.7%	73	25	34.2%	4	3	75%	150	14	9.5%
Chikangawa	Northern	16	12	75.0%	23	8	34.8%	1	1	100%	213	108	50.9%
Linthipe	Central	8	5	62.5%	20	10	50.0%	3	3	100%	12	2	19.8%
Lobi	Central	13	10	76.9%	28	18	64.3%	3	3	100%	184	39	21.2%
Lizulu	Central	20	7	35.0%	67	29	43.3%	4	4	100%	94	77	81.9%
Masasa	Central	6	0	0.0%	10	5	50.0%	2	1	50%	40	13	33.6%
Mponela	Central	-	-	-	-	-	-	-	-	-	189	-	-
Chikuse	Central	-	-	-	-	-	-	-	-	-	99	-	-
Nsanama	Southern	22	4	18.2%	73	29	39.7%	11	11	100%	25	7	26.7%
Sorgin	Southern	13	5	38.5%	31	17	54.8%	12	10	83%	110	90	81.9%
Namwera	Southern	29	21	72.4%	52	32	61.5%	3	3	100%	150	80	53.3%
Nselema	Southern	15	6	40.0%	75	64	85.3%	6	6	100%	27	9	33.6%
Ntaja	Southern	23	14	60.9%	194	106	54.6%	4	4	100%	96	29	30.2%
Ndeka	Southern	21	-	-	58	35	60.3%	6	6	100%	100	-	-
Total		258	103	-	869	469	-	68	64	-	1,769	603	-
Average		16.1	6.9	43.1%	54.3	29.3	53.9%	4.3	4.0	94.3%	98	40.2	40.7%

Table 8-7-2-2 Summary Table of Surveyed Public Facilities

Type of Public Facility	Existing	Electrified	Available Daily Load Data
a) Secondary School	26	15	8
b) Primary School	25	5	5
c) Hospital	1	1	1
d) Health Center	16	11	8
e) Under Five Clinic	3	1	1
f) Maternity	4	4	0
g) Orphanage	2	1	0
h) Police Station	5	3	1
i) Police Unit	5	4	4
j) Immigration Office	0	0	0
k) Post Office/Post Agency	15	9	9
l) Radio Stations	0	0	0
m) Church	69	9	5
n) Mosque	20	9	5
o) Community Halls/Recreation Centers	10	8	0
p) Court	4	1	0
q) Government Offices	29	14	2
r) Community/ Cooperative Offices	12	8	1
s) Non-government organizations	9	4	1
t) Other (specify:)	3	2	2
Total	258	103	53

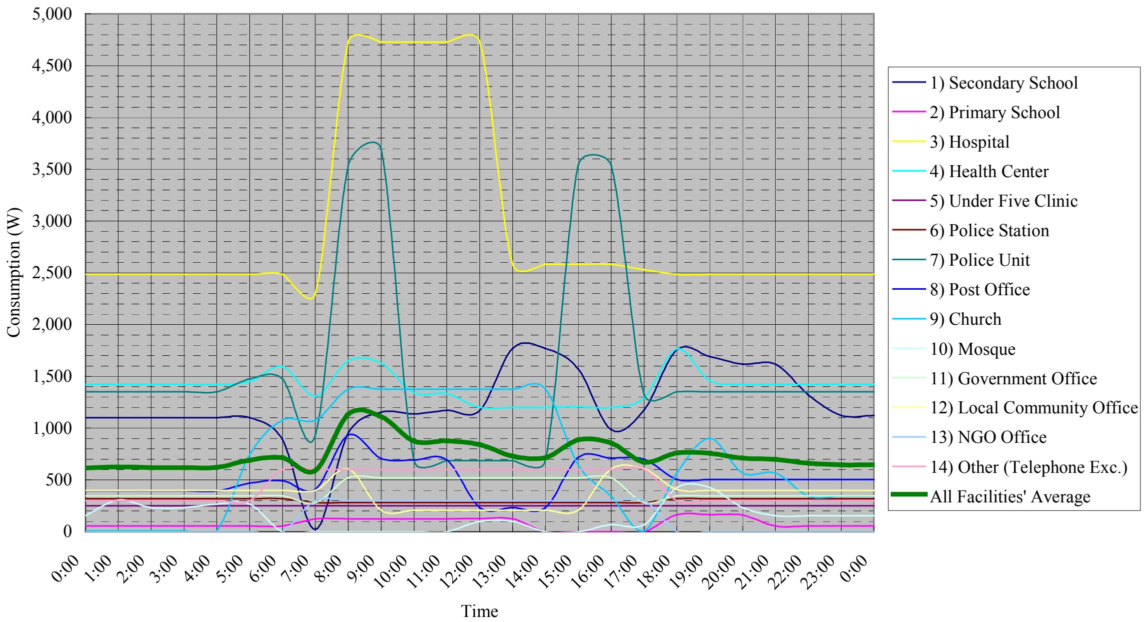


Fig. 8-7-2-1 Average Daily Load Curve per Unit for Each Public Facility

Table 8-7-2-3 Numbers of Existing and Electrified Public Facilities in Each Electrified Trading Center

TC Name	Region	Existing in TC	Electrified
Uliwa	Northern	16	2
Phwesi	Northern	7	5
Bwengu	Northern	16	1
Enukweni	Northern	11	6
Embangweni	Northern	22	5
Chikangawa	Northern	16	12
Linthipe	Central	8	5
Lobi	Central	13	10
Lizulu	Central	20	7
Masasa	Central	6	0
Mponela	Central	-	-
Chikuse	Central	-	-
Nsanama	Southern	22	4
Sorgin	Southern	13	5
Namwera	Southern	29	21
Nselema	Southern	15	6
Ntaja	Southern	23	14
Ndeka	Southern	21	-
Total		258	103
Average		16.1	6.9

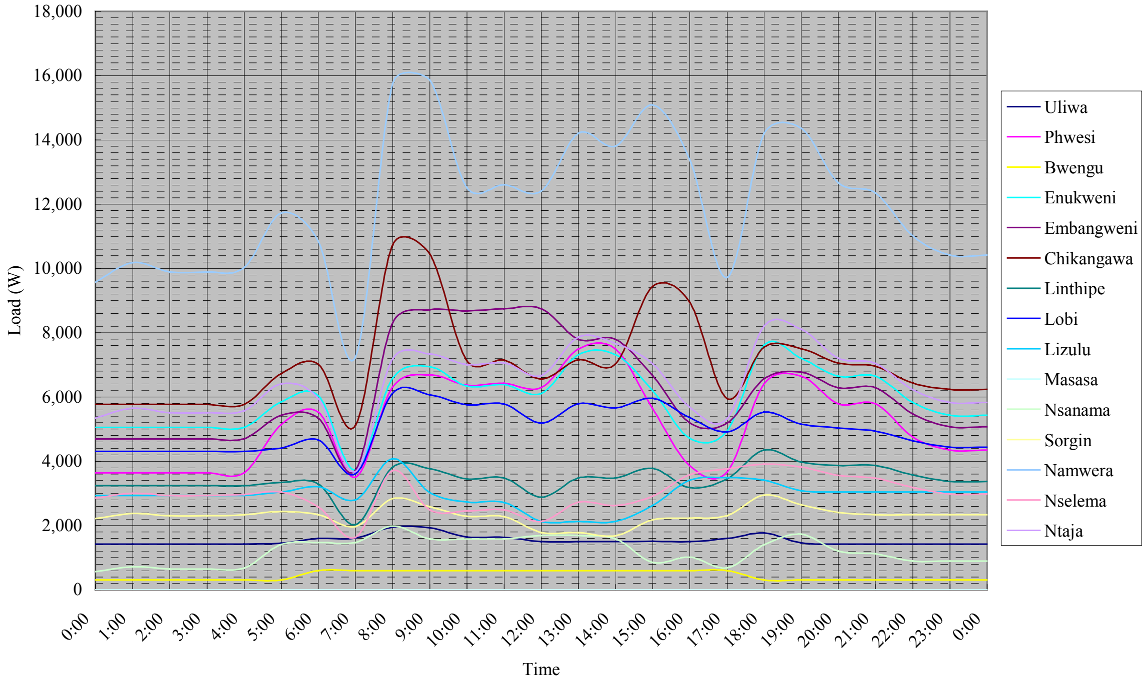


Fig. 8-7-2-2 Public Facilities' Daily Load Curves for Electrified Trading Centers

8.7.2.2 Estimation of Daily Demand for Business Entities

Survey results indicated that there are 869 business entities operating in the electrified TCs investigated in this survey. Of these, only 469 receive electricity from ESCOM. Data that was significant for the calculation of electricity demand curves was collected from 81 of these electrified business entities. Table 8-7-2-4 summarizes the investigation results regarding business entities.

Figure 8-7-2-3 shows the average daily load curves per business entity in each of the 17 electrified TCs (from a total of 18 surveyed TCs with the exception of Chikuse). Data from these average daily load curves multiplied by the number of electrified business entities in a TC (indicated in Table 8-7-2-4) resulted in the daily load curves of business entities for electrified TCs, as shown in Figure 8-7-2-4. The curves for two TCs – Mponela and Chikuse – could not be calculated since the number of electrified business entities in these TCs could not be verified as part of the survey.

Table 8-7-2-4 Numbers of Existing and Electrified Business Entities in Each Electrified Trading Center

TC Name	Region	Existing in TC	Electrified	Available Daily Load Data
Uliwa	Northern	69	36	7
Phwesi	Northern	22	11	5
Bwengu	Northern	27	21	5
Enukweni	Northern	47	23	4
Embangweni	Northern	73	25	6
Chikangawa	Northern	23	8	2
Linthipe	Central	20	10	5
Lobi	Central	28	18	6
Lizulu	Central	67	29	7
Masasa	Central	10	5	3
Mponela	Central	-	-	6
Chikuse	Central	-	-	-
Nsanama	Southern	73	29	3
Sorgin	Southern	31	17	2
Namwera	Southern	52	32	4
Nselema	Southern	75	64	8
Ntaja	Southern	194	106	6
Ndeka	Southern	58	35	2
Total		869	469	81
Average		54.3	29.3	4.8

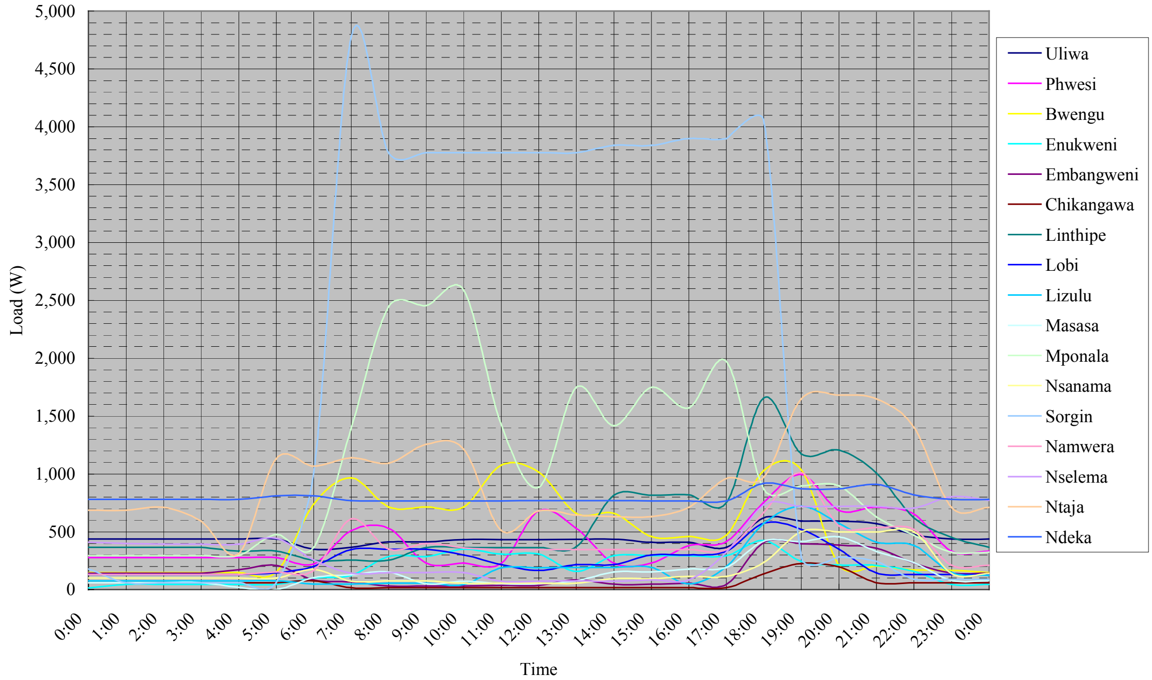


Fig. 8-7-2-3 Business Entity's Unit Average Daily Load Curve for Each Electrified Trading Center

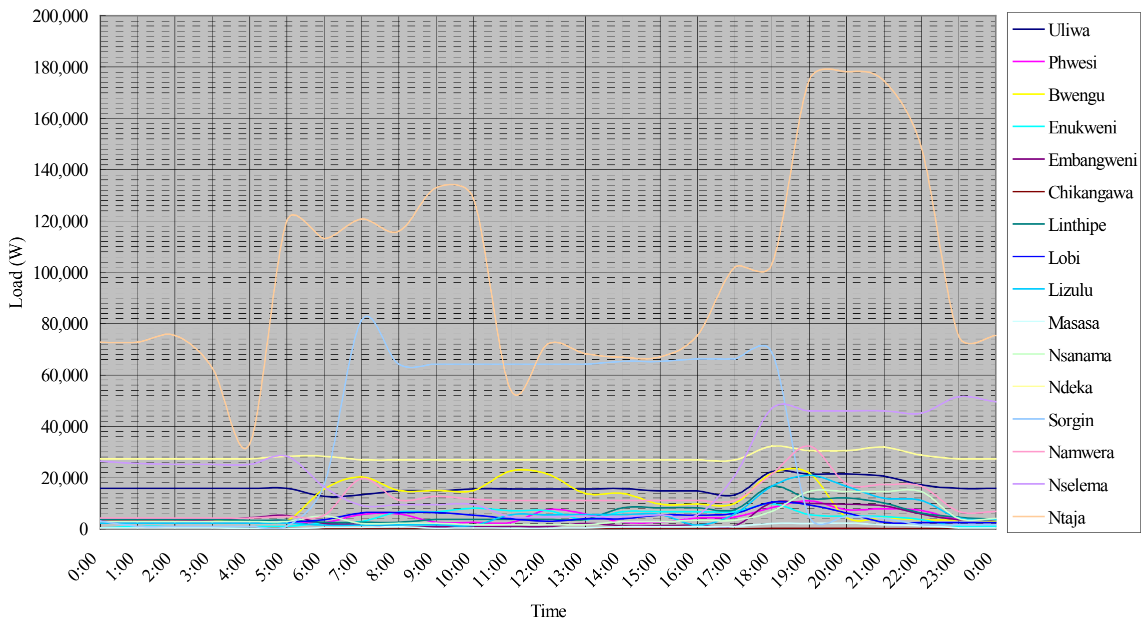


Fig. 8-7-2-4 Business Entities' Daily Load Curves for Electrified Trading Centers

8.7.2.3 Estimation of Daily Demand for Maize Mills

Results showed that there are 68 maize mills in the electrified TCs surveyed, and that 64 of these are electrified. The average electrification rate is 94.3%, which is relatively high compared to the rate of 53.9% for business entities (refer to Table 8-7-2-1). The unitary capacity of 20 kW/unit for maize mills is large, and an average of 4.3 units are installed in each TC. Therefore, maize mills are considered to be one of the major electricity users, probably the largest consumers, in a TC, thus necessitating distinction from other business entities in this study. Table 8-7-2-5 summarizes the investigation results regarding maize mills.

The unitary capacity of maize mills – 20 kW – multiplied by the number of electrified maize mills in a TC (shown in Table 8-7-2-5) and by the operation hours – generally from 6:00a.m. to 6:00p.m. – resulted in the daily load curves of maize mills for the electrified TCs, as shown in Figure 8-7-2-5. The curves for two TCs – Mponela and Chikuse – could not be calculated since the number of electrified maize mills in these TCs could not be verified as part of the survey.

Table 8-7-2-5 Numbers of Existing and Electrified Maize Mills in Each Electrified Trading Center

TC Name	Region	Existing in TC	Electrified	Available Daily Load Data
Uliwa	Northern	3	3	-
Phwesi	Northern	1	1	1
Bwengu	Northern	2	2	-
Enukweni	Northern	3	3	1
Embangweni	Northern	4	3	-
Chikangawa	Northern	1	1	-
Linthipe	Central	3	3	-
Lobi	Central	3	3	-
Lizulu	Central	4	4	-
Masasa	Central	2	1	-
Mponela	Central	-	-	-
Chikuse	Central	-	-	-
Nsanama	Southern	11	11	-
Sorgin	Southern	12	10	-
Namwera	Southern	3	3	-
Nselema	Southern	6	6	-
Ntaja	Southern	4	4	-
Ndeka	Southern	6	6	-
Total		68	64	2
Average		4.3	4.0	1

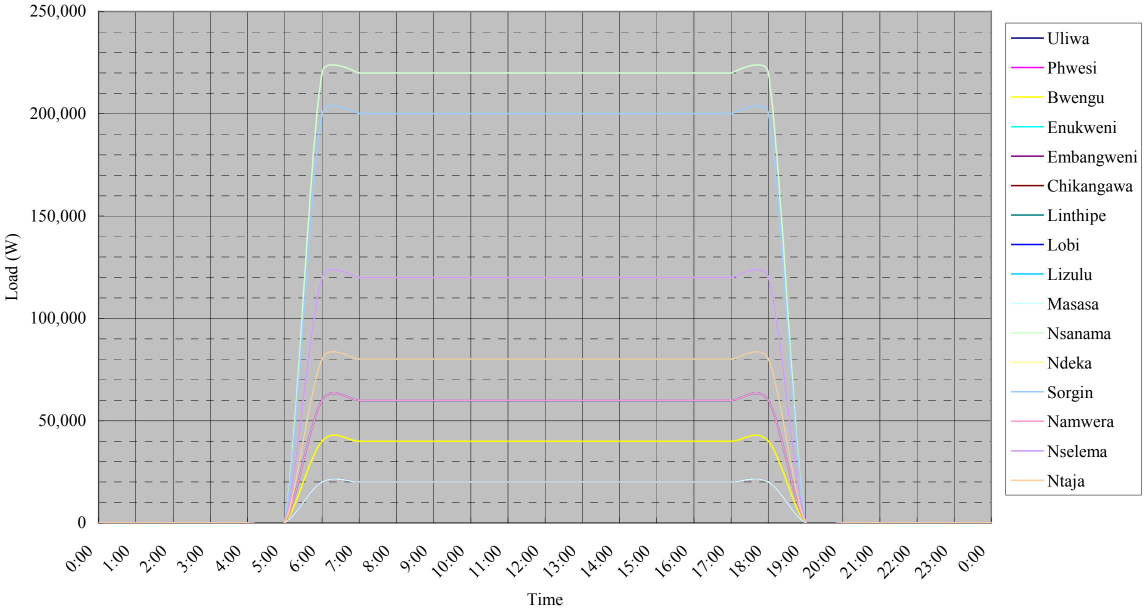


Fig. 8-7-2-5 Maize Mills' Daily Load Curves for Electrified Trading Centers

8.7.2.4 Estimation of Daily Demand for Households

The survey results showed that there are 1,769 households in the electrified TCs considered in this survey. Of these, 603 households are electrified. Data that was significant for the calculation of electricity demand curves was collected from 77 of these electrified households. Table 8-7-2-6 summarizes the investigation results regarding households.

Figure 8-7-2-6 shows the average daily load curves of households in each of the 15 electrified TCs (from a total of 18 surveyed TCs with the exception of Chikangawa, Chikuse and Ndeka). Data from these average daily load curves multiplied by the number of electrified households in a TC (shown in Table 8-7-2-6), resulted in the daily load curves of households for the electrified TCs, as shown in Figure 8-7-2-7. Daily load curves for four TCs could not be created since necessary data was not available for three TCs (Chikangawa, Chikuse and Ndeka) and the number of electrified households in one TC (Mponela) could not be verified as part of the survey.

Table 8-7-2-6 Numbers of Existing and Electrified Households in Each Electrified Trading Center

TC Name	Region	Existing in TC	Electrified	Available Daily Load Data
Uliwa	Northern	100	15	2
Phwesi	Northern	142	104	7
Bwengu	Northern	18	9	6
Enukweni	Northern	20	6	4
Embangweni	Northern	150	14	7
Chikangawa	Northern	213	108	-
Linthipe	Central	12	2	2
Lobi	Central	184	39	7
Lizulu	Central	94	77	3
Masasa	Central	40	13	1
Mponela	Central	189	-	12
Chikuse	Central	99	-	-
Nsanama	Southern	25	7	3
Sorgin	Southern	110	90	8
Namwera	Southern	150	80	4
Nselema	Southern	27	9	5
Ntaja	Southern	96	29	1
Ndeka	Southern	100	-	-
Total		1,769	603	72
Average		98.3	40.2	4.8

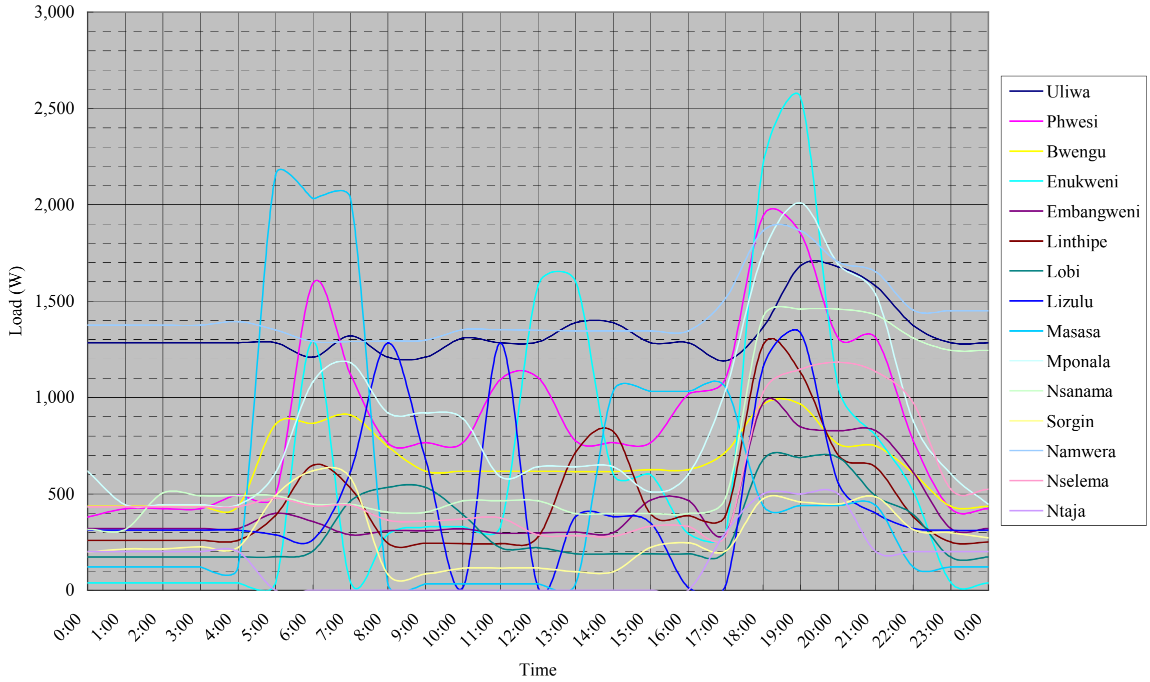


Fig. 8-7-2-6 Household's Unit Average Daily Load Curve for Each Electrified Trading Center

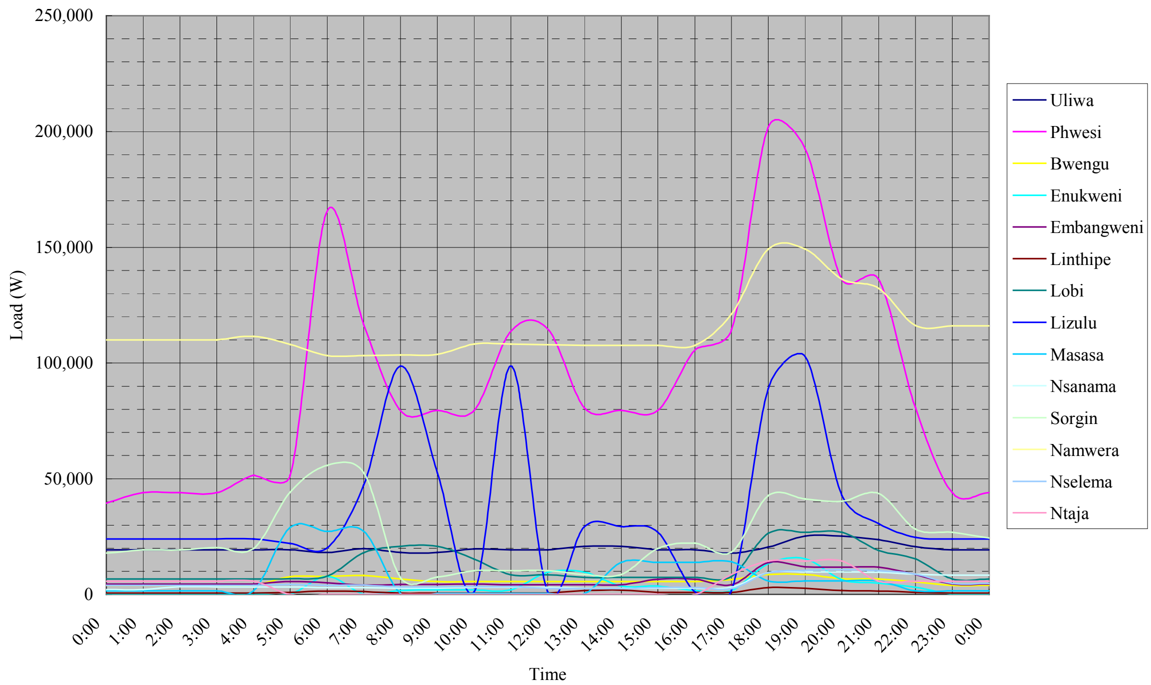


Fig. 8-7-2-7 Households' Daily Load Curves for Electrified Trading Centers

8.7.2.5 Estimated Daily Load Curve and Peak Demand for Each Electrified Trading Center

A daily load curve for each electrified TC surveyed is estimated by adding up the daily load curves for four different types of consumers: 1) public facilities, 2) business entities, 3) maize mills and 4) households. By following the process explained in sections 8.7.2.1 to 8.7.2.4, the daily load curves of these four types of consumers were estimated for each TC (Figures 8-7-2-2, 8-7-2-4, 8-7-2-5 and 8-7-2-7, respectively). The results of this calculation – cumulative summation – are shown in Figure 8-7-2-8, identifying the estimated daily load curves for each electrified TC participating in this survey. The daily load curves for only 14 of the 18 electrified TCs surveyed, are plotted, since data from 4 TCs was insufficient to create demand curves. A detailed timetable for all TCs, which is related to the demand curves, is shown in Table 8-7-2-7. In this table, the daily peak demand for each electrified TCs is underlined.

Based on these results, features of electricity consumption of TCs located in the rural areas of Malawi, as provided below, were delineated.

1) Of the total amount of electricity consumption in a TC, the consumption of maize mills shares a high proportion.
2) The daily peak demand of a TC occurs in the morning from 6:00 to 7:00 or in the evening from 18:00 to 19:00, coinciding with breakfast or dinnertime, during which a fast increase of electricity consumption for food preparation overlaps with the operation of maize mills.

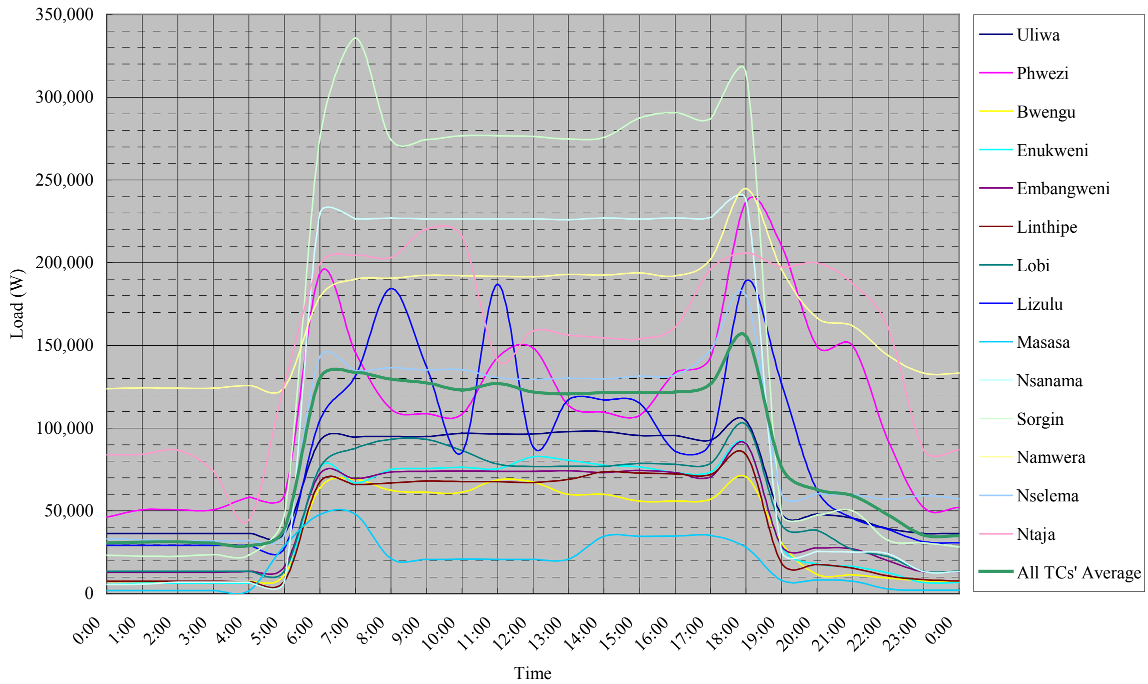


Fig. 8-7-2-8 Daily Load Curves for Electrified Trading Centers

Table 8-7-2-7 Time Table of Daily Demand in Surveyed Electrified Trading Centers (1/3)

Trading Center	Type of Users	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
Uliwa	Public Facility	1,421	1,421	1,421	1,421	1,421	1,449	1,594	1,607	1,949	1,927	1,642	1,633	1,499	1,499	1,499	1,507	1,499	1,594	1,765	1,458	1,421	1,421	1,421	1,421
	Business Entity	15,753	15,753	15,753	15,753	15,753	15,753	12,615	13,253	14,847	14,847	15,578	15,578	15,578	15,619	15,691	14,745	14,745	13,191	22,346	21,353	21,353	20,530	17,182	15,753
	Maize Mill	0	0	0	0	0	0	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	0	0	0	0	0
	Household	19,260	19,260	19,260	19,260	19,260	19,260	18,120	19,808	18,120	18,120	19,620	19,260	19,320	20,820	20,820	19,260	19,260	17,850	20,460	25,260	25,170	23,670	20,610	19,260
	Daily Demand	**36,433**	**36,433**	**36,433**	**36,433**	**36,433**	**36,462**	**92,329**	**94,668**	**94,916**	**94,895**	**96,839**	**96,471**	**96,397**	**97,938**	**98,010**	**95,512**	**95,503**	**92,635**	**104,571**	**48,071**	**47,944**	**45,621**	**39,213**	**36,433**
	DL exc. Maize Mill	*36,433*	*36,433*	*36,433*	*36,433*	*36,433*	*36,462*	*32,329*	*34,668*	*34,916*	*34,895*	*36,839*	*36,471*	*36,397*	*37,938*	*38,010*	*35,512*	*35,503*	*32,635*	*44,571*	*48,071*	*47,944*	*45,621*	*39,213*	*36,433*
Phwezi	Public Facility	3,645	3,645	3,645	3,645	3,645	5,140	5,524	3,505	6,310	6,688	6,369	6,427	6,293	7,490	7,490	5,635	3,857	3,665	6,410	6,642	5,788	5,788	4,752	4,352
	Business Entity	3,047	3,047	3,047	3,047	3,047	3,047	2,460	5,617	5,837	2,537	2,537	2,508	7,487	5,837	2,537	2,537	4,187	4,583	8,301	10,941	7,524	7,843	7,172	3,648
	Maize Mill	0	0	0	0	0	0	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	0	0	0	0	0
	Household	39,520	43,977	43,977	43,977	51,406	51,406	165,583	116,554	79,411	79,545	79,545	113,717	114,712	80,541	79,545	79,545	105,545	114,415	201,953	192,549	136,091	136,091	80,734	43,977
	Daily Demand	**46,212**	**50,669**	**50,669**	**50,669**	**58,098**	**59,593**	**193,567**	**145,676**	**111,558**	**108,770**	**108,451**	**142,652**	**148,492**	**113,867**	**109,572**	**107,717**	**133,589**	**142,663**	**236,664**	**210,131**	**149,404**	**149,723**	**92,657**	**51,976**
	DL exc. Maize Mill	*46,212*	*50,669*	*50,669*	*50,669*	*58,098*	*59,593*	*173,567*	*125,676*	*91,558*	*88,770*	*88,451*	*122,652*	*128,492*	*93,867*	*89,572*	*87,717*	*113,589*	*122,663*	*216,664*	*210,131*	*149,404*	*149,723*	*92,657*	*51,976*
Bwengu	Public Facility	300	300	300	300	300	300	600	600	600	600	600	600	600	600	600	600	600	600	300	300	300	300	300	300
	Business Entity	3,108	3,108	3,108	3,108	3,108	3,192	15,519	20,307	15,015	15,015	15,015	22,575	21,315	13,839	13,839	9,639	9,639	9,891	21,651	21,735	4,473	4,263	3,591	3,528
	Maize Mill	0	0	0	0	0	0	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	0	0	0	0	0
	Household	3,915	3,915	3,915	3,915	3,915	7,743	7,799	8,189	6,707	5,559	5,559	5,559	5,559	5,541	5,541	5,631	5,631	6,441	8,679	8,679	6,827	6,737	5,463	3,915
	Daily Demand	**7,323**	**7,323**	**7,323**	**7,323**	**7,323**	**11,235**	**63,918**	**69,096**	**62,322**	**61,174**	**61,174**	**68,734**	**67,474**	**59,980**	**59,980**	**55,870**	**55,870**	**56,932**	**70,630**	**30,714**	**11,600**	**11,300**	**9,354**	**7,743**
	DL exc. Maize Mill	*7,323*	*7,323*	*7,323*	*7,323*	*7,323*	*11,235*	*23,918*	*29,096*	*22,322*	*21,174*	*21,174*	*28,734*	*27,474*	*19,980*	*19,980*	*15,870*	*15,870*	*16,932*	*30,630*	*30,714*	*11,600*	*11,300*	*9,354*	*7,743*
Enukweni	Public Facility	5,056	5,056	5,056	5,056	5,056	5,846	6,041	3,736	6,582	6,939	6,334	6,384	6,115	7,312	7,312	6,199	4,712	4,949	7,609	7,200	6,642	6,642	5,829	5,429
	Business Entity	345	1,035	1,035	1,035	1,035	1,035	2,300	2,875	6,601	6,601	8,033	7,073	7,073	3,623	6,739	6,739	6,739	6,739	9,775	5,578	4,888	4,819	3,611	1,035
	Maize Mill	0	0	0	0	0	0	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	0	0	0	0	0
	Household	226	226	226	226	226	226	7,798	261	1,749	1,975	1,988	1,988	9,539	9,669	3,639	3,615	1,776	1,776	13,325	15,413	6,354	4,841	3,093	244
	Daily Demand	**5,627**	**6,317**	**6,317**	**6,317**	**6,317**	**7,107**	**76,140**	**66,871**	**74,932**	**75,515**	**76,356**	**75,445**	**82,727**	**80,604**	**77,690**	**76,553**	**73,227**	**73,464**	**90,709**	**28,190**	**17,884**	**16,301**	**12,533**	**6,708**
	DL exc. Maize Mill	*5,627*	*6,317*	*6,317*	*6,317*	*6,317*	*7,107*	*16,140*	*6,871*	*14,932*	*15,515*	*16,356*	*15,445*	*22,727*	*20,604*	*17,690*	*16,553*	*13,227*	*13,464*	*30,709*	*28,190*	*17,884*	*16,301*	*12,533*	*6,708*
Embangweni	Public Facility	4,699	4,699	4,699	4,699	4,699	5,432	5,339	3,721	8,314	8,714	8,681	8,748	8,748	7,795	7,795	6,664	5,195	5,191	6,564	6,769	6,286	6,286	5,472	5,072
	Business Entity	3,571	3,571	3,571	3,571	4,304	5,239	2,096	1,679	786	818	818	925	925	2,139	1,171	1,171	1,386	1,136	10,204	9,932	9,611	8,996	5,757	3,571
	Maize Mill	0	0	0	0	0	0	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	0	0	0	0	0
	Household	4,536	4,536	4,536	4,536	4,536	5,654	5,058	4,064	4,364	4,364	4,504	4,186	4,210	4,271	4,222	6,628	6,604	4,174	13,766	12,022	11,715	11,715	8,667	4,536
	Daily Demand	**12,806**	**12,806**	**12,806**	**12,806**	**13,539**	**16,325**	**72,494**	**69,463**	**73,464**	**73,896**	**74,002**	**73,858**	**73,883**	**74,205**	**73,188**	**74,464**	**73,184**	**70,501**	**90,533**	**28,724**	**27,611**	**26,997**	**19,896**	**13,180**
	DL exc. Maize Mill	*12,806*	*12,806*	*12,806*	*12,806*	*13,539*	*16,325*	*12,494*	*9,463*	*13,464*	*13,896*	*14,002*	*13,858*	*13,883*	*14,205*	*13,188*	*14,464*	*13,184*	*10,501*	*30,533*	*28,724*	*27,611*	*26,997*	*19,896*	*13,180*
Linthipe	Public Facility	3,238	3,238	3,238	3,238	3,238	3,341	3,294	2,021	3,815	3,768	3,452	3,477	2,882	3,481	3,481	3,775	3,176	3,449	4,346	3,975	3,863	3,863	3,568	3,368
	Business Entity	3,658	3,658	3,658	3,658	3,318	3,338	2,538	2,556	2,556	3,636	3,636	3,636	3,636	3,710	8,160	8,160	8,184	7,524	16,584	11,752	12,062	10,062	6,208	4,522
	Maize Mill	0	0	0	0	0	0	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	0	0	0	0	0
	Household	614	614	614	614	614	922	1,542	1,258	579	579	575	575	656	1,700	1,958	940	919	924	3,022	2,683	1,664	1,517	905	594
	Daily Demand	**7,510**	**7,510**	**7,510**	**7,510**	**7,170**	**7,602**	**67,374**	**65,836**	**66,950**	**67,984**	**67,663**	**67,687**	**67,175**	**68,891**	**73,599**	**72,875**	**72,279**	**71,897**	**83,952**	**18,410**	**17,589**	**15,442**	**10,680**	**8,484**
	DL exc. Maize Mill	*7,510*	*7,510*	*7,510*	*7,510*	*7,170*	*7,602*	*7,374*	*5,836*	*6,950*	*7,984*	*7,663*	*7,687*	*7,175*	*8,891*	*13,599*	*12,875*	*12,279*	*11,897*	*23,952*	*18,410*	*17,589*	*15,442*	*10,680*	*8,484*

Table 8-7-2-7 Time Table of Daily Demand in Surveyed Electrified Trading Centers (2/3)

Trading Center	Type of Users	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
Lobi	Public Facility	4,308	4,308	4,308	4,308	4,308	4,411	4,664	3,605	6,118	6,072	5,756	5,781	5,189	5,785	5,661	5,955	5,356	4,909	5,524	5,153	5,038	4,933	4,638	4,438
	Business Entity	2,382	2,382	2,382	2,382	2,382	2,622	3,627	6,237	6,291	6,291	5,391	3,891	2,991	3,891	3,891	5,391	5,391	5,991	10,341	9,387	6,279	2,610	2,382	2,382
	Maize Mill	0	0	0	0	0	0	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	0	0	0	0	0
	Household	6,686	6,686	6,686	6,686	6,686	6,758	7,923	18,018	20,804	20,804	15,282	8,597	8,597	7,399	7,349	7,349	7,349	7,822	26,409	26,882	26,882	19,032	15,333	6,686
	Daily Demand	**13,376**	**13,376**	**13,376**	**13,376**	**13,376**	**13,792**	**76,214**	**87,860**	**93,213**	**93,167**	**86,429**	**78,268**	**76,777**	**77,075**	**76,901**	**78,695**	**78,095**	**78,722**	**102,274**	**41,422**	**38,199**	**26,575**	**22,352**	**13,506**
	DL exc. Maize Mill	*13,376*	*13,376*	*13,376*	*13,376*	*13,376*	*13,792*	*16,214*	*27,860*	*33,213*	*33,167*	*26,429*	*18,268*	*16,777*	*17,075*	*16,901*	*18,695*	*18,095*	*18,722*	*42,274*	*41,422*	*38,199*	*26,575*	*22,352*	*13,506*
Lizulu	Public Facility	2,936	2,936	2,936	2,936	2,936	3,039	3,206	2,799	4,075	3,028	2,729	2,720	2,126	2,126	2,126	2,619	3,404	3,487	3,404	3,083	3,046	3,046	3,046	3,046
	Business Entity	2,200	2,200	2,200	2,200	2,200	2,241	1,417	1,417	1,591	1,591	1,301	5,444	5,473	5,597	5,597	5,597	1,454	5,804	16,592	20,921	16,571	11,911	11,107	4,271
	Maize Mill	0	0	0	0	0	0	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	0	0	0	0	0
	Household	23,994	23,994	23,994	23,994	23,994	22,069	20,170	47,372	98,696	52,504	1,180	98,696	1,180	29,409	29,409	26,842	1,180	1,848	88,970	102,828	42,779	30,666	24,661	23,994
	Daily Demand	**29,130**	**29,130**	**29,130**	**29,130**	**29,130**	**27,350**	**104,793**	**131,588**	**184,362**	**137,124**	**85,210**	**186,860**	**88,779**	**117,132**	**117,132**	**115,058**	**86,039**	**91,139**	**188,966**	**126,832**	**62,396**	**45,623**	**38,814**	**31,311**
	DL exc. Maize Mill	*29,130*	*29,130*	*29,130*	*29,130*	*29,130*	*27,350*	*24,793*	*51,588*	*104,362*	*57,124*	*5,210*	*106,860*	*8,779*	*37,132*	*37,132*	*35,058*	*6,039*	*11,139*	*108,966*	*126,832*	*62,396*	*45,623*	*38,814*	*31,311*
Masasa	Public Facility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Business Entity	300	300	300	300	100	0	517	650	767	250	367	250	250	383	767	767	900	967	2,100	2,083	2,283	1,650	1,167	400
	Maize Mill	0	0	0	0	0	0	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	0	0	0	0	0
	Household	1,613	1,613	1,613	1,613	1,613	28,923	27,310	27,310	430	430	430	430	430	430	13,870	13,870	13,870	14,139	5,900	5,900	5,900	5,900	1,613	1,613
	Daily Demand	**1,913**	**1,913**	**1,913**	**1,913**	**1,713**	**28,923**	**47,827**	**47,960**	**21,197**	**20,680**	**20,797**	**20,680**	**20,680**	**20,813**	**34,637**	**34,637**	**34,770**	**35,106**	**28,000**	**7,983**	**8,183**	**7,550**	**2,779**	**2,013**
	DL exc. Maize Mill	*1,913*	*1,913*	*1,913*	*1,913*	*1,713*	*28,923*	*27,827*	*27,960*	*1,197*	*680*	*797*	*680*	*680*	*813*	*14,637*	*14,637*	*14,770*	*15,106*	*8,000*	*7,983*	*8,183*	*7,550*	*2,779*	*2,013*
Nsanama	Public Facility	563	715	643	643	677	1,410	1,477	1,477	1,984	1,584	1,584	1,584	1,684	1,684	1,584	850	1,017	684	1,399	1,725	1,200	1,120	897	897
	Business Entity	2,900	2,900	2,900	2,900	2,900	2,900	5,036	2,136	2,194	2,194	1,614	1,614	1,614	1,614	2,774	2,774	3,354	3,354	6,825	14,558	14,500	14,500	14,500	4,060
	Maize Mill	0	0	0	0	0	0	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	220,000	0	0	0	0	0
	Household	2,103	2,103	3,371	3,271	3,271	3,271	2,970	2,970	2,703	2,703	3,091	3,091	3,091	2,657	2,657	2,657	2,657	3,191	9,465	9,732	9,732	9,534	8,733	8,310
	Daily Demand	**5,566**	**5,718**	**6,914**	**6,814**	**6,847**	**7,581**	**229,483**	**226,583**	**226,881**	**226,481**	**226,289**	**226,289**	**226,389**	**225,955**	**227,015**	**226,281**	**227,028**	**227,229**	**237,689**	**26,015**	**25,432**	**25,154**	**24,130**	**13,267**
	DL exc. Maize Mill	*5,566*	*5,718*	*6,914*	*6,814*	*6,847*	*7,581*	*9,483*	*6,583*	*6,881*	*6,481*	*6,289*	*6,289*	*6,389*	*5,955*	*7,015*	*6,281*	*7,028*	*7,229*	*17,689*	*26,015*	*25,432*	*25,154*	*24,130*	*13,267*
Sorgin	Public Facility	2,219	2,371	2,299	2,299	2,333	2,436	2,336	1,969	2,831	2,584	2,285	2,276	1,782	1,782	1,682	2,175	2,227	2,310	2,945	2,638	2,409	2,329	2,329	2,329
	Business Entity	3,060	1,020	1,020	1,020	1,020	1,063	17,213	81,218	64,175	64,175	64,175	64,175	64,218	64,218	65,272	65,272	66,292	66,292	68,825	4,803	4,803	4,123	1,530	1,530
	Maize Mill	0	0	0	0	0	0	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	0	0	0	0	0
	Household	17,905	19,257	19,257	20,327	19,921	44,200	55,799	52,522	7,342	7,568	10,270	10,270	10,327	8,660	8,660	19,921	22,173	18,345	42,725	41,318	40,270	43,604	28,288	26,869
	Daily Demand	**23,185**	**22,648**	**22,576**	**23,646**	**23,274**	**47,699**	**275,348**	**335,709**	**274,348**	**274,327**	**276,730**	**276,722**	**276,326**	**274,659**	**275,613**	**287,368**	**290,692**	**286,946**	**314,495**	**48,758**	**47,482**	**50,055**	**32,147**	**30,729**
	DL exc. Maize Mill	*23,185*	*22,648*	*22,576*	*23,646*	*23,274*	*47,699*	*75,348*	*135,709*	*74,348*	*74,327*	*76,730*	*76,722*	*76,326*	*74,659*	*75,613*	*87,368*	*90,692*	*86,946*	*114,495*	*48,758*	*47,482*	*50,055*	*32,147*	*30,729*
Namwera	Public Facility	9,576	10,184	9,896	9,896	10,030	11,725	10,851	7,251	15,760	15,863	12,514	12,605	12,411	14,206	13,806	15,087	13,384	9,719	14,201	14,361	12,665	12,345	11,013	10,413
	Business Entity	4,224	4,224	4,224	4,224	4,224	4,864	5,328	19,568	11,248	12,752	11,536	11,096	11,096	11,096	11,096	11,096	11,096	11,096	21,376	32,320	17,640	17,208	16,624	6,784
	Maize Mill	0	0	0	0	0	0	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	0	0	0	0	0
	Household	110,000	110,000	110,000	110,000	111,500	108,000	103,200	103,200	103,440	103,740	108,140	108,140	107,900	107,600	107,600	107,600	107,600	121,200	149,200	149,200	136,240	132,240	116,240	116,000
	Daily Demand	**123,800**	**124,408**	**124,120**	**124,120**	**125,754**	**124,589**	**179,379**	**190,019**	**190,448**	**192,355**	**192,190**	**191,841**	**191,407**	**192,902**	**192,502**	**193,783**	**192,080**	**202,015**	**244,777**	**195,881**	**166,545**	**161,793**	**143,877**	**133,197**
	DL exc. Maize Mill	*123,800*	*124,408*	*124,120*	*124,120*	*125,754*	*124,589*	*119,379*	*130,019*	*130,448*	*132,355*	*132,190*	*131,841*	*131,407*	*132,902*	*132,502*	*133,783*	*132,080*	*142,015*	*184,777*	*195,881*	*166,545*	*161,793*	*143,877*	*133,197*

Table 8-7-2-7 Time Table of Daily Demand in Surveyed Electrified Trading Centers (3/3)

Trading Center	Type of Users	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
Nselema	Public Facility	2,850	3,002	2,930	2,930	2,964	3,039	2,581	1,634	3,707	2,482	2,451	2,485	2,125	2,723	2,623	2,909	3,585	3,763	3,907	3,822	3,555	3,475	3,180	2,980
	Business Entity	26,336	25,536	25,136	25,136	25,136	28,336	16,416	9,136	9,456	9,456	9,456	4,656	4,656	4,896	4,656	5,496	5,496	20,696	46,936	46,016	46,016	46,016	45,056	51,456
	Maize Mill	0	0	0	0	0	0	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	0	0	0	0	0
	Household	3,932	3,932	3,932	3,932	3,932	4,331	3,955	3,995	3,288	3,248	3,357	3,397	2,607	2,567	2,540	3,008	3,008	2,540	9,310	10,398	10,729	10,289	8,813	4,748
	Daily Demand	**33,118**	**32,470**	**31,998**	**31,998**	**32,031**	**35,706**	**142,952**	**134,765**	**136,450**	**135,185**	**135,264**	**130,537**	**129,388**	**130,187**	**129,819**	**131,413**	**132,089**	**146,999**	**180,153**	**60,237**	**60,300**	**59,781**	**57,049**	**59,185**
	DL exc. Maize Mill	*33,118*	*32,470*	*31,998*	*31,998*	*32,031*	*35,706*	*22,952*	*14,765*	*16,450*	*15,185*	*15,264*	*10,537*	*9,388*	*10,187*	*9,819*	*11,413*	*12,089*	*26,999*	*60,153*	*60,237*	*60,300*	*59,781*	*57,049*	*59,185*
Ntaja	Public Facility	5,347	5,651	5,507	5,507	5,573	6,410	5,950	3,680	7,185	7,339	7,006	7,064	6,670	7,867	7,667	7,029	5,678	5,328	8,209	8,108	7,203	7,043	6,230	5,830
	Business Entity	72,787	72,787	75,437	62,717	33,037	120,063	113,173	120,769	115,999	133,030	128,790	54,237	72,186	68,299	66,886	66,974	75,437	101,937	103,103	174,829	178,186	174,653	148,753	75,437
	Maize Mill	0	0	0	0	0	0	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000	0	0	0	0	0
	Household	5,789	5,789	5,789	5,789	5,789	0	0	0	0	0	0	0	0	0	0	0	0	8,683	14,472	14,472	14,472	5,789	5,789	5,789
	Daily Demand	**83,922**	**84,226**	**86,732**	**74,012**	**44,399**	**126,473**	**199,122**	**204,449**	**203,184**	**220,369**	**215,796**	**141,301**	**158,856**	**156,166**	**154,553**	**154,004**	**161,115**	**195,948**	**205,784**	**197,409**	**199,861**	**187,485**	**160,772**	**87,055**
	DL exc. Maize Mill	*83,922*	*84,226*	*86,732*	*74,012*	*44,399*	*126,473*	*119,122*	*124,449*	*123,184*	*140,369*	*135,796*	*61,301*	*78,856*	*76,166*	*74,553*	*74,004*	*81,115*	*115,948*	*125,784*	*197,409*	*199,861*	*187,485*	*160,772*	*87,055*
All TCs' Average Daily Demand		**30,709**	**31,068**	**31,273**	**30,433**	**28,957**	**39,317**	**130,067**	**133,610**	**129,587**	**127,280**	**123,085**	**126,953**	**121,768**	**120,741**	**121,444**	**121,731**	**121,826**	**126,585**	**155,657**	**76,341**	**62,888**	**59,243**	**47,590**	**35,342**

8.7.3 Development of a Daily Peak Demand Forecast Model [Step 2]

8.7.3.1 Relationship between number of households and peak demand (except maize mills) in electrified TCs

One of the characteristics of maize mills is that they consume a considerably greater amount of electricity than other types of consumers – public facilities, business entities and households, as explained in a previous section. In addition to this characteristic, there is no significant correlation between the scale of TCs and the number of maize mills installed in them. Therefore, a daily peak demand forecast model for an unelectrified TC was developed such that the actual consumption of maize mills is added to the daily peak demand forecast of the other types of consumers.

The daily peak demand with and without consumption of maize mills, together with the number of households for each of the electrified TCs considered in this survey, are indicated in Table 8-7-3-1, which has been prepared from data shown in Table 8-7-2-7. The relationship between the number of households and the daily peak demand (with the exception of maize mills) for each of the TCs is plotted in Figure 8-7-3-1. Although these two variables exhibit a tendency to be proportional in the data distribution, it seemed that two different types of groups intermingled: one was strongly proportional while the other was weakly proportional – high and low rates of peak demand increase in accordance with the increase of the number of households, respectively. Through careful data sorting and analyses, the criterion that divided the data into two groups was found to be "years after the electrification". This means that the group of TCs electrified more than 5 years ago showed strong proportionality (refer to red dots in Figure 8-7-3-1), while those electrified 5 years or less ago showed weak proportionality (refer to yellow triangles in Figure 8-7-3-1). This tendency can be explained by the level of understanding of the usefulness and importance by as yet unconnected users in addition to their need to save enough money for ESCOM connection 5 years after the TC has been electrified. Thus, at that stage, the electrification rate in the TC will stabilize and the daily peak demand will steadily become strongly proportional to the number of households in the TC as a result. In fact, as shown in Equation 8-2, a linear regression model used to evaluate the daily peak demand without the consumption of maize mills in electrified TCs, supported this conclusion. This model applied to the group of TCs electrified more than 5 years ago (refer to Equation 8-2) showed high values of the following factors: coefficient of determination (R^2), equal to 0.87, significance of the partial regression coefficient (t-statistics), $6.99 > t_{0.025}(\gamma = 7) = 2.36$, and significance of the linear regression model (F-statistics), $48.94 > F_{0.025}(1, 8) = 7.57$.

$$y = 1{,}403x + 5{,}304 \qquad \text{(Equation 8-2)}$$

y: Daily Peak Demand without Maize Mills' Consumption in a TC (W)

x: Number of Households in a TC

Since the purpose of this study is to formulate a rural electrification master plan for 20 years from now, it was decided that no problems would arise if the demand forecast model suitable for the group of TCs electrified more than 5 years ago is adopted. An advantage of this simple regression model is that it enables to facilitate estimates of each TC's daily peak demand, (consumed by all types of electricity users except maize mills), with a single variable: the number of households in a TC. This means that if only the number of households in an unelectrified TC is obtained, its daily peak demand (except maize mills consumption) can be forecasted. In Malawi, national population census is carried out regularly every ten years, and thus the number of households in each TC can be easily obtained and update guaranteed. By adopting this simple regression model, the increase rates of public facilities or business entities in unelectrified TCs need not be taken into account over the 20 year period, since this is extremely difficult to estimate logically using the available data (all these factors take into account the growth rate of the number of households as explained in a later section). This is another advantage of this model.

Table 8-7-3-1 Peak demand except Maize Mills and Number of Households in Electrified TCs

Trading Center	Peak Load (W)	Peak Load Except Maize Mills (W)	Number of Households
Uliwa	104,571	48,071	100
Phwezi	236,664	216,664	142
Bwengu	70,630	30,714	18
Enukweni	90,709	30,709	20
Embangweni	90,533	30,533	150
Lithipe	83,952	23,952	12
Lobi	102,274	42,274	184
Lizulu	188,966	126,832	94
Masasa	47,960	28,923	40
Nsanama	237,689	26,015	25
Sorgin	335,709	135,709	110
Namwera	244,777	195,881	150
Nselema	180,153	60,300	27
Ntaja	220,369	199,861	96
All TCs Average	159,640	85,460	83.4

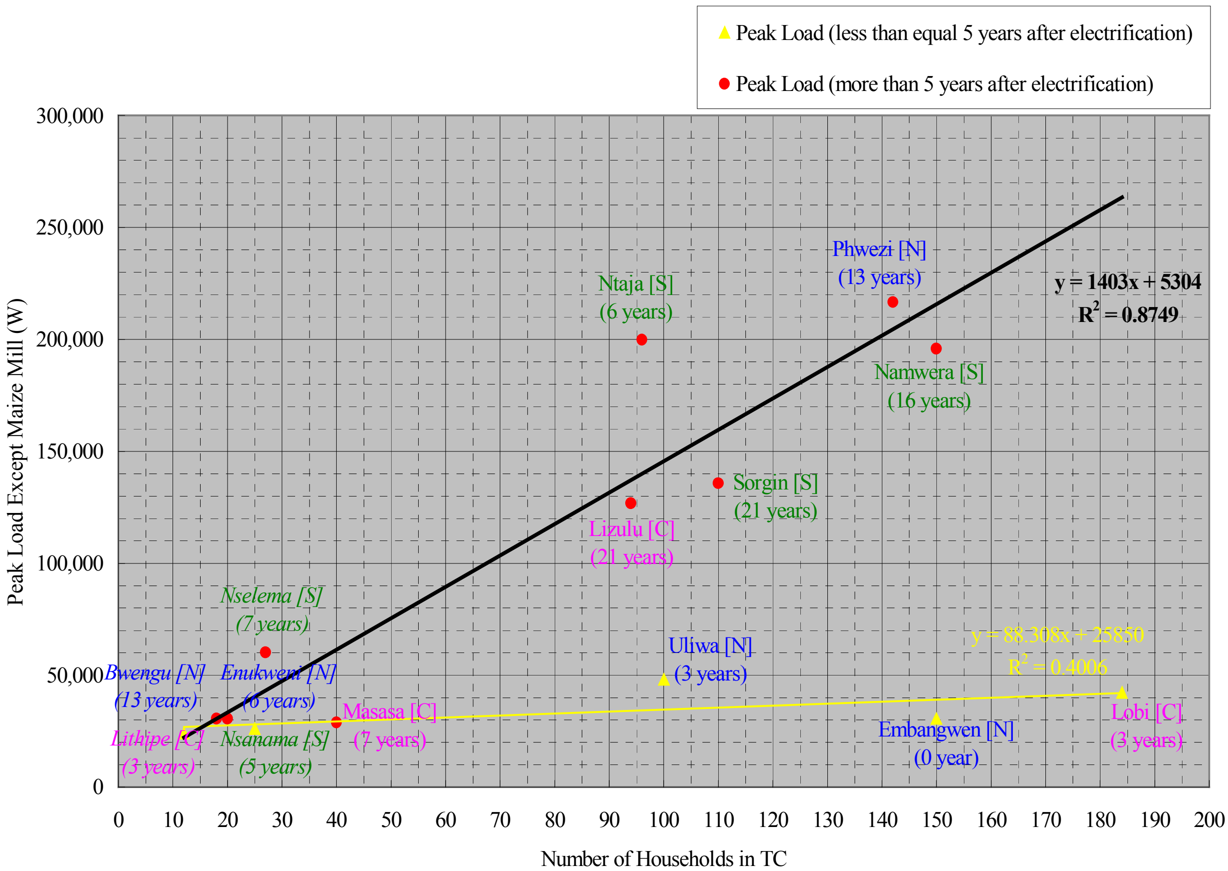


Fig. 8-7-3-1 Linear Regression Model for Peak Demand except Maize Mills in Electrified TCs

8.7.3.2 Peak demand forecast model

By adding the electricity consumption of maize mills (which can be estimated by the data collected in the socio-economic survey), to the estimated demand found by using the simple regression model developed in the previous section 8.7.3.2, the total daily peak demand of each TC can be forecasted. Since the unitary capacity of maize mills is known (20 kW [= 20,000W] as explained in section 8.7.2.3), the total electricity consumption by maize mills in a TC can be estimated by multiplying the unitary capacity by the number of maize mills installed in the TC investigated in the socio-economic survey. Therefore, a peak demand forecast model as shown in Equation 8-3 can be developed by adding maize mills' consumption to Equation 8-2. A diversity factor was newly introduced in Equation 8-3. The reason for introducing this factor is to adjust the following discrepancies:

1) Electric appliances – such as refrigerators – are not always consuming electricity, even if they are turned on.
2) Actual usage of some electric appliances can often be much shorter than one hour, which is the minimum unit for recording the usage of each appliance in the socio-economic survey.
3) Even if the consumption of multiple electric appliances or multiple consumers is observed to coincide at a certain period of time, the actual electricity consumption time of each consumer is supposed to be distributed equally in that period.

In Japan, a research indicates that the diversity factor converges to a value of 0.5 (50%) for an area/building, which has more than 20 households, and this value is commonly used. Although there was no research available regarding the diversity factor in Malawi, tendencies of electricity consumption seemed to be same as those in Japan. The value of 0.5 was therefore adopted as the diversity factor for this study.

$$Y = (1{,}403X_1 + 5{,}304) \times D + 20{,}000X_2 \qquad \text{(Equation 8-3)}$$

Y : Daily Peak Demand in a TC (W)
X_1: Number of Households in a TC
X_2: Number of Maize Mills in a TC
D : Diversity Factor = 0.5 (50%)

8.7.3.3 Growth of the number of households in unelectrified TCs

By adopting the peak demand forecast model (Equation 8-3) developed in the previous section, the potential electricity demand of each unelectrified TC can be forecasted. As for the independent variable in that equation, the number of households in an unelectrified TC, data was made available by investigating results of the 1998 national population census. To forecast the potential demand at present (2001), therefore, the increased number of households 3 years after the census needs to be considered. Similarly, to predict the potential demand in each unelectrified TC every 5 years until 2021, an increase rate in the number of households for unelectrified TCs needs to be taken into account. A rate of 1.27% is adopted for the annual increase of the number of households, based on the actual records of the national censuses of 1987 and 1998. Equations 8-4 and 8-5 indicate how the number of households in each TC is forecasted between 2001 and 2021 by using the 1998 census data. Table 8-7-3-2 shows the forecasted results of the number of households in unelectrified TCs, which were identified as high priority TCs for electrification, every 5 years until 2021.

$$X_{1\,[2001]} = X_{1\,[1998]} \times (1+0.0127)^{3} \qquad \text{(Equation 8-4)}$$

$$X_{1\,[2001+n]} = X_{1\,[2001]} \times (1+0.0127)^{n} = X_{1\,[1998]} \times (1+0.0127)^{n+3} \qquad \text{(Equation 8-5)}$$

$X_{1\,[1998]}$: Number of Households in a TC in 1998 Census

$X_{1\,[2001]}$: Number of Households in a TC in 2001

$X_{1\,[2001+n]}$: Number of Households in a TC in "n" years after 2001

Table 8-7-3-2 Numbers of Households in Unelectrified TCs from 2001 to 2021

Area	District	Unelectrified TC	Number of Households					
			'98 Census	2001	2006	2011	2016	2021
Northern	Chitipa	Nthalire	280	291	310	330	351	374
	Chitipa	Lupita	277	288	306	326	348	370
	Karonga	Kibwe	341	354	377	402	428	456
	Karonga	Pusi	249	259	275	293	313	333
	Rumphi	Katowo	207	215	229	244	260	277
	Rumphi	Chitimba	18	19	20	21	23	24
	Nkhata Bay	Mpamba	77	80	85	91	97	103
	Nkhata Bay	Kavuzi	142	147	157	167	178	190
	Mzimba	Edingeni	5	5	6	6	6	7
	Mzimba	Euthini	221	230	244	260	277	295
	Likoma	Likoma	150	156	166	177	188	201
	Likoma	Chizumulu	275	286	304	324	345	368
Central	Kasungu	Chamama	42	44	46	49	53	56
	Kasungu	Chulu	-	-	-	-	-	-
	Nkhotakota	Mkaika	365	379	404	430	458	488
	Nkhotakota	Dwambazi	285	296	315	336	358	381
	Ntchisi	Nthesa	8	8	9	9	10	11
	Ntchisi	Khuwi	50	52	55	59	63	67
	Dowa	Thambwe	127	132	140	150	159	170
	Dowa	Nambuma	299	311	331	352	375	400
	Dowa	Chikuse	65	68	72	77	82	87
	Salima	Kandulu	118	123	131	139	148	158
	Salima	Chilambula	43	45	48	51	54	57
	Lilongwe	Chilobwe	239	248	264	282	300	319
	Lilongwe	Nyanja	39	41	43	46	49	52
	Mchinji	Mkanda	160	166	177	189	201	214
	Mchinji	Chiosya	115	119	127	136	144	154
	Dedza	Kabwazi	32	33	35	38	40	43
	Dedza	Golomoti	30	31	33	35	38	40
	Ntcheu	Kandeu	73	76	81	86	92	98
	Ntcheu	Sharpvalle	400	415	442	471	502	535
Southern	Mangochi	Makanjira	200	208	221	236	251	267
	Mangochi	Chilipa	10	10	11	12	13	13
	Machinga	Chikwewu	290	301	321	342	364	388
	Machinga	Nampeya	339	352	375	399	425	453
	Balaka	Chendausiku	200	208	221	236	251	267
	Balaka	Kwitanda	49	51	54	58	61	66
	Zomba	Jenale	23	24	25	27	29	31
	Zomba	Sunuzi	100	104	111	118	126	134
	Chiradzulu	Milepa	21	22	23	25	26	28
	Chiradzulu	Ndunde	30	31	33	35	38	40
	Blantyre	Chikuli	94	98	104	111	118	126
	Blantyre	Mombo	15	16	17	18	19	20
	Mwanza	Thambani	160	166	177	189	201	214
	Mwanza	Lisungwi	102	106	113	120	128	136
	Thyolo	Nansadi	226	235	250	266	284	302
	Thyolo	Fifite	100	104	111	118	126	134
	Mulanje	Chinyama	100	104	111	118	126	134
	Mulanje	Nanthombozi	66	69	73	78	83	88
	Phalombe	Chilinga	17	18	19	20	21	23
	Phalombe	Mlomba	80	83	88	94	100	107
	Chikwawa	Chapananga	195	203	216	230	245	261
	Chikwawa	Livunzu	11	11	12	13	14	15
	Nsanje	Tengani	300	312	332	353	377	401
	Nsanje	Mankhokwe	127	132	140	150	159	170
	Nsanje	Marka	280	291	310	330	351	374
Average			143.0	148.6	158	169	180	191

8.7.3.4 Escalation of the number of maize mills

In order to forecast the potential demand in unelectrified TCs every 5 years until 2021 by using the Equation 8-3, an increase in the number of maize mills (the independent variable X_2) needs to be taken into account, as well as the number of households as explained in the previous section. The results of the socio-economic survey indicated that one maize mill provides services to an average of 30.5 households in electrified TCs, while it provides services to an average of 78.2 households in unelectrified TCs[5], as shown in Tables 8-7-3-3 and 8-7-3-4, respectively. This means that although one maize mill was installed for an average of every 78.2 households before a TC was electrified, the number of mills increased to an average of one mill for every 30.5 households after the TC became electrified. Equation 8-6, which was formulated using these average values, forecasts the number of maize mills from 2001 to 2021. Table 8-7-3-5 shows these forecasted results for unelectrified TCs, which were identified as high priority TCs for electrification, every 5 years from 2001 to 2021.

$$X_{2\,[2001+n]} = X_{2\,[2001]} + (X_{1\,[2001+n]} - X_{1\,[2001]})/MME \qquad \text{(Equation 8-6)}$$

$X_{2\,[2001+n]}$: Number of Maize Mills in a TC in "n" years after 2001
$X_{2\,[2001]}$: Number of Maize Mills in a TC obtained by the Socio-economic Survey in 2001
$X_{1\,[2001+n]}$: Number of Households in a TC in "n" years after 2001
$X_{1\,[2001]}$: Number of Households in a TC in 2001

MME : Average Numbers of Customers per Maize Mill in Electrified TCs = 30.5 HH/MM

[5] Although there is no significant correlation between the scale of TCs and the number of maize mills installed, as stated in Section 8.7.3.1, it was confirmed that the service ratio of households per maize mill in the electrified and unelectrified TCs was definitely different by a 95% of significance level. Therefore, to determine the increase rate of maize mills in a TC after electrification, it was decided to use the average service ratio of households per maize mill obtained from electrified TCs in the socio-economic survey.

Table 8-7-3-3 Numbers of Maize Mills in Electrified TCs

Trading Center	District	Region	# of HH in TC	# of Maize Mills in TC	# of HH per Maize Mill
Uliwa	Karonga	N	100	3	33
Phwezi	Rumphi	N	142	1	142
Bwengu	Mzimba	N	18	2	9
Enukweni	Mzimba	N	20	3	7
Embangweni	Mzimba	N	150	4	38
Lithipe	Dedza	C	12	3	4
Lobi	Dedza	C	184	3	61
Lizulu	Ntcheu	C	94	4	24
Masasa	Ntcheu	C	40	2	20
Nsanama	Machinga	S	25	11	2
Sorgin	Nsanje	S	110	12	9
Namwera	Mangochi	S	150	3	50
Nselema	Machinga	S	27	6	5
Ntaja	Machinga	S	96	4	24
Average			83.4	4.4	30.5

Table 8-7-3-4 Numbers of Maize Mills in Unelectrified TCs

Trading Center	District	Region	# of HH in TC	# of Maize Mills in TC	# of HH per Maize Mill
Nthalire	Chitipa	N	280	3	93
Lupita	Chitipa	N	277	3	92
Kibwe	Karonga	N	341	0	-
Pusi	Karonga	N	249	4	62
Katowo	Rumphi	N	207	3	69
Chitimba	Rumphi	N	18	0	-
Mpamba	Nkhata Bay	N	77	1	77
Kavuzi	Nkhata Bay	N	142	1	142
Edingeni	Mzimba	N	5	1	5
Euthini	Mzimba	N	221	5	44
Likoma	Likoma	N	150	2	75
Chamama	Kasungu	N	42	5	8
Mkaika	Nkhotakota	C	365	4	91
Dwambazi	Nkhotakota	C	285	1	285
Nthesa	Ntchisi	C	8	2	4
Khuwi	Ntchisi	C	50	1	50
Thambwe	Dowa	C	127	0	-
Nambuma	Dowa	C	299	4	75
Chikuse	Dowa	C	65	1	65
Kandulu	Salima	C	118	1	118
Chilambula	Salima	C	43	0	-
Chilobwe	Lilongwe	C	239	2	120
Mkanda	Mchinji	C	160	4	40
Chiosya	Mchinji	C	115	3	38
Kabwazi	Dedza	C	32	1	32
Golomoti	Dedza	C	30	4	8
Kandeu	Ntcheu	C	73	1	73
Sharpvalle	Ntcheu	C	400	3	133
Makanjira	Mangochi	S	200	9	22
Chilipa	Mangochi	S	10	1	10
Chikwewu	Machinga	S	290	2	145
Nampeya	Machinga	S	339	1	339
Chendausiku	Balaka	S	200	1	200
Kwitanda	Balaka	S	49	0	-
Jenale	Zomba	S	23	2	12
Sunuzi	Zomba	S	100	0	-
Milepa	Chiradzulu	S	21	2	11
Ndunde	Chiradzulu	S	30	1	30
Chikuli	Blantyre	S	94	0	-
Mombo	Blantyre	S	15	0	-
Thambani	Mwanza	S	160	2	80
Lisungwi	Mwanza	S	102	1	102
Nansadi	Thyolo	S	226	0	-
Fifite	Thyolo	S	100	2	50
Chinyama	Mulanje	S	100	1	100
Nanthombozi	Mulanje	S	66	2	33
Chilinga	Phalombe	S	17	3	6
Mlomba	Phalombe	S	80	2	40
Tengani	Nsanje	S	300	2	150
Average			141.6	1.9	78.2

Table 8-7-3-5 Forecasted Numbers of Maize Mills in Unelectrified TCs from 2001 to 2021

Area	District	Unelectrified TC	Number of Maize Mills				
			2001	2006	2011	2016	2021
Northern	Chitipa	Nthalire	3	4	4	5	6
	Chitipa	Lupita	3	4	4	5	6
	Karonga	Kibwe	0	1	2	2	3
	Karonga	Pusi	4	5	5	6	6
	Rumphi	Katowo	3	3	4	4	5
	Rumphi	Chitimba	0	0	0	0	0
	Nkhata Bay	Mpamba	1	1	1	2	2
	Nkhata Bay	Kavuzi	1	1	2	2	2
	Mzimba	Edingeni	1	1	1	1	1
	Mzimba	Euthini	5	5	6	7	7
	Likoma	Likoma	2	2	3	3	3
	Likoma	Chizumulu	1	2	2	3	4
Central	Kasungu	Chamama	5	5	5	5	5
	Kasungu	Chulu	-	-	-	-	-
	Nkhotakota	Mkaika	4	5	6	7	8
	Nkhotakota	Dwambazi	1	2	2	3	4
	Ntchisi	Nthesa	2	2	2	2	2
	Ntchisi	Khuwi	1	1	1	1	1
	Dowa	Thambwe	0	0	1	1	1
	Dowa	Nambuma	4	5	5	6	7
	Dowa	Chikuse	1	1	1	1	2
	Salima	Kandulu	1	1	2	2	2
	Salima	Chilambula	0	0	0	0	0
	Lilongwe	Chilobwe	2	3	3	4	4
	Lilongwe	Nyanja	1	1	1	1	1
	Mchinji	Mkanda	4	4	5	5	6
	Mchinji	Chiosya	3	3	4	4	4
	Dedza	Kabwazi	1	1	1	1	1
	Dedza	Golomoti	4	4	4	4	4
	Ntcheu	Kandeu	1	1	1	2	2
	Ntcheu	Sharpvalle	3	4	5	6	7
Southern	Mangochi	Makanjira	9	9	10	10	11
	Mangochi	Chilipa	1	1	1	1	1
	Machinga	Chikwewu	2	3	3	4	5
	Machinga	Nampeya	1	2	3	3	4
	Balaka	Chendausiku	1	1	2	2	3
	Balaka	Kwitanda	0	0	0	0	0
	Zomba	Jenale	2	2	2	2	2
	Zomba	Sunuzi	0	0	0	1	1
	Chiradzulu	Milepa	2	2	2	2	2
	Chiradzulu	Ndunde	1	1	1	1	1
	Blantyre	Chikuli	0	0	0	1	1
	Blantyre	Mombo	0	0	0	0	0
	Mwanza	Thambani	2	2	3	3	4
	Mwanza	Lisungwi	1	1	1	2	2
	Thyolo	Nansadi	0	1	1	2	2
	Thyolo	Fifite	2	2	2	3	3
	Mulanje	Chinyama	1	1	1	2	2
	Mulanje	Nanthombozi	2	2	2	2	3
	Phalombe	Chilinga	3	3	3	3	3
	Phalombe	Mlomba	2	2	2	3	3
	Chikwawa	Chapananga	3	3	4	4	5
	Chikwawa	Livunzu	1	1	1	1	1
	Nsanje	Tengani	2	3	3	4	5
	Nsanje	Mankhokwe	2	2	3	3	3
	Nsanje	Marka	4	5	5	6	7
Average			1.9	2	3	3	3

8.7.3.5 Final form of the peak demand forecast model

Equation 8-7 shows the final form of the peak demand forecast model for each TC "n" years after 2001. This model was formulated by including in Equation 8-3 an increase in both the number of households (Equation 8-5) and maize mills (Equation 8-6), as explained in section 8.7.3.2.

$$Y_{[2001+n]} = (1{,}403\ X_{1\ [2001+n]} + 5{,}304) \times D + 20{,}000\ X_{2\ [2001+n]} \qquad \text{(Equation 8-7)}$$

$Y_{[2001+n]}$: Forecasted Daily Peak Demand in a TC in "n" years after 2001 (W)
$X_{1\ [2001+n]}$: Number of Households in a TC in "n" years after 2001 (refer to Equation 8-5)
$X_{2\ [2001+n]}$: Number of Maize Mills in a TC in "n" years after 2001 (refer to Equation 8-6)
D : Diversity Factor = 0.5 (50%)

8.7.4 Forecast of Potential Demand for Unelectrified Trading Centers [Step 3]

Table 8-7-4-1 shows the results of the forecasted potential demand (for every 5 years from 2001 to 2021 using Equation 8-7 formulated in section 8.7.3.5) for 48 unelectrified TCs. These were selected as the two top prioritized TCs for electrification from each of the 27 districts – 54 TCs in total – excluding 6 TCs[6] nominated for REP Phase IV. Forecasted results for every 5 years from 2001 to 2021 are shown as bar graphs in Figures 3-7-4-1 to 3-7-4-5. In these graphs, forecasted demands for each type of consumer are shown as follows: a) public facilities (navy blue), b) business entities (dark red), c) households (yellow) and d) maize mills (light blue). The demand from maize mills in each unelectrified TC was calculated by the number of maize mills (forecasted by using Equation 8-6) multiplied by the unitary capacity of 20kW. The demand for the other three types of customer was calculated by dividing the total forecasted demand without the maize mills in the following proportions:

a) Public Facilities : 8.4%
b) Business Entities: 41.7%
c) Households : 49.9%

These proportions were average values obtained by analyzing the demand records in electrified TCs.

Predicted electric energy consumption (kWh/day)[7] data for 2021, based on forecasted potential demand for each unelectrified TC, is also shown in Table 8-7-4-2.

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[6] Likoma, Chizumulu (Likoma District); Chulu (Kasungu District); Nambuma (Dowa District); Lisungwi (Mwanza District) and Chapananga (Chikwawa District)

[7] The detailed method used to calculate the electric energy consumption is explained in Section 4-3-3 of the Rural Electrification Manual.

Table 8-7-4-1 Forecasted Peak Demand for Prioritized Unelectrified TCs from 2001 to 2021

Area	District	Unelectrified TC	TC's Forecasted Peak Demand (W)				
			2001	2006	2011	2016	2021
Northern	Chitipa	Nthalire	266,651	299,938	314,091	349,165	385,222
	Chitipa	Lupita	264,465	297,610	311,611	346,524	382,408
	Karonga	Kibwe	251,094	287,276	324,511	342,870	382,424
	Karonga	Pusi	264,065	295,882	308,467	341,873	356,151
	Rumphi	Katowo	213,466	223,289	253,751	264,896	296,766
	Rumphi	Chitimba	15,766	16,620	17,530	18,499	19,531
	Nkhata Bay	Mpamba	78,752	82,406	86,298	110,443	114,859
	Nkhata Bay	Kavuzi	126,109	132,847	160,025	167,669	175,812
	Mzimba	Edingeni	26,295	26,532	26,785	27,054	27,341
	Mzimba	Euthini	263,666	274,153	305,323	337,221	349,894
Central	Kasungu	Chamama	133,252	135,245	137,368	139,629	142,037
	Nkhotakota	Mkaika	348,579	385,900	424,349	464,000	504,930
	Nkhotakota	Dwambazi	230,294	263,818	278,224	313,567	349,910
	Ntchisi	Nthesa	48,481	48,860	49,265	49,695	50,154
	Ntchisi	Khuwi	59,080	61,453	63,980	66,672	69,539
	Dowa	Thambwe	95,180	101,207	127,626	134,463	141,746
	Salima	Kandulu	108,623	114,223	140,187	146,540	153,306
	Salima	Chilambula	33,980	36,021	38,194	40,509	42,975
	Lilongwe	Chilobwe	216,780	248,121	260,202	293,069	306,774
	Lilongwe	Nyanja	51,066	52,917	54,888	56,988	59,224
	Mchinji	Mkanda	199,223	206,816	234,903	243,517	272,692
	Mchinji	Chiosya	146,437	151,895	177,707	183,899	190,493
	Dedza	Kabwazi	45,966	47,485	49,102	50,825	52,660
	Dedza	Golomoti	104,509	105,933	107,449	109,064	110,784
	Ntcheu	Kandeu	75,837	79,302	82,991	106,922	111,108
	Ntcheu	Sharpvalle	354,079	393,061	433,279	474,814	517,751
Southern	Mangochi	Makanjira	328,366	337,856	367,965	378,733	410,202
	Mangochi	Chilipa	29,938	30,412	30,918	31,456	32,029
	Machinga	Chikwewu	253,937	287,698	302,357	337,969	374,599
	Machinga	Nampeya	269,637	305,724	342,858	361,109	400,549
	Balaka	Chendausiku	168,366	177,856	207,965	218,733	250,202
	Balaka	Kwitanda	38,352	40,677	43,154	45,792	48,602
	Zomba	Jenale	59,409	60,501	61,663	62,901	64,220
	Zomba	Sunuzi	75,509	80,254	85,309	110,692	116,427
	Chiradzulu	Milepa	57,952	58,948	60,010	61,140	62,345
	Chiradzulu	Ndunde	44,509	45,933	47,449	49,064	50,784
	Blantyre	Chikuli	71,137	75,598	80,349	105,410	110,800
	Blantyre	Mombo	13,581	14,292	15,051	15,858	16,718
	Mwanza	Thambani	159,223	166,816	194,903	203,517	232,692
	Thyolo	Nansadi	167,308	198,033	209,456	241,623	254,583
	Thyolo	Fifite	115,509	120,254	125,309	150,692	156,427
	Mulanje	Chinyama	95,509	100,254	105,309	130,692	136,427
	Mulanje	Nanthombozi	90,737	93,869	97,205	100,759	124,543
	Phalombe	Chilinga	75,038	75,844	76,704	77,619	78,594
	Phalombe	Mlomba	100,937	104,734	108,777	133,084	137,672
	Chikwawa	Livunzu	30,666	31,188	31,744	32,336	32,967
	Nsanje	Tengani	261,222	295,459	310,622	346,773	383,977
	Nsanje	Mankhokwe	135,180	141,207	167,626	174,463	181,746
Average			142,813	157,651	171,063	186,764	202,239

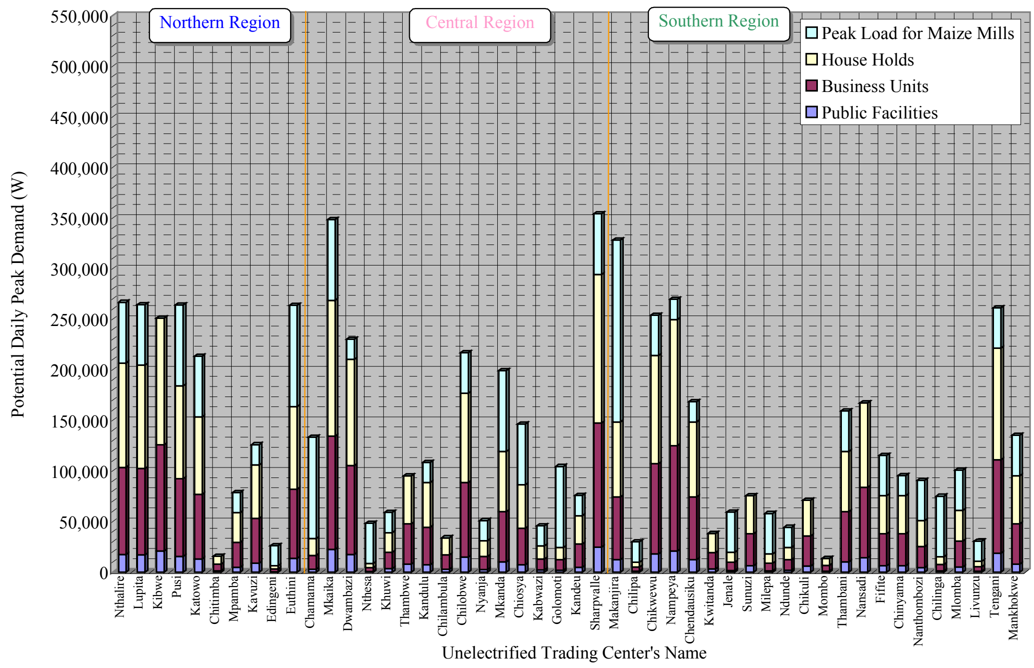


Fig. 8-7-4-1 Potential Daily Peak Demand in Unelectrified TCs in 2001

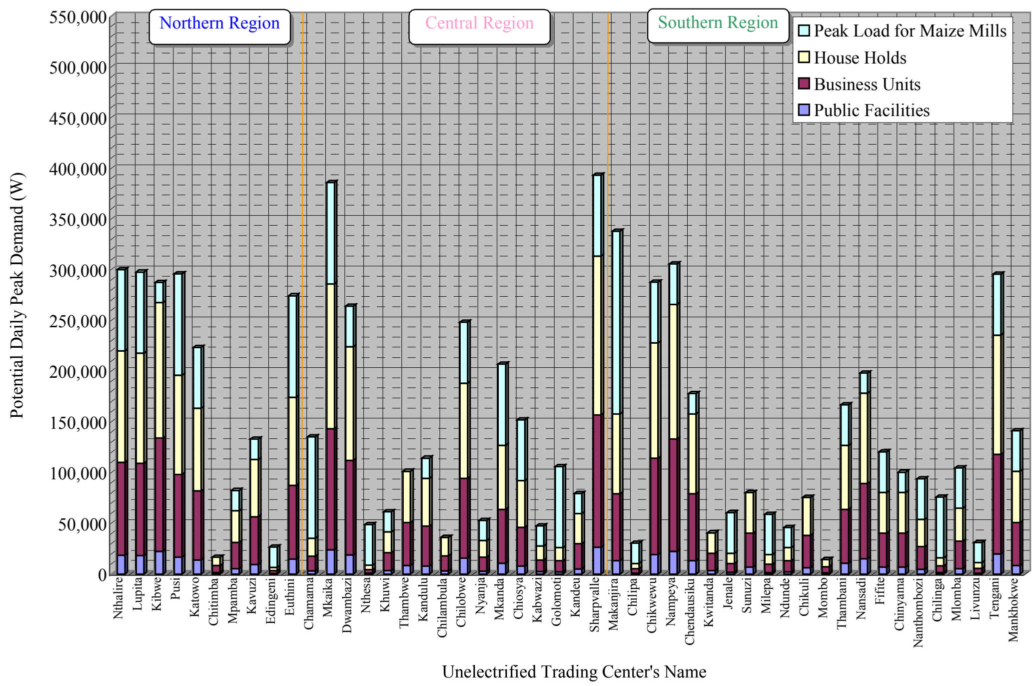


Fig. 8-7-4-2 Potential Daily Peak Demand in Unelectrified TCs in 2006

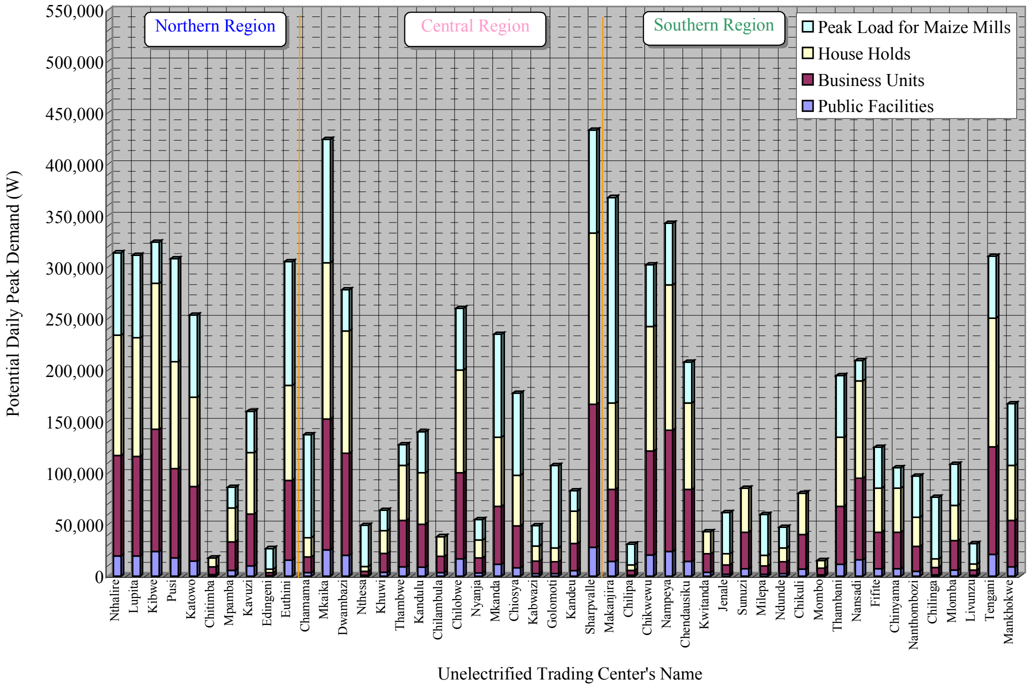


Fig. 8-7-4-3 Potential Daily Peak Demand in Unelectrified TCs in 2011

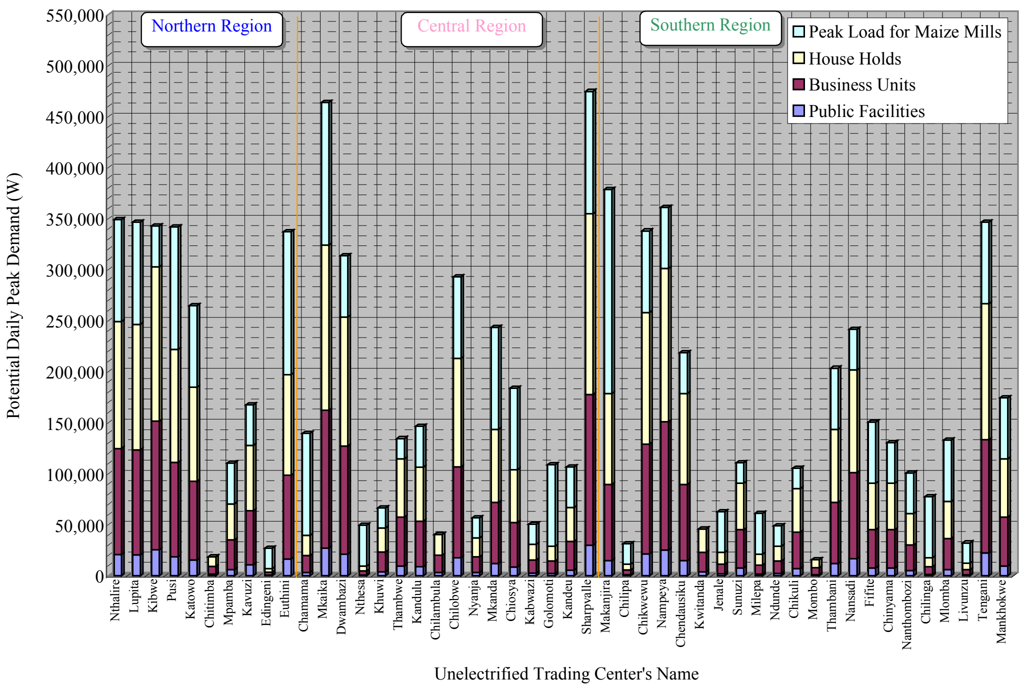


Fig. 8-7-4-4 Potential Daily Peak Demand in Unelectrified TCs in 2016

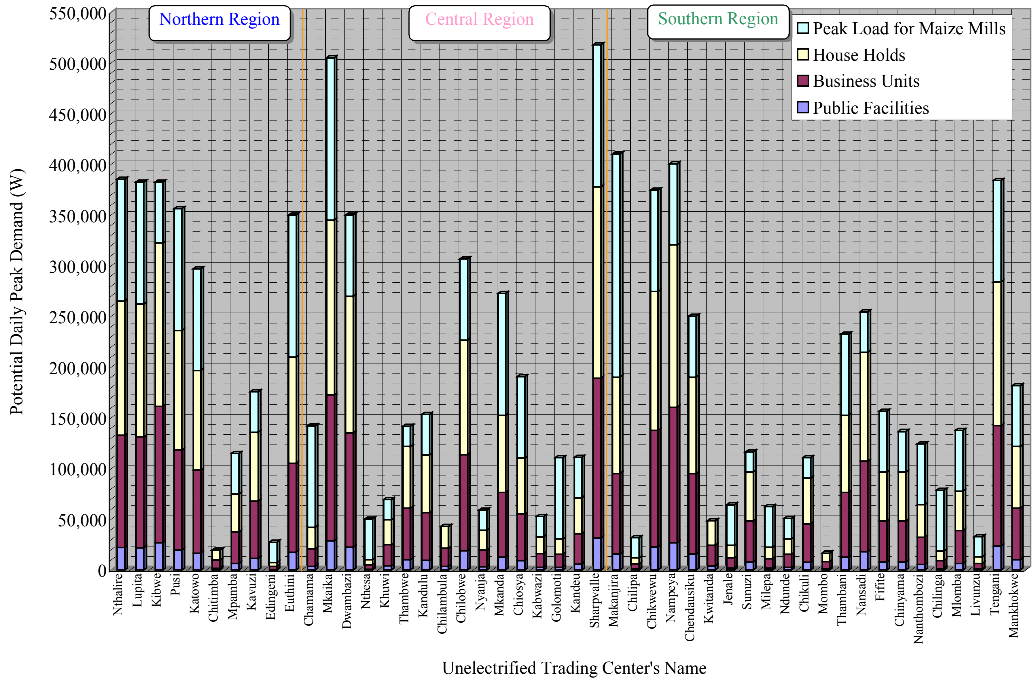


Fig. 8-7-4-5 Potential Daily Peak Demand in Unelectrified TCs in 2021

Table 8-7-4-2 Forecasted Electric Energy Consumption [kWh/day] for Unelectrified TCs in 2021 (1/2)

Trading Center	District	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	Total [kWh/day]
Nthalire	Chitipa	76.4	77.1	76.4	73.5	84.5	209.6	326.3	325.7	317.8	309.8	309.4	307.8	300.1	299.7	300.9	301.4	307.4	349.2	287.1	172.3	151.1	132.2	102.6	86.9	5,285
Lupita	Chitipa	75.9	76.6	75.8	73.0	83.9	208.1	323.9	323.3	315.5	307.5	307.1	305.5	297.9	297.5	298.7	299.2	305.1	346.7	285.0	171.0	150.0	131.2	101.9	86.3	5,247
Kibwe	Karonga	75.9	76.6	75.8	73.0	83.9	208.1	323.9	323.3	315.5	307.6	307.2	305.5	297.9	297.5	298.7	299.2	305.2	346.7	285.0	171.0	150.0	131.2	101.9	86.3	5,247
Pusi	Karonga	70.7	71.3	70.6	67.9	78.1	193.8	301.7	301.1	293.9	286.4	286.0	284.5	277.4	277.1	278.2	278.6	284.2	322.9	265.4	159.3	139.7	122.2	94.9	80.3	4,886
Katowo	Rumphi	58.9	59.4	58.8	56.6	65.1	161.5	251.4	250.9	244.9	238.7	238.4	237.1	231.2	230.9	231.8	232.2	236.8	269.1	221.2	132.7	116.4	101.8	79.1	66.9	4,072
Chitimba	Rumphi	3.9	3.9	3.9	3.7	4.3	10.6	16.5	16.5	16.1	15.7	15.7	15.6	15.2	15.2	15.3	15.3	15.6	17.7	14.6	8.7	7.7	6.7	5.2	4.4	268
Mpamba	Nkhata Bay	22.8	23.0	22.8	21.9	25.2	62.5	97.3	97.1	94.8	92.4	92.3	91.8	89.5	89.4	89.7	89.9	91.7	104.1	85.6	51.4	45.1	39.4	30.6	25.9	1,576
Kavuzi	Nkhata Bay	34.9	35.2	34.8	33.5	38.6	95.7	148.9	148.6	145.1	141.4	141.2	140.5	137.0	136.8	137.3	137.5	140.3	159.4	131.0	78.6	69.0	60.3	46.8	39.7	2,412
Edingeni	Mzimba	5.4	5.5	5.4	5.2	6.0	14.9	23.2	23.1	22.6	22.0	22.0	21.8	21.3	21.3	21.4	21.4	21.8	24.8	20.4	12.2	10.7	9.4	7.3	6.2	375
Euthini	Mzimba	69.4	70.1	69.4	66.8	76.7	190.4	296.4	295.8	288.7	281.4	281.0	279.5	272.6	272.2	273.3	273.7	279.2	317.2	260.7	156.5	137.3	120.1	93.2	78.9	4,800
Chamama	Kasungu	28.2	28.4	28.2	27.1	31.2	77.3	120.3	120.1	117.2	114.2	114.1	113.5	110.6	110.5	110.9	111.1	113.3	128.8	105.8	63.5	55.7	48.7	37.8	32.0	1,949
Mkaika	Nkhotakota	100.2	101.1	100.1	96.3	110.7	274.7	427.7	426.9	416.6	406.1	405.5	403.4	393.3	392.8	394.4	395.0	402.9	457.8	376.3	225.8	198.1	173.3	134.5	113.9	6,928
Dwambazi	Nkhotakota	69.4	70.1	69.4	66.8	76.7	190.4	296.4	295.8	288.7	281.4	281.0	279.6	272.6	272.2	273.3	273.8	279.2	317.2	260.8	156.5	137.3	120.1	93.2	78.9	4,801
Nthesa	Ntchisi	10.0	10.0	9.9	9.6	11.0	27.3	42.5	42.4	41.4	40.3	40.3	40.1	39.1	39.0	39.2	39.2	40.0	45.5	37.4	22.4	19.7	17.2	13.4	11.3	688
Khuwi	Ntchisi	13.8	13.9	13.8	13.3	15.3	37.8	58.9	58.8	57.4	55.9	55.9	55.6	54.2	54.1	54.3	54.4	55.5	63.0	51.8	31.1	27.3	23.9	18.5	15.7	954
Thambwe	Dowa	28.1	28.4	28.1	27.0	31.1	77.1	120.1	119.8	117.0	114.0	113.8	113.2	110.4	110.3	110.7	110.9	113.1	128.5	105.6	63.4	55.6	48.6	37.8	32.0	1,945
Kandulu	Salima	30.4	30.7	30.4	29.2	33.6	83.4	129.8	129.6	126.5	123.3	123.1	122.5	119.4	119.3	119.8	119.9	122.3	139.0	114.2	68.6	60.1	52.6	40.8	34.6	2,103
Chilambula	Salima	8.5	8.6	8.5	8.2	9.4	23.4	36.4	36.3	35.5	34.6	34.5	34.3	33.5	33.4	33.6	33.6	34.3	39.0	32.0	19.2	16.9	14.7	11.4	9.7	590
Chilobwe	Lilongwe	60.9	61.4	60.8	58.5	67.3	166.9	259.8	259.4	253.1	246.7	246.4	245.1	239.0	238.7	239.6	240.0	244.8	278.1	228.6	137.2	120.3	105.3	81.7	69.2	4,209
Nyanja	Lilongwe	11.8	11.9	11.7	11.3	13.0	32.2	50.2	50.1	48.9	47.6	47.6	47.3	46.1	46.1	46.3	46.3	47.3	53.7	44.1	26.5	23.2	20.3	15.8	13.4	813
Mkanda	Mchinji	54.1	54.6	54.1	52.0	59.8	148.4	231.0	230.5	225.0	219.3	219.0	217.9	212.4	212.1	213.0	213.3	217.6	247.2	203.2	122.0	107.0	93.6	72.6	61.5	3,741
Chiosya	Mchinji	37.8	38.1	37.8	36.3	41.8	103.6	161.3	161.1	157.2	153.2	153.0	152.2	148.4	148.2	148.8	149.0	152.0	172.7	142.0	85.2	74.7	65.4	50.7	43.0	2,614
Kabwazi	Dedza	10.4	10.5	10.4	10.0	11.5	28.7	44.6	44.5	43.5	42.4	42.3	42.1	41.0	41.0	41.1	41.2	42.0	47.7	39.2	23.6	20.7	18.1	14.0	11.9	722
Golomoti	Dedza	22.0	22.2	22.0	21.1	24.3	60.3	93.8	93.7	91.4	89.1	89.0	88.5	86.3	86.2	86.5	86.7	88.4	100.4	82.6	49.5	43.5	38.0	29.5	25.0	1,520

Table 8-7-4-2 Forecasted Electric Energy Consumption [kWh/day] for Unelectrified TCs in 2021 (2/2)

Trading Center	District	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	Total [kWh/day]
Kandeu	Ntcheu	22.0	22.2	22.0	21.2	24.4	60.5	94.1	93.9	91.7	89.4	89.2	88.8	86.6	86.4	86.8	86.9	88.7	100.7	82.8	49.7	43.6	38.1	29.6	25.1	1,524
Sharpvalle	Ntcheu	102.7	103.7	102.6	98.8	113.5	281.7	438.5	437.7	427.2	416.4	415.8	413.7	403.3	402.8	404.4	405.1	413.1	469.4	385.8	231.6	203.1	177.7	137.9	116.8	7,103
Makanjira	Mangochi	81.4	82.1	81.3	78.3	90.0	223.2	347.4	346.8	338.5	329.9	329.5	327.7	319.5	319.1	320.4	320.9	327.3	371.9	305.7	183.5	160.9	140.8	109.3	92.5	5,628
Chilipa	Mangochi	6.4	6.4	6.3	6.1	7.0	17.4	27.1	27.1	26.4	25.8	25.7	25.6	25.0	24.9	25.0	25.1	25.6	29.0	23.9	14.3	12.6	11.0	8.5	7.2	439
Chikwewu	Machinga	74.3	75.0	74.2	71.5	82.2	203.8	317.3	316.7	309.1	301.3	300.9	299.3	291.8	291.4	292.6	293.1	298.9	339.6	279.2	167.5	147.0	128.5	99.8	84.5	5,139
Nampeya	Machinga	79.5	80.2	79.4	76.4	87.8	217.9	339.3	338.6	330.5	322.1	321.7	320.0	312.0	311.6	312.9	313.4	319.6	363.1	298.5	179.1	157.1	137.5	106.7	90.4	5,495
Chendausiku	Balaka	49.6	50.1	49.6	47.7	54.9	136.1	211.9	211.5	206.4	201.2	201.0	199.9	194.9	194.6	195.4	195.7	199.6	226.8	186.5	111.9	98.2	85.9	66.7	56.4	3,433
Kwitanda	Balaka	9.6	9.7	9.6	9.3	10.7	26.4	41.2	41.1	40.1	39.1	39.0	38.8	37.9	37.8	38.0	38.0	38.8	44.1	36.2	21.7	19.1	16.7	12.9	11.0	667
Jenale	Zomba	12.7	12.9	12.7	12.3	14.1	34.9	54.4	54.3	53.0	51.6	51.6	51.3	50.0	50.0	50.2	50.2	51.2	58.2	47.9	28.7	25.2	22.0	17.1	14.5	881
Sunuzi	Zomba	23.1	23.3	23.1	22.2	25.5	63.3	98.6	98.4	96.1	93.6	93.5	93.0	90.7	90.6	90.9	91.1	92.9	105.6	86.8	52.1	45.7	40.0	31.0	26.3	1,597
Milepa	Chiradzulu	12.4	12.5	12.4	11.9	13.7	33.9	52.8	52.7	51.4	50.1	50.1	49.8	48.6	48.5	48.7	48.8	49.7	56.5	46.5	27.9	24.5	21.4	16.6	14.1	855
Ndunde	Chiradzulu	10.1	10.2	10.1	9.7	11.1	27.6	43.0	42.9	41.9	40.8	40.8	40.6	39.6	39.5	39.7	39.7	40.5	46.0	37.8	22.7	19.9	17.4	13.5	11.5	697
Chikuli	Blantyre	22.0	22.2	22.0	21.1	24.3	60.3	93.8	93.7	91.4	89.1	89.0	88.5	86.3	86.2	86.5	86.7	88.4	100.5	82.6	49.6	43.5	38.0	29.5	25.0	1,520
Mombo	Blantyre	3.3	3.3	3.3	3.2	3.7	9.1	14.2	14.1	13.8	13.4	13.4	13.4	13.0	13.0	13.1	13.1	13.3	15.2	12.5	7.5	6.6	5.7	4.5	3.8	229
Thambani	Mwanza	46.2	46.6	46.1	44.4	51.0	126.6	197.1	196.7	192.0	187.1	186.9	185.9	181.3	181.0	181.8	182.0	185.7	211.0	173.4	104.1	91.3	79.9	62.0	52.5	3,192
Nansadi	Thyolo	50.5	51.0	50.5	48.6	55.8	138.5	215.6	215.2	210.1	204.7	204.5	203.4	198.3	198.1	198.9	199.2	203.1	230.8	189.7	113.9	99.9	87.4	67.8	57.4	3,493
Fifite	Thyolo	31.0	31.3	31.0	29.8	34.3	85.1	132.5	132.2	129.1	125.8	125.6	125.0	121.9	121.7	122.2	122.4	124.8	141.8	116.6	70.0	61.4	53.7	41.7	35.3	2,146
Chinyama	Mulanje	27.1	27.3	27.0	26.0	29.9	74.2	115.6	115.3	112.6	109.7	109.6	109.0	106.3	106.1	106.6	106.7	108.9	123.7	101.7	61.0	53.5	46.8	36.3	30.8	1,872
Nanthombozi	Mulanje	24.7	24.9	24.7	23.8	27.3	67.8	105.5	105.3	102.8	100.2	100.0	99.5	97.0	96.9	97.3	97.4	99.4	112.9	92.8	55.7	48.9	42.7	33.2	28.1	1,709
Chilinga	Phalombe	15.6	15.7	15.6	15.0	17.2	42.8	66.6	66.4	64.8	63.2	63.1	62.8	61.2	61.1	61.4	61.5	62.7	71.3	58.6	35.1	30.8	27.0	20.9	17.7	1,078
Mlomba	Phalombe	27.3	27.6	27.3	26.3	30.2	74.9	116.6	116.4	113.6	110.7	110.6	110.0	107.2	107.1	107.5	107.7	109.9	124.8	102.6	61.6	54.0	47.2	36.7	31.1	1,889
Livunzu	Chikwawa	6.5	6.6	6.5	6.3	7.2	17.9	27.9	27.9	27.2	26.5	26.5	26.3	25.7	25.6	25.8	25.8	26.3	29.9	24.6	14.7	12.9	11.3	8.8	7.4	452
Tengani	Nsanje	76.2	76.9	76.1	73.3	84.2	208.9	325.2	324.6	316.8	308.8	308.4	306.8	299.1	298.7	299.9	300.4	306.4	348.1	286.1	171.7	150.6	131.8	102.3	86.6	5,268
Mankhokwe	Nsanje	36.1	36.4	36.0	34.7	39.9	98.9	153.9	153.7	150.0	146.2	146.0	145.2	141.6	141.4	142.0	142.2	145.0	164.8	135.4	81.3	71.3	62.4	48.4	41.0	2,494

8.8 Social Aspects Evaluation: Ability and Willingness to Pay

With regard to the initial costs (such as connection fee, in-house wiring cost in order to receive electricity from ESCOM and monthly tariffs), the actual amounts that customers – both households and business entities – paid or are paying were investigated at the electrified TCs in the socio-economic survey. In unelectrified TCs, willingness to pay for the initial costs was investigated for unelectrified households and business entities. Significance of the difference between the willingness to pay and the actual paid amount of initial costs was statistically analyzed.

Both willingness to pay and ability to pay for a sustainable monthly tariff were also estimated by through statistical analysis for each of the following three groups of data collected in the survey:

1) Monthly income per each of the categories: electrified households, unelectrified households, electrified business entities and unelectrified business entities.
2) Monthly electricity tariffs actually paid or being paid by electrified customers, and the willing to pay by potential customers in unelectrified TCs
3) Ratio of the monthly tariffs actually paid or being paid to the monthly income of electrified customers, and the ratio of monthly tariffs willing to be paid to the monthly income of potential customers in unelectrified TCs

This analysis will determine whether these TCs had been left unelectrified even though potential customers have financial capability to pay for electricity or whether this was because potential customers cannot afford to pay for electricity.

8.8.1 Correlation of variables expected to affect the implementation of rural electrification

Analysis of data collected from the survey identified strong correlations between variables. These variables are arranged in two groups as follows:

[Group 1]: Economic Conditions of both Present and Potential Customers

1) Monthly income
2) Total savings
3) Total monthly sales
4) Maximum amount willing to pay for ESCOM connection fee and in-house wiring cost (only answers of more than MK0)

Note: Interviewees answered items 1) to 4) numerically.

[Group 2]: Interest in Electrification

5) Interest in ESCOM connection (have interest/no interest)
6) Willingness to pay monthly tariff to ESCOM (have/don't have)
7) Capability of paying ESCOM connection fee and in-house wiring cost (have/don't have)

Note: Interviewees answered items 5) to 7) from two choices.

Correlations for a total of eight variables, including the additional variable shown below added to the previously introduced seven variables, are shown in Table 8-8-1-1.

8) Maximum amount willing to pay for monthly electricity tariffs (only answers of more than MK0)

The following tendencies can be observed in the correlation of variables shown in the table.

a) The higher monthly sales are, the higher the monthly income and total savings that are generated. As a result, the higher total monthly sales, monthly income and total savings are, the higher the amount customers are willing to pay for the ESCOM connection fee and in-house wiring cost (correlations between Group 1 variables).
b) Residents who are interested in connecting to ESCOM, tend to be willing to pay higher amounts for the ESCOM connection fee and in-house wiring cost (correlations between Group 2 variables).
c) Nonetheless, there is no tendency for residents who are more economically advantaged (with high total monthly sales, monthly income and total savings) to express more interest in connecting to ESCOM. In fact, the people who are most interested in electrification are not necessarily the people who can afford to pay for electricity (correlations between Group 1 and Group 2 variables).
d) Furthermore, neither capability of paying for electricity nor higher interest in electrification correlates very highly with willingness to pay the monthly tariff to ESCOM. In other words, it cannot be assumed that people who are highly interested in ESCOM connection are people earning enough to consistently pay electricity tariffs (correlation between added variable 8 and Group 1 & Group 2 variables).

From the perspective of making rural electrification projects sustainable, analysis regarding willingness/ability to pay for monthly electricity tariffs by potential customers in unelectrified TCs needs to be carried out in detail, as suggested from the tendencies shown above. Regarding potential customers' willingness to pay for ESCOM connection fees and in-house wiring costs, it was also considered necessary to determine how much of an obstacle expensive connection fees and wiring costs might be in the process of rural electrification, by comparing willingness to pay with the actual amount paid by electrified customers. In light of these conditions, detailed verifications were executed as explained in the following sections.

Table 8-8-1-1 Highly correlated variables among data collected in the survey

[Group 1]

	Monthly Income	Total Savings (inc. last month)	Monthly Total Sales Amount	Max. Amount of Willingness to Pay for ESCOM Connection and In-house Wiring [>0MK]	Max. Amount of Willingness to Pay for Monthly Electricity Charge [>0MK]	Interest for ESCOM Connection	Willingness to Pay for Monthly Tariff to ESCOM	Affordability for Connection and In-house Wiring
Monthly Income	1.00	**0.750**	**0.834**	**0.881**	0.156	0.003	0.030	0.031
Total Savings (inc. last month)	**0.750**	1.00	**0.676**	**0.731**	0.230	-0.043	0.004	0.009
Monthly Total Sales Amount	**0.834**	**0.676**	1.00	**0.787**	0.219	0.011	0.048	0.050
Max. Amount of Willingness to Pay for ESCOM Connection and In-house Wiring [>0MK]	**0.881**	**0.731**	**0.787**	1.00	0.268	0.023	0.013	0.038
Max. Amount of Willingness to Pay for Monthly Electricity Charge [>0MK]	0.156	0.230	0.219	0.268	1.00	0.013	0.006	0.060
Interest for ESCOM Connection	0.003	-0.043	0.011	0.023	0.013	1.00	**0.779**	**0.746**
Willingness to Pay for Monthly Tariff to ESCOM	0.030	0.004	0.048	0.013	0.006	**0.779**	1.00	**0.958**
Affordability for Connection and In-house Wiring	0.031	0.009	0.050	0.038	0.060	**0.746**	**0.958**	1.00

[Group 2]

8.8.2 Comparison of monthly income by electrification status and types of customer

Monthly income data collected for the socio-economic survey were arranged into four categories by electrification status (electrified or unelectrified) and by types of customer (households or business entities), as shown below. For each of these four categories, basic statistical analysis was executed and results are as indicated in Table 8-8-2-1.

a) Households' Monthly Income in Electrified TCs [Electrified Households' Monthly Income]

b) Households' Monthly Income in Unelectrified TCs [Unelectrified Households' Monthly Income]

c) Business Entities' Monthly Income in Electrified TCs [Electrified Business Entities' Monthly Income]

d) Business Entities' Monthly Income in Unelectrified TCs [Unelectrified Business Entities' Monthly Income]

Table 8-8-2-1 Summaries of Basic Statistics for Monthly Incomes in Four Categories

a) Households' Monthly Income in Electrified TCs Effective Sample Number: 59 Average: MK 17,020 (named "Electrified Households' Monthly Income" here in after) Standard Deviation: MK 26,538 Standard Error: MK 3,455 95% Confidence Interval: MK 10,104< <MK 23,935
b) Households' Monthly Income in Unelectrified TCs Effective Sample Number: 404 Average: MK 8,305 (named "Unelectrified Households' Monthly Income" here in after) Standard Deviation: MK 16,281 Standard Error: MK 810 95% Confidence Interval: MK 6,713< <MK 9,897
c) Business Entities' Monthly Income in Electrified TCs Effective Sample Number: 68 Average: MK 22,580 (named "Electrified Business Entities' Monthly Income" here in after) Standard Deviation: MK 32,039 Standard Error: MK 3,885 95% Confidence Interval: MK 14,825< <MK 30,336
d) Business Entities' Monthly Income in Unelectrified TCs Effective Sample Number: 316 Average: MK 23,618 (named "Unelectrified Business Entities' Monthly Income" here in after) Standard Deviation: MK 143,725 Standard Error: MK 8,085 95% Confidence Interval: MK 7,710< <MK 39,525

Table 8-8-2-2 shows results of null hypotheses tests with a significance level of 5% among those four categories. The following four points were clarified:

1) Monthly incomes are significantly different between electrified households and unelectrified households: the difference is MK 8,715 in average.
2) Monthly incomes are not significantly different between electrified business entities and unelectrified business entities.
3) In electrified TCs, monthly incomes are not significantly different between households and business entities.
4) In unelectrified TCs, monthly incomes are significantly different between households

and business entities: the difference is an average of MK 14,275.

Therefore, regarding monthly incomes, a rearrangement into the following two groups is possible: 1) unelectrified households and 2) the other three categories (electrified households, electrified business entities and unelectrified business entities). In other words, monthly incomes of unelectrified business entities are not significantly different from those of electrified business entities (or those of electrified households). Thus, by assuming that the unelectrified business entities are capable of expending an electrification tariff at the same amount as the electrified business entities expend due to the similarity of incomes, the electrification rate of business entities in a TC after extending ESCOM distribution lines can be expected to reach as at the same rate as in a presently electrified TC. Regarding monthly incomes of unelectrified households, it is noted that they differ significantly from those of electrified households (and also those of both electrified and unelectrified business entities).

Even though these unelectrified TCs were selected from each District with highly priority for electrification, financial difficulties were still identified. Worse economic conditions would be anticipated for unelectrified TCs with lower priority, which were not investigated in our survey. Therefore, careful considerations such as introducing some public policies to support households' electrification need to be developed as a matter of priority.

Table 8-8-2-2 Summaries of Null Hypotheses Tests' Results regarding Monthly Incomes in Four Categories

<Case 1-1: a) & b)> H_0: "Electrified Households' Monthly Income" is equal to "Unelectrified Households' Monthly Income" Test Result: Reject the Hypothesis H_0 with 95% Confidence. This means that households' monthly income in electrified TCs (MK 17,020) significantly differs from that in unelectrified TCs (MK 8,305), in average. Difference of Averages: MK 8,715
<Case 1-2: c) & d)> H_0: "Electrified Business Entities' Monthly Income" is equal to "Unelectrified Business Entities' Monthly Income" Test Result: Can't reject the Hypothesis H_0 with 95% Confidence. This means that business entities' monthly income in electrified TCs (MK 22,580) does not significantly differ from that in unelectrified TCs (MK 23,618), in average.
<Case 1-3: a) & c)> H_0: "Electrified Households' Monthly Income" is equal to "Electrified Business Entities' Monthly Income" Test Result: Can't reject the Hypothesis H_0 with 95% Confidence. This means that households' monthly income (MK 17,020) does not significantly differ from business entities' one (MK 22,580) in electrified TCs, in average.
<Case 1-4: b) & d)> H_0: "Unelectrified Households' Monthly Income" is equal to "Unelectrified Business Entities' Monthly Income" Test Result: Reject the Hypothesis H_0 with 95% Confidence. This means that households' monthly income (MK 8,305) significantly differs from business entities' one (MK 22,580) in unelectrified TCs, in average. Difference of Averages: MK 14,275

8.8.3 Willingness to pay for ESCOM connection fees and in-house wiring costs

Basic statistical analysis was conducted regarding the actual ESCOM connection fees amount and in-house wiring costs (named "connection costs" hereafter) paid by two categories of electrified customers (households and business entities). The analysis results are shown in Table 8-8-3-1.

Table 8-8-3-2 shows results of null hypotheses tests (H_0: "ESCOM Connection Costs Paid by Households" is equal to "ESCOM Connection Costs Paid by Business Entities") with a significance level of 5%. Findings indicated that the amount of connection costs actually paid were not significantly different between electrified households and business entities. Thus, basic statistics regarding connection costs were recalculated treating these as a single group. Table 8-8-3-3 summarizes the recalculated statistics.

Table 8-8-3-1 Summaries of Basic Statistics for ESCOM Connection Fee and In-house Wiring Costs Paid by each of Households and Business Entities

a) Costs Paid by Electrified Households for ESCOM Connection and In-house Wiring Effective Sample Number: 77 Average: MK 12,645 (named "ESCOM Connection Costs Paid by Households" here in after) Standard Deviation: MK 10,647 Standard Error: MK 1,213 95% Confidence Interval: MK 10,229< <MK 15,062
b) Costs Paid by Electrified Business Entities for ESCOM Connection and In-house Wiring Effective Sample Number: 77 Average: MK 11,081 (named "ESCOM Connection Costs Paid by Business Entities" here in after) Standard Deviation: MK 9,637 Standard Error: MK 1,098 95% Confidence Interval: MK 8,894< <MK 13,268

Table 8-8-3-2 Summary of Null Hypotheses Test's Result regarding ESCOM Connection Fee and In-house Wiring Costs Paid by each of Households and Business Entities

<Case 2-1: a) & b)> H_0: "ESCOM Connection Costs Paid by Households" is equal to "ESCOM Connection Costs Paid by Business Entities" Test Result: Can't reject the Hypothesis H_0 with 95% Confidence. This means that ESCOM connection and in-house wiring costs paid by households (MK 10,647) do not significantly differ from those paid by business entities (MK 11,081) in electrified TCs, in average.

Table 8-8-3-3 Summaries of Basic Statistics for ESCOM Connection Fee and In-house Wiring Costs Paid by both Households and Business Entities

c) Costs Paid by both Electrified Households and Business Entities for ESCOM Connection and In-house Wiring Effective Sample Number: 154 Average: MK 11,930 (named "ESCOM Connection Costs" here in after) Standard Deviation: MK 10,152 Standard Error: MK 820 95% Confidence Interval: MK 10,300< <MK 13,550

Following this, basic statistical analysis was carried out regarding willingness to pay for ESCOM connection fees and in-house wiring costs (named "willingness to pay for connection costs" hereafter) by unelectrified customers (arranged into two categories: households and business entities). In the analysis, only data from those willing to pay more than MK0 were taken into account. The analysis results are shown in Table 8-8-3-4.

Table 8-8-3-5 shows results of null hypotheses test (H_0: "Households' Willingness to Pay for ESCOM Connection [>MK0]" is equal to "Business Entities' Willingness to Pay for ESCOM Connection [>MK0]") with a significance level of 5%. Results indicated that the amount unelectrified households are willing to pay, and the amount business entities are willing to pay for connection costs were not significantly different. Thus, basic statistics regarding willingness to pay for connection costs were recalculated treating both of them as a single group. Table 8-8-3-6 summarizes the recalculated statistics.

Table 8-8-3-4 Summaries of Basic Statistics for Willingness to Pay for ESCOM Connection fee and In-house Wiring Cost by each of Households and Business Entities

d) Willingness to Pay for ESCOM Connection and In-house Wiring Costs by Households, Whom Want to Pay More than MK0, in Unelectrified TCs Effective Sample Number: 295 Average: MK 6,175 (named "Households' Willingness to Pay for ESCOM Connection [>MK0]" here in after) Standard Deviation: MK 10,261 Standard Error: MK 597 95% Confidence Interval: MK 4,989< <MK 7,350
e) Willingness to Pay for ESCOM Connection and In-house Wiring Costs by Business Entities, Whom Want to Pay More than MK0, in Unelectrified TCs Effective Sample Number: 298 Average: MK 9,812 (named "Business Entities' Willingness to Pay for ESCOM Connection [>MK0]" here in after) Standard Deviation: MK 30,265 Standard Error: MK 1,753 95% Confidence Interval: MK 6,362< <MK 13,262

Table 8-8-3-5 Summary of Null Hypotheses Test's Result regarding Willingness to Pay for ESCOM Connection fee and In-house Wiring Cost by each of Households and Business Entities

<Case 2-2: d) & e)> H_0: "Households' Willingness to Pay for ESCOM Connection [>MK0]" is equal to "Business Entities' Willingness to Pay for ESCOM Connection [>MK0]" Test Result: Can't reject the Hypothesis H_0 with 95% Confidence. This means that household' willingness to pay for ESCOM connection and in-house wiring, among which are more than MK0, (MK 6,175) does not significantly differ from business entities' one (MK 9,812) in electrified TCs, in average.

Table 8-8-3-6 Summaries of Basic Statistics for Willingness to Pay for ESCOM Connection fee and In-house Wiring Cost by both Households and Business Entities

f) Willingness to Pay for ESCOM Connection and In-house Wiring Costs by both Households and Business Entities, Whom Want to Pay More than MK0, in Unelectrified TCs Effective Sample Number: 593 Average: MK 7,577 (named "Willingness to Pay for ESCOM Connection [>MK0]" here in after) Standard Deviation: MK 20,260 Standard Error: MK 832 95% Confidence Interval: MK 5,944< <MK 9,210

Table 8-8-3-7 shows statistical results of the connection costs actually paid (MK 11,930 in average) and willingness to pay for connection costs (MK 7,577 in average) by households and business entities together.

Finally, Table 8-8-3-8 shows results of null hypotheses test (H_0: "ESCOM Connection Costs" is equal to "Willingness to Pay for ESCOM Connection [>MK0]") with a significance level of 5%. A significant difference was found between these two types of data. In other words, although electrified customers actually paid MK 11,930 on average for connection costs, potential customers (unelectrified residents) are only willing to pay MK 7,577 on average. The gap in these two values is an average of MK 4,353. Thus, even if TCs are electrified by extending ESCOM distribution lines, residents may possibly stay unelectrified because relatively expensive connection costs impede the progress of electrification. Some countermeasures to fill the gap between the necessary connection costs and willingness to pay for connection costs (MK 4,353) need to be considered in order to increase the number of electrified customers thereby rising the electrification rate.

Table 8-8-3-7 Summaries of Basic Statistics for Actually Paid Connection Costs and Willingness to Pay for Connection Costs

<u>c) Costs Paid by both Households and Business Entities for ESCOM Connection and In-house Wiring in Electrified TCs</u> Effective Sample Number: 154 Average: MK 11,930 (named "ESCOM Connection Costs" here in after) Standard Deviation: MK 10,152 Standard Error: MK 820 95% Confidence Interval: MK 10,300< <MK 13,550
<u>f) Willingness to Pay for ESCOM Connection and In-house Wiring Costs by both Households and Business Entities, Whom Want to Pay More than MK0, in Unelectrified TCs</u> Effective Sample Number: 593 Average: MK 7,577 (named "Willingness to Pay for ESCOM Connection [>MK0]" here in after) Standard Deviation: MK 20,260 Standard Error: MK 832 95% Confidence Interval: MK 5,944< <MK 9,210

Table 8-8-3-8 Summary of Null Hypotheses Test's Result regarding Actually Paid Connection Costs and Willingness to Pay for Connection Costs

<Case 2-3: c) & f)> H_0: "ESCOM Connection Costs" is equal to "Willingness to Pay for ESCOM Connection [>MK0]" Test Result: Reject the Hypothesis H_0 with 95% Confidence. This means that actual costs paid by both households and business entities for ESCOM connection and in-house wiring (MK 11,930) significantly differ from willingness to pay for that of more than MK0 (MK 7,577) in electrified TCs, in average. Difference of Averages: MK 4,353

8.8.4 Willingness to pay for monthly electricity tariffs

Basic statistical analysis was carried out regarding the actual amount of monthly electricity tariffs (named "monthly tariff" hereafter) paid by two categories of electrified customers (households and business entities). The analysis results are shown in Table 8-8-4-1.

Table 8-8-4-2 shows results of null hypotheses test (H_0: "Monthly Electricity Tariff for Households" is equal to "Monthly Electricity Tariff for Business Entities") with a significance level of 5%. Results indicated that amount of monthly tariffs paid were not significantly different between electrified households and business entities. Thus, basic statistics regarding the monthly tariff were recalculated treating both of them as a single group. Table 8-8-4-3 summarizes the recalculated statistics.

Table 8-8-4-1 Summaries of Basic Statistics for Monthly Electricity Tariff Paid by each of Households and Business Entities

a) Monthly Electricity Tariff Paid by Households in Electrified TCs Effective Sample Number: 64 Average: MK 1,347 (named "Monthly Electricity Tariff for Households" here in after) Standard Deviation: MK 2,320 Standard Error: MK 290 95% Confidence Interval: MK 767< <MK 1,927
b) Monthly Electricity Tariff Paid by Business Entities in Electrified TCs Effective Sample Number: 73 Average: MK 4,117 (named "Monthly Electricity Tariff for Business Entities" here in after) Standard Deviation: MK 10,215 Standard Error: MK 464 95% Confidence Interval: MK 1,734< <MK 6,500

Table 8-8-4-2 Summary of Null Hypotheses Test's Result regarding Monthly Electricity Tariff Paid by each of Households and Business Entities

<Case 3-1: a) & b)> H_0: "Monthly Electricity Tariff for Households" is equal to "Monthly Electricity Tariff for Business Entities" Test Result: Can't reject the Hypothesis H_0 with 95% Confidence. This means that monthly electricity tariff paid by households (MK 1,347) do not significantly differ from that paid by business entities (MK 4,117) in electrified TCs, in average.

Table 8-8-4-3 Summaries of Basic Statistics for Monthly Electricity Tariff Paid by both Households and Business Entities

c) Monthly Electricity Tariff Paid by both Households and Business Entities in Electrified TCs Effective Sample Number: 137 Average: MK 2,823 (named "Monthly Electricity Tariff in Electrified TCs" here in after) Standard Deviation: MK 7,724 Standard Error: MK 660 95% Confidence Interval: MK 1,518< <MK 4,128

Following this, basic statistical analysis was carried out regarding willingness to pay for monthly electricity tariffs (named "willingness to pay for monthly tariffs" here after) by unelectrified customers arranged into two categories: households and business entities. In the analysis, only data from those willing to pay more than MK0 but less than their total monthly income were considered viable. The analysis results are shown in Table 8-8-4-4.

Table 8-8-4-5 shows results of null hypotheses test (H_0: "Households' Willingness to Pay for Monthly Tariff" is equal to "Business Entities' Willingness to Pay for Monthly Tariff") with a significance level of 5%. A significant difference was found between these two types of data. In other words, although unelectrified business entities are willing to pay MK 3,110 on average the monthly tariff, unelectrified households are only willing to pay MK 1,838 on average. The gap in these two values is an average of MK 1,272. Therefore, in the next step of this analysis, actually paid monthly tariff and willingness to pay for it were compared in each of the two categories: households and business entities.

Table 8-8-4-4 Summaries of Basic Statistics for Willingness to Pay for Monthly Electricity Tariff by each of Households and Business Entities

d) Households' Willingness to Pay for Monthly Electricity Tariff in Unelectrified TCs Effective Sample Number: 296 Average: MK 1,838 (named "Households' Willingness to Pay for Monthly Tariff" here in after) Standard Deviation: MK 2,605 Standard Error: MK 151 95% Confidence Interval: MK 1,540< <MK 2,136
e) Business Entities' Willingness to Pay for Monthly Electricity Tariff in Unelectrified TCs Effective Sample Number: 312 Average: MK 3,110 (named "Business Entities' Willingness to Pay for Monthly Tariff" here in after) Standard Deviation: MK 3,155 Standard Error: MK 178 95% Confidence Interval: MK 2,758< <MK 3462

Table 8-8-4-5 Summary of Null Hypotheses Test's Result regarding Willingness to Pay for Monthly Electricity Tariff by each of Households and Business Entities

< Case 3-2: d) & e)> H_0: "Households' Willingness to Pay for Monthly Tariff" is equal to "Business Entities' Willingness to Pay for Monthly Tariff" Test Result: Reject the Hypothesis H_0 with 95% Confidence. This means that household's willingness to pay for monthly electricity tariff (MK 1,838 significantly differ from business entities' one (MK 3,110) in unelectrified TCs, in average. Difference of Averages: MK 1,272

Table 8-8-4-6 shows the statistical results of the monthly tariff actually paid and willingness to pay for monthly tariffs by each of households and business entities.

Table 8-8-4-7 shows results of null hypotheses test (H_0: "Monthly Electricity Tariff for Households" is equal to "Households' Willingness to Pay for Monthly Tariff") with a significance level of 5%. As a result, no significant difference was found between these two types of data. In other words, unelectrified households are willing to pay at least the same amount for the monthly tariffs as electrified households had been paying, in order to be electrified.

While, Table 8-8-4-8 shows results of null hypotheses test (H_0: "Monthly Electricity Tariff for Business Entities" is equal to "Business Entities' Willingness to Pay for Monthly Tariff") with a significance level of 5%. As a result, no significant difference was found between these two types of data. In other words, unelectrified business entities are willing to pay at least the same amount for the monthly tariffs as electrified business entities had been paying, in order to be electrified.

Those analysis results indicate that both households and business entities currently unelectrified are willing to pay as approximately the same amount of monthly tariff as ones currently electrified had been paying. In fact, it was clarified that unelectrified households' willingness to pay the monthly tariff (MK 1,838) is about 30% more than electrified ones' actually paid amount of it (MK 1,347). Therefore, it can be safely said that once potential customers get electrified, may possibly be capable of continued payment for monthly electricity tariffs. In the next section, the ability of potential customers to pay for monthly tariffs is verified.

Table 8-8-4-6 Summaries of Basic Statistics for Actually Paid Monthly Tariff and Willingness to Pay for Monthly Tariff

a) Monthly Electricity Tariff Paid by Households in Electrified TCs Effective Sample Number: 64 Average: MK 1,347 (named "Monthly Electricity Tariff for Households" here in after) Standard Deviation: MK 2,320 Standard Error: MK 290 95% Confidence Interval: MK 767< <MK 1,927
b) Monthly Electricity Tariff Paid by Business Entities in Electrified TCs Effective Sample Number: 73 Average: MK 4,117 (named "Monthly Electricity Tariff for Business Entities" here in after) Standard Deviation: MK 10,215 Standard Error: MK 464 95% Confidence Interval: MK 1,734< <MK 6,500
d) Households' Willingness to Pay for Monthly Electricity Tariff in Unelectrified TCs Effective Sample Number: 296 Average: MK 1,838 (named "Households' Willingness to Pay for Monthly Tariff" here in after) Standard Deviation: MK 2,605 Standard Error: MK 151 95% Confidence Interval: MK 1,540< <MK 2,136
e) Business Entities' Willingness to Pay for Monthly Electricity Tariff in Unelectrified TCs Effective Sample Number: 312 Average: MK 3,110 (named "Business Entities' Willingness to Pay for Monthly Tariff" here in after) Standard Deviation: MK 3,155 Standard Error: MK 178 95% Confidence Interval: MK 2,758< <MK 3462

Table 8-8-4-7 Summary of Null Hypotheses Test's Result regarding Actually Paid Monthly Tariff and Willingness to Pay for Monthly Tariff by Households

<Case 3-3: a) & d)> H_0: "Monthly Electricity Tariff for Households" is equal to "Households' Willingness to Pay for Monthly Tariff" Test Result: Can't reject the Hypothesis H_0 with 95% Confidence. This means that monthly ESCOM tariff paid by households in electrified TCs (MK 1,347) does not significantly differ from willingness to pay by ones in unelectrified TCs (MK 1,838), in average.

Table 8-8-4-8 Summary of Null Hypotheses Test's Result regarding Actually Paid Monthly Tariff and Willingness to Pay for Monthly Tariff by Business Entities

<Case 3-4: b) & e)> H_0: "Monthly Electricity Tariff for Business Entities" is equal to "Business Entities' Willingness to Pay for Monthly Tariff" Test Result: Can't reject the Hypothesis H_0 with 95% Confidence. This means that monthly ESCOM tariff paid by business entities in electrified TCs (MK 4,117) does not significantly differ from willingness to pay by ones in unelectrified TCs (MK 3,110), in average.

8.8.5 Ability to pay monthly electricity tariff

Basic statistical analysis was carried out regarding the ratio of monthly tariff to the monthly income (named "monthly tariff ratio" hereafter) for electrified customers arranged into two categories: households and business entities. The analysis results are shown in Table 8-8-5-1.

Table 8-8-5-2 shows results of null hypotheses test (H_0: "Households' Ratio of Monthly Tariff to Monthly Income" is equal to "Business Entities' Ratio of Monthly Tariff to Monthly Income") with a significance level of 5%. Results indicated that the monthly tariff ratios were not significantly different between electrified households and business entities. Thus, basic statistics regarding the monthly tariff ratio were recalculated treating both of them as a single group. Table 8-8-5-3 summarizes the recalculated statistics when the payment for monthly electricity tariff by electrified households and business entities is 17% of their monthly income in average.

Table 8-8-5-1 Summaries of Basic Statistics for Ratio of Monthly Tariff to Monthly Income for each of Households and Business Entities

a) Electrified Households' Ratio of Monthly Tariff to Monthly Income Effective Sample Number: 56 Average: 0.17 (named "Households' Ratio of Monthly Tariff to Monthly Income" here in after) Standard Deviation: 0.23 Standard Error: 0.03 95% Confidence Interval: 0.11< <0.23
b) Electrified Business Entities' Ratio of Monthly Tariff to Monthly Income Effective Sample Number: 65 Average: 0.16 (named "Business Entities' Ratio of Monthly Tariff to Monthly Income" here in after) Standard Deviation: 0.17 Standard Error: 0.02 95% Confidence Interval: 0.12< <0.20

Table 8-8-5-2 Summary of Null Hypotheses Test's Result regarding Ratio of Monthly Tariff to Monthly Income for each of Households and Business Entities

<Case 4-1: a) & b)> H_0: "Households' Ratio of Monthly Tariff to Monthly Income" is equal to "Business Entities' Ratio of Monthly Tariff to Monthly Income" Test Result: Can't reject the Hypothesis H_0 with 95% Confidence. This means that households' ratio of monthly bills to monthly income (0.17) does not significantly differ from business entities' one (0.16) in electrified TCs, in average.

Table 8-8-5-3 Summaries of Basic Statistics for Ratio of Monthly Tariff to Monthly Income for both Households and Business Entities

c) Rate of Monthly Tariff to Monthly Income in Electrified TCs Effective Sample Number: 121 Average: 0.17 (named "Ratio of Monthly Tariff to Monthly Income in Electrified TCs" here in after) Standard Deviation: 0.20 Standard Error: 0.02 95% Confidence Interval: 0.13< <0.20

Following this, basic statistical analysis was carried out regarding the ratio of willingness to pay monthly tariffs to the monthly income (named “monthly tariff ratio of willingness to pay” hereafter) for unelectrified customers arranged into two categories: households and business entities. In the analysis, only data from those who are willing to pay more than MK0 but less than their total monthly income were considered viable. The analysis results are shown in Table 8-8-5-4.

Table 8-8-5-5 shows results of null hypotheses test (H_0: “Unelectrified Households’ Ratio of Monthly Tariff to Monthly Income” is equal to “Unelectrified Business Entities’ Ratio of Monthly Tariff to Monthly Income”) with a significance level of 5%. Results indicated that the monthly tariff ratio of willingness to pay was not significantly different between unelectrified households and business entities. Thus, basic statistics of the monthly tariff ratio of willingness to pay were recalculated treating both of them as a single group. Table 8-8-5-6 summarizes the recalculated statistics when the willingness to pay for monthly electricity tariff by electrified households and business entities is 25% of their monthly income in average.

Table 8-8-5-4 Summaries of Basic Statistics for Ratio of Willingness to Pay for Monthly Tariff to Monthly Income for each of Households and Business Entities

<u>d) Unelectrified Households’ Ratio of Willingness to Pay for Monthly Tariff to Monthly Income</u>

Effective Sample Number: 249
Average: 0.249 (named “Unelectrified Households’ Ratio of Monthly Tariff to Monthly Income” here in after)
Standard Deviation: 0.230
Standard Error: 0.015
95% Confidence Interval: 0.218< <0.275

<u>e) Unelectrified Business Entities’ Ratio of Willingness to Pay for Monthly Bills to Monthly Incomes</u>

Effective Sample Number: 270
Average: 0.250 (named “Unelectrified Business Entities’ Ratio of Monthly Tariff to Monthly Income” here in after)
Standard Deviation: 0.223
Standard Error: 0.013
95% Confidence Interval: 0.223< <0.277

Table 8-8-5-5 Summary of Null Hypotheses Test’s Result regarding Ratio of Willingness to Pay for Monthly Tariff to Monthly Income for each of Households and Business Entities

< Case 4-2: d) & e)>

H_0: “Unelectrified Households’ Ratio of Monthly Tariff to Monthly Income” is equal to “Unelectrified Business Entities’ Rate of Monthly Tariff to Monthly Income”

Test Result: Can’t reject the Hypothesis H_0 with 95% Confidence. This means that households’ ratio of willingness to pay for monthly tariff to monthly income (0.249) does not significantly differ from business entities’ one (0.250) in unelectrified TCs, in average.

Table 8-8-5-6 Summaries of Basic Statistics for Ratio of Willingness to Pay for Monthly Tariff to Monthly Income for both Households and Business Entities

<u>f) Ratio of Monthly Bills to Monthly Incomes in Unelectrified TCs</u>

Effective Sample Number: 519
Average: 0.248 (named “Ratio of Monthly Tariff to Monthly Income in Unelectrified TCs” here in after)
Standard Deviation: 0.226
Standard Error: 0.010
95% Confidence Interval: 0.229< <0.268

Table 8-8-5-7 shows the statistical summaries of the ratios of monthly tariff actually paid to the monthly income (0.17 on average) and willingness to pay monthly tariff to the monthly income (0.248 on average) for households and business entities together.

Finally, Table 8-8-5-8 shows results of null hypotheses test (H_0: “Rate of Monthly Tariff to Monthly Income in Electrified TCs” is equal to “Rate of Monthly Tariff to Monthly Income in Unelectrified TCs”) with a significance level of 5%. A significant difference was found between these two types of data. In other words, it was found that unelectrified residents eager to use electricity even if they pay more ratio of the monthly tariff to monthly income than electrified customers had been paying.

The question still remains; whether unelectrified residents are able to sustain for paying monthly tariff even more income ratio than electrified residents’ one. As verified in section 8.8.2, unelectrified households’ monthly income is significantly lower than the rest of categories’ one. Assuming that households’ monthly income (MK 8,305) will not change even after they become electrified and monthly tariff will be the same as the currently electrified customers’ average (MK 1,347), the monthly tariff ratio will still not exceed 17% – which is the average ratio of actually paid monthly tariff to monthly income for currently electrified residents. Therefore, it can be safely said that once potential customers get electrified, they may possibly be capable of continued payment for monthly tariffs, if the ratio of it to monthly income is about 17%. Before TCs will be electrified, execution of detailed investigation for unelectrified households’ income would be highly recommended. Especially, if the ratio of monthly tariffs for households will exceed 20% – the upper limit of 95% confidence interval for the current customers’ one – on average, some countermeasures should be considered.

Table 8-8-5-7 Summaries of Basic Statistics for Ratio of Actually Paid Monthly Tariff and Willingness to Pay for Monthly Tariff to each Monthly Income

<u>c) Ratio of Monthly Tariff to Monthly Income in Electrified TCs</u> Effective Sample Number: 121 Average: 0.17 (named “Ratio of Monthly Tariff to Monthly Income in Electrified TCs” here in after) Standard Deviation: 0.20 Standard Error: 0.02 95% Confidence Interval: 0.13< <0.20
<u>f) Ratio of Monthly Bills to Monthly Incomes in Unelectrified TCs</u> Effective Sample Number: 519 Average: 0.248 (named “Ratio of Monthly Tariff to Monthly Income in Unelectrified TCs” here in after) Standard Deviation: 0.226 Standard Error: 0.010 95% Confidence Interval: 0.229< <0.268

Table 8-8-5-8 Summary of Null Hypotheses Test’s Result regarding Ratio of Actually Paid Monthly Tariff and Willingness to Pay for Monthly Tariff to each Monthly Income

<Case 4-3: c) & f)> H_0: “Ratio of Monthly Tariff to Monthly Income in Electrified TCs” is equal to “Ratio of Monthly Tariff to Monthly Income in Unelectrified TCs” Test Result: Reject the Hypothesis H_0 with 95% Confidence. This means that ratio of monthly tariff to monthly income in electrified TCs (0.17) significantly differ from that in unelectrified TCs (0.248), in average. Difference of Averages: 0.078

8.9 Summary of Analysis Results

Results of analysis so far can be summarized as follows:

1) Forecast of potential daily peak demand in an unelectrified TC is possible by applying a linear regression model, called the "Peak Demand Forecast Model", that has independent variables which are the numbers of households and maize mills in the unelectrified TC.
2) In an electrified TC in rural areas, maize mills' electricity consumption occupies a high proportion of the TC's total consumption.
3) The daily peak demand in a TC appears in the morning from 6:00 to 7:00 or in the evening from 18:00 to 19:00, coinciding with breakfast or dinner, during which time electricity consumption rapidly increases for food preparation, overlapping with the operation hours of maize mills.
4) Regarding ESCOM connection fees and in-house wiring costs, a significant difference exists between the amount actually paid by electrified customers and the amount potential unelectrified customers are willing to pay, this difference being approximately MK 4,500 on average. Unless countermeasures are adopted in order to fill in this gap, rapid increase of the electrification ratio cannot be expected.
5) Once potential business entities manage to pay ESCOM connection fees and in-house wiring fees and get electrified, they may possibly be capable of continued payment for monthly electricity tariffs. Regarding potential households, a ratio of the monthly tariff to the monthly income less than 17% would be acceptable since they face economic disadvantage. If the ratio were expected to exceed 20% for these potential households, continued monthly payment could not be guaranteed. Therefore, investigation regarding ability to pay monthly tariffs is essential before these households become electrified.

References

1. Introductory Statistics for Business and Economics (Third Edition), Thomas H. Wonnacott and Ronald J. Wonnacott, 1984, John Wiley & Sons, Inc.

2. Basic Econometrics (Second Edition), Damodar N. Gujarati, 1988, McGraw-Hill Publishing Company

Photo 8-1 Medium Scaled Trading Center
(Jenda TC in Mzimba District)

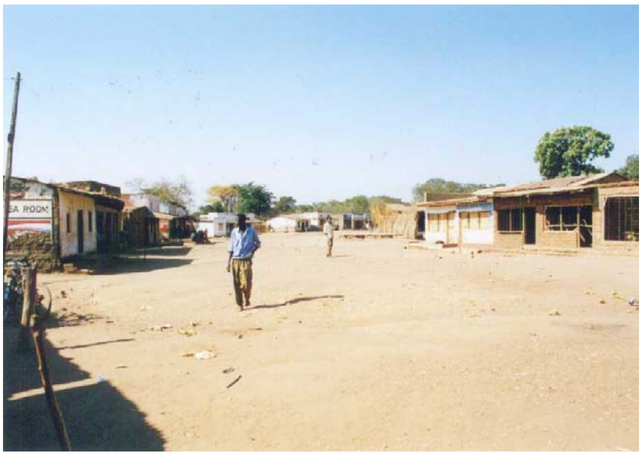


Photo 8-2 Small Scaled Trading Center
(NambumaTC in Dowa District)

Photo 8-3 Market in Medium Scaled Trading Center
(Jenda TC in Mzimba District)

Photo 8-4 Market in Medium Scaled Trading Center
(Jenda TC in Mzimba District)

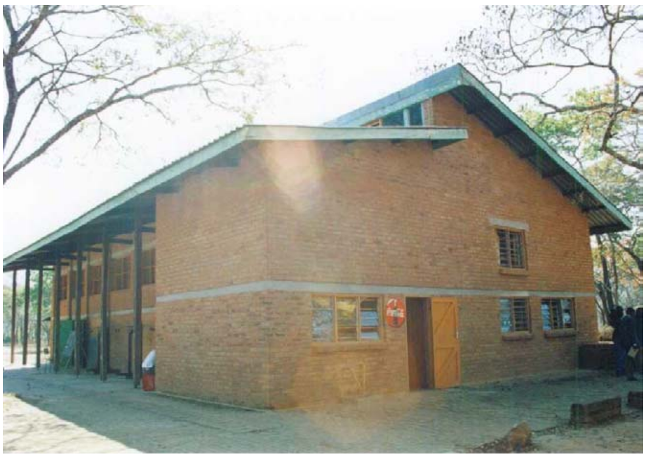


Photo 8-5 Community Hall in Trading Center
(Mbalachanda TC in Mzimba District)

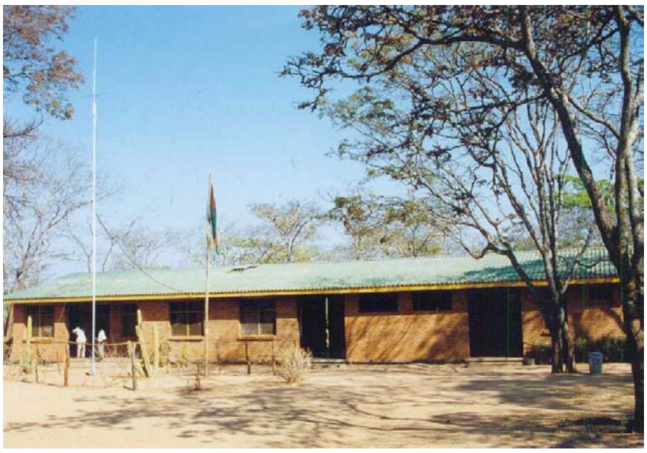


Photo 8-6 Hospital with Solar Home System
(Mbalachanda TC in Mzimba District)

Photo 8-7 School Funded by MASAF
(Kwitanda TC in Balaka District)

Photo 8-8 School of Under Construction Funded by MASAF
(Nambuma TC in Dowa District)

Photo 8-9 Church in Trading Center
(Nambuma TC in Dowa District)

Photo 8-10 Post Office with Solar Home System for Radio Telecommunication System
(Bulala TC in Mzimba District)

Photo 8-11 Telephone Office with Solar Home System
(Mbalachanda TC in Mzimba District)

Photo 8-12 Installed Solar Home System for Telephone Office
(Mbalachanda TC in Mzimba District)

Photo 8-13 Road Constructed by Local Community
(Kwitanda TC in Balaka District)

Photo 8-14 Water Pumping from Borehole
in Trading Center

Photo 8-15 Maize Mill in Trading Center

Photo 8-16 Paraffin Refrigerator at Retail Shop
in Trading Center

Photo 8-17 Room in a Household at Electrified Trading Center
(Dedza TC in Dedza District)

Photo 8-18 Typical Unelectrified Rural Village

CHAPTER 9 RURAL ELECTRIFICATION DATABASE

Chapter 9 Rural Electrification Database

Database developed in this study will be utilized on the following three purposes:

1) Make counterpart personnel to access collected data and analyses results in this study easier
2) Store collected data during this study in suitable forms for further analyses in the future
3) Update and accumulate newly collected data in the future in the uniform form

Since this database is linked with results of socio-economic survey executed in this master plan study, structure of the database must support this linkage. The structure consists of two data-set groups – technical data sets and socioeconomic ones – as socio-economic survey had two research purposes: technical aspects evaluation and socioeconomic aspects evaluation. Personal computer with Microsoft Access was utilized to elaborate this database system.

9.1 Data Contents

Collected data items in the socio-economic survey can be classified into the three major categories shown bellows:

1) Trading Centers' basic numerical data (such as population, market fees etc.) provided from key informants
2) Quantitative attributes of households and business entities (residents in TCs)
3) Quantitative attributes of public facilities

Numbers of questions asked for each type of categories – interviewees – are summarized on Table 9-1-1. Among these questions, some involved multiple sub-questions and thus total sampled data items became plentiful (also refer to Table 9-1-1).

Table 9-1-1 Number of Data Items Collected by Each Type of Interviewees

Categories of Interviewees	Number of Questions	Sampled Data Items
1) Key Informants	31	240
2) Households/Business Entities	72	460
3) Public Facilities	27	270

9.2 Process of Database Elaboration

The database elaboration process is as follows.

a) Input of socio-economic survey data into Excel program
b) Analysis of these data and selection of items critical for choosing a proposed electrification site. Some data items were converted from Excel to SPSS – statistical analysis program – and analyzed in the program.

c) Selection of key items for data searching process (for example, population, market fees, existence of schools/hospitals, etc.)
d) Export of Excel data into Access program
e) Elaboration of input form, renewal form, search form, etc. and screen layout.

A point to notice

a) Data collection of unelectrified TCs is ongoing. These collected data need to be input and renewed every time the latest data are obtained.
b) As for data consist in the database, essential items for choosing a proposed electrification site, such as market fees, costs of each electrification methods – distribution line extension, micro hydropower development, and SHS installation – and TCs' basic numerical data, are selected.
c) Concerning the searching items, it is possible to sort the data according to the priority of electrification and the method of electrification.
d) These selected data were exported from Excel into Access program.

9.3 Database Components

Regarding inputted data, direct access to each of two types of data sets – the socio-economic aspects and the technical aspects – was made possible in the database system.

As for the socio-economic aspects' evaluation data, collected data in the socio-economic survey were summarized in a large table, which enables counterparts to execute further statistical analysis by referring data among it. To carry out detail statistical analysis, special packages such as SPSS, SAS, Excel to name a few need to be used. Therefore, data format, which make the data conversion to applicable form of these packages possible, was selected.

As for the technical aspects' evaluation data, collected data in the socio-economic survey were accumulated in the database, and a function to retrieve those data of which relate to estimate a potential demand in unelectrified TC and to selection of optimal electrification method, such as listed below, were added:

- Electrification priority
- Costs of each electrification methods: distribution line extension, micro hydropower development, and SHS installation
- Trading Centers' basic numerical data

It is anticipated that two searching methods – 1) Visual Data Access Method and 2) Index Data Access Method – will be utilized when a particular TC is required. Both methods are outlined below.

1) Visual Data Access Method

Fig. 9-3-1 shows an image of the initial screen. The map of Malawi, distinguishing each district, is located the left side of screen.

1. Click the district on the map (the screen within the blue line in Fig. 9-3-1) to get the district's data.
2. The screen changes as shown in Fig. 9-3-2, and the district data is shown .
3. Click the section within the red line to show the TC's data.

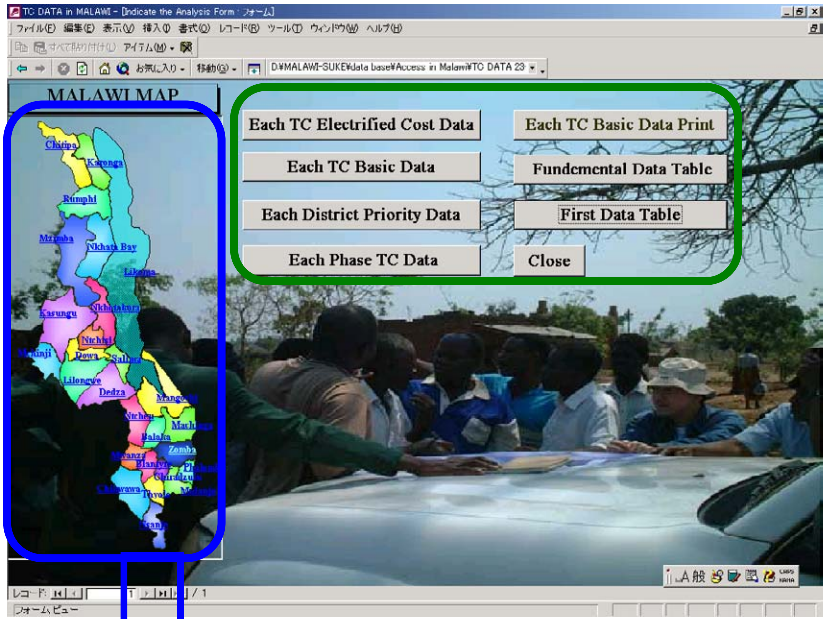


Fig. 9-3-1 Database's Menu Screen

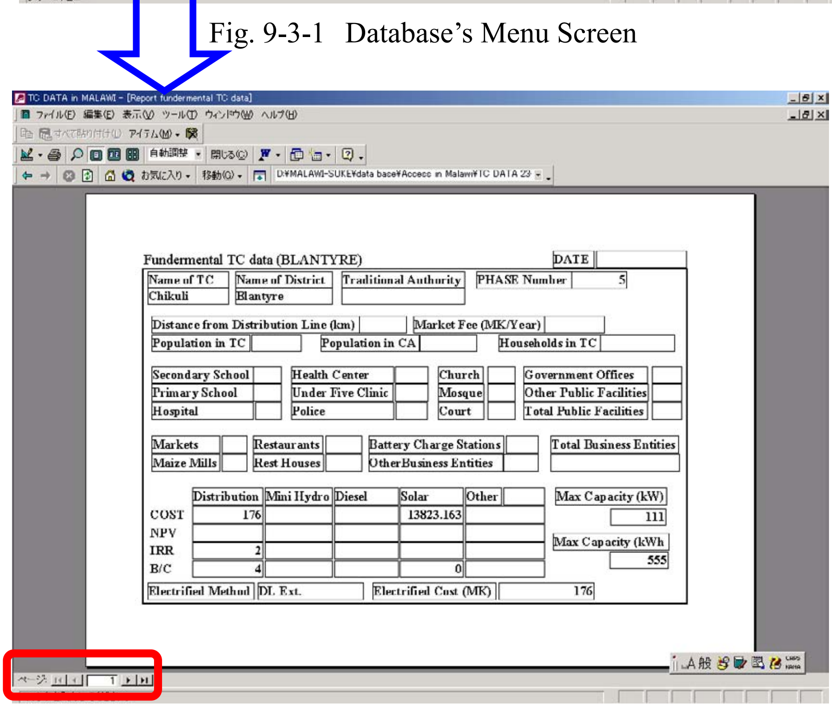


Fig. 9-3-2 TC's Data Screen

2) Index Data Access Method

The upper part of the screen, shown in Fig. 9-3-1, is the index of the seven Search Forms. The contents of the Search Forms are as follows.

a) Electrified Cost Data

Input the district name to find the district's construction and maintenance cost data.

b) TC Basic Data

Input the district name to find basic data about the district, Public Facilities and Business Entities.

c) District Priority Data

Input the district name to find the priority of electrification of the TC.

d) TC Data per Phase

Input the Phase number to get the name of the TCs proposed for electrification in that phase.

e) TC Basic Data Print

This is the screen to print the Basic Data of any TC.

f) Fundamental Data Table

This is the source table that includes all the above contents.

g) First Data Table

This is the source table that includes all the above contents

<u>Operation procedure</u>

The section within the green line in Fig. 9-3-1 shows the seven buttons that indicate the information to be searched.

The operation procedure is as follows.

a) Electrified TC Cost Data

1. Click this button to move to the form shown in Fig. 9-3-3.
2. Input the district name in the yellow section as shown in Fig. 9-3-3.
3. Get the district's construction and maintenance cost data as shown in Fig. 9-3-4.

b) TC Basic Data

1. Click this button to move to the form shown in Fig. 9-3-3.
2. Input the district name in the yellow section as shown in Fig. 9-3-3.
3. Get basic data about the district, Public Facilities and Business Entities, as shown

in Fig. 9-3-5.

c) District Priority Data
   1. Click this button to move to the form shown in Fig. 9-3-3.
   2. Input the district name in the yellow section as shown in Fig. 9-3-3.
   3. Get the priority data table of the TC's electrification as shown in Fig. 9-3-6.

d) TC Data per Phase
   1. Click this button to move to the form shown in Fig. 9-3-3.
   2. Input the Phase number in the yellow section as shown in Fig. 9-3-3.
   3. Get the name of the TCs proposed for electrification in that phase as shown in Fig. 9-3-7.

e) TC Basic Data Print
   1. Click this button to move to the form shown in Fig. 9-3-8.
   2. This is the screen for printing the TC's Basic Data.
   3. Click within the red section to print the data that is searched.

f) Fundamental Data Table
   1. Click this button to move to the form shown in Fig. 9-3-9.
   2. This is the source table that includes all the above contents.

g) First Data Table
   1. Click this button to move to the form shown in Fig. 9-3-10.
   2. This is the source table that includes all the above contents.

It is possible to input and edit the data from each form. Since the whole data base is interconnected, if one single part is inputted or revised, the rest is renewed automatically.

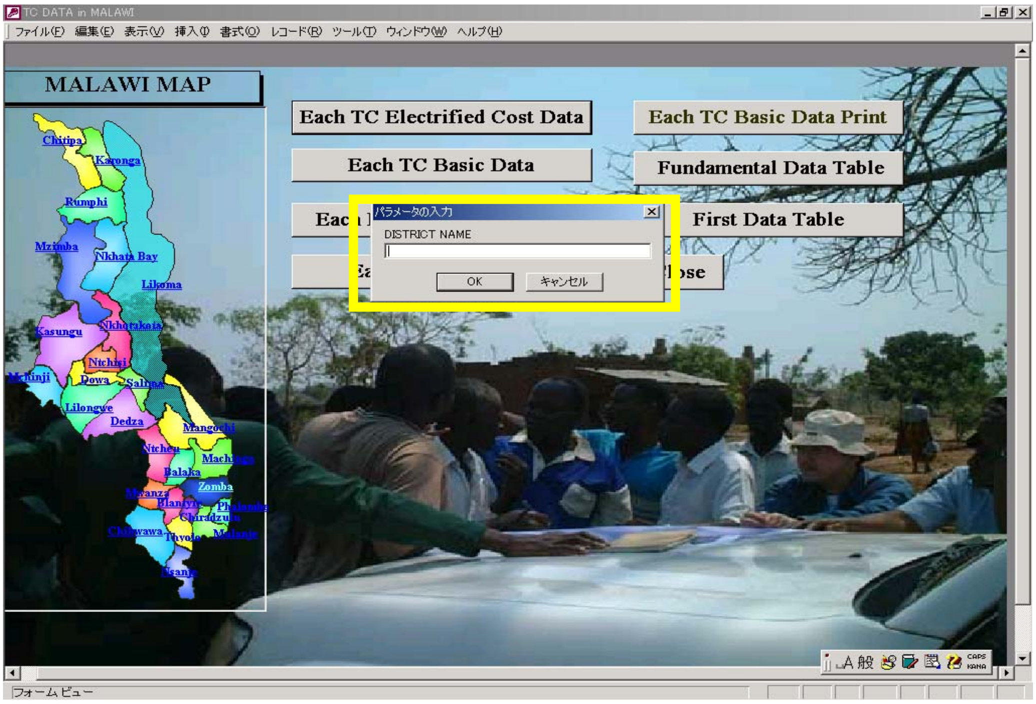


Fig. 9-3-3　The screen for inputting the parameter

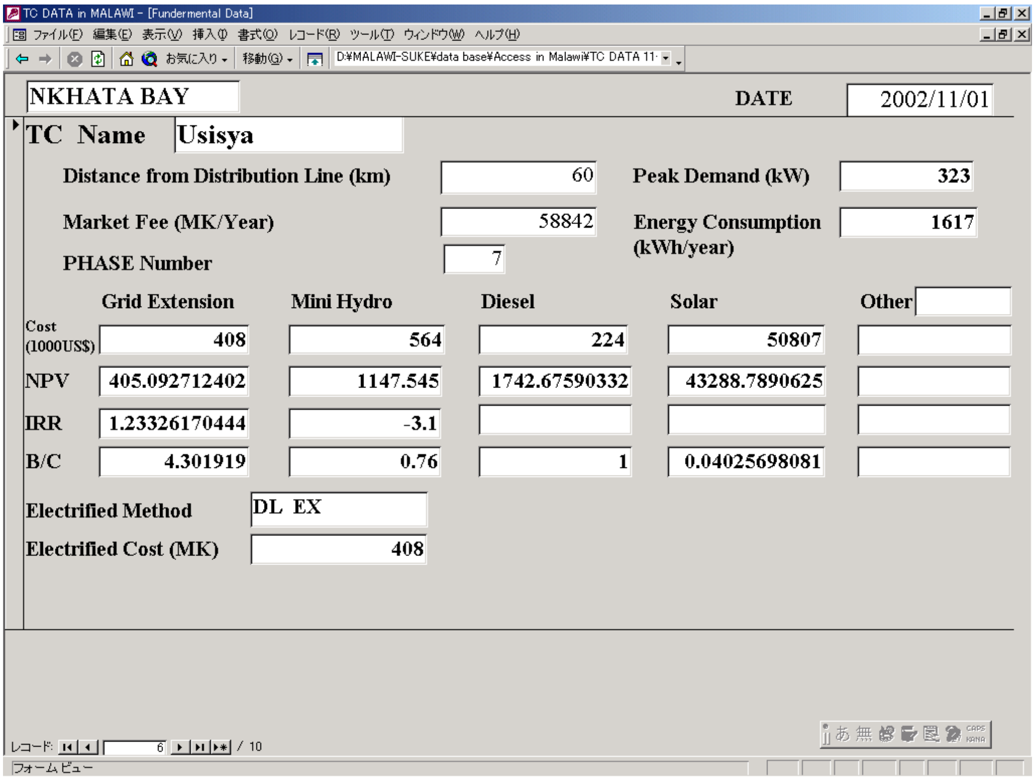
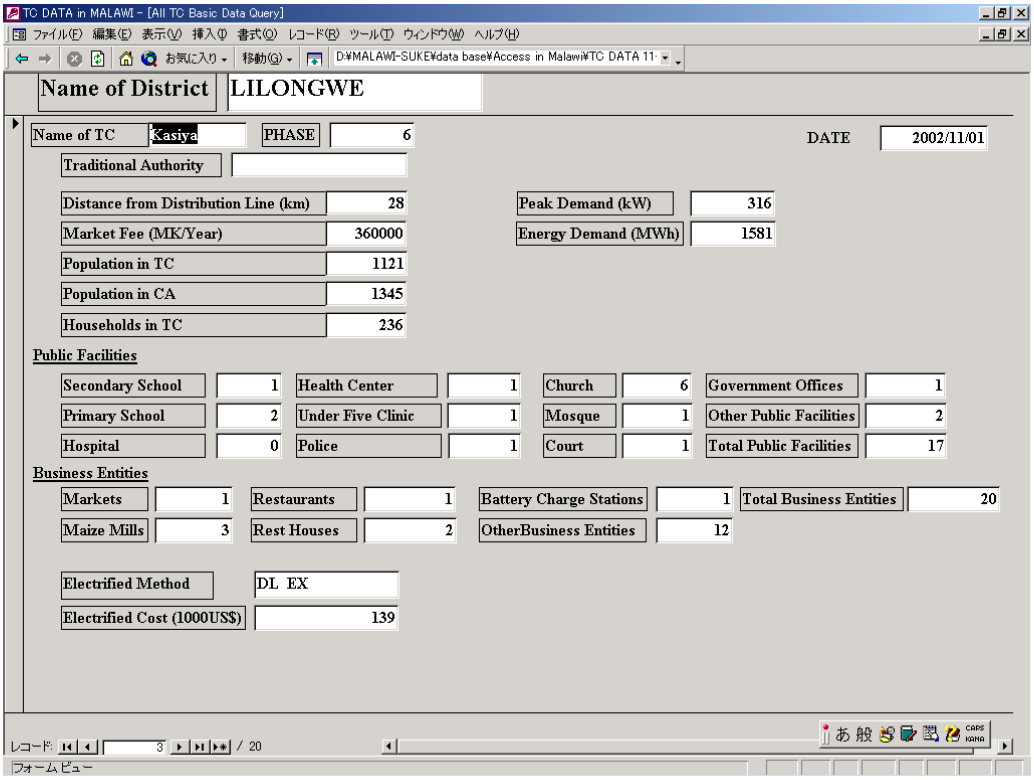


Fig. 9-3-4　Each TC's Electrified Cost Data


TC DATA in MALAWI - [All TC Basic Data Query]

Name of District	LILONGWE

Name of TC	Kasiya	PHASE	6
DATE	2002/11/01		
Traditional Authority			
Distance from Distribution Line (km)	28	Peak Demand (kW)	316
Market Fee (MK/Year)	360000	Energy Demand (MWh)	1581
Population in TC	1121		
Population in CA	1345		
Households in TC	236		

Public Facilities

Secondary School	1	Health Center	1	Church	6	Government Offices	1
Primary School	2	Under Five Clinic	1	Mosque	1	Other Public Facilities	2
Hospital	0	Police	1	Court	1	Total Public Facilities	17

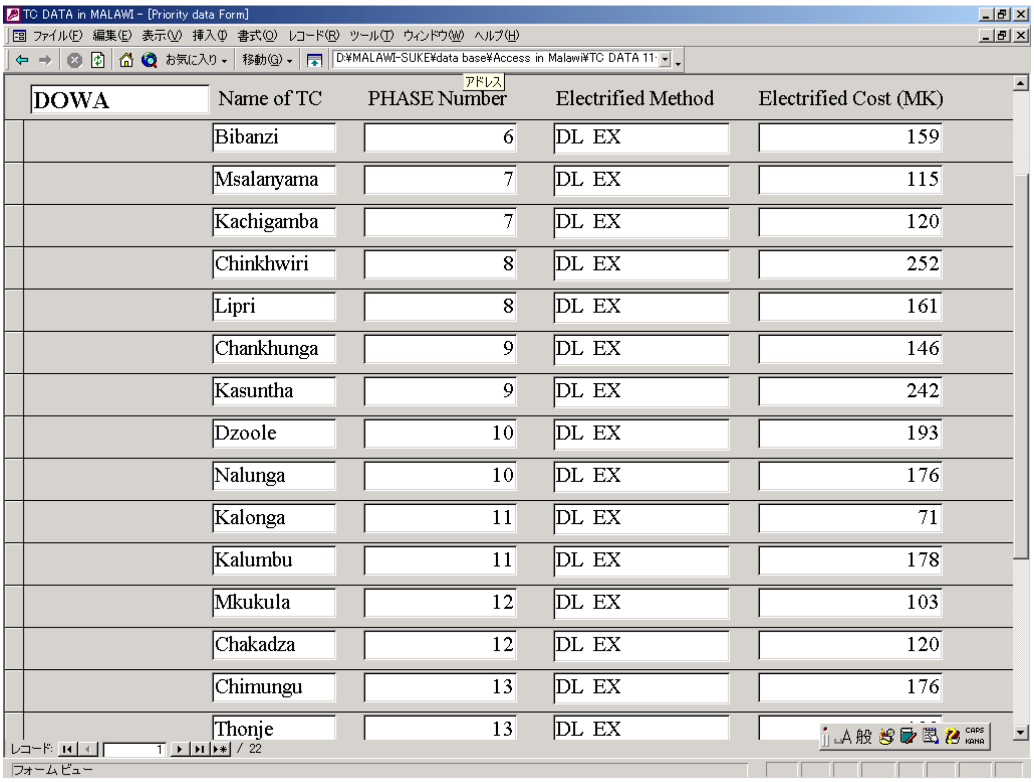
Business Entities

Markets	1	Restaurants	1	Battery Charge Stations	1	Total Business Entities	20
Maize Mills	3	Rest Houses	2	OtherBusiness Entities	12		

Electrified Method	DL EX
Electrified Cost (1000US$)	139

レコード: 3 / 20

Fig. 9-3-5 Each TC's Basic Data


TC DATA in MALAWI - [Priority data Form]

DOWA	Name of TC	PHASE Number	Electrified Method	Electrified Cost (MK)
	Bibanzi	6	DL EX	159
	Msalanyama	7	DL EX	115
	Kachigamba	7	DL EX	120
	Chinkhwiri	8	DL EX	252
	Lipri	8	DL EX	161
	Chankhunga	9	DL EX	146
	Kasuntha	9	DL EX	242
	Dzoole	10	DL EX	193
	Nalunga	10	DL EX	176
	Kalonga	11	DL EX	71
	Kalumbu	11	DL EX	178
	Mkukula	12	DL EX	103
	Chakadza	12	DL EX	120
	Chimungu	13	DL EX	176
	Thonje	13	DL EX	[illegible]

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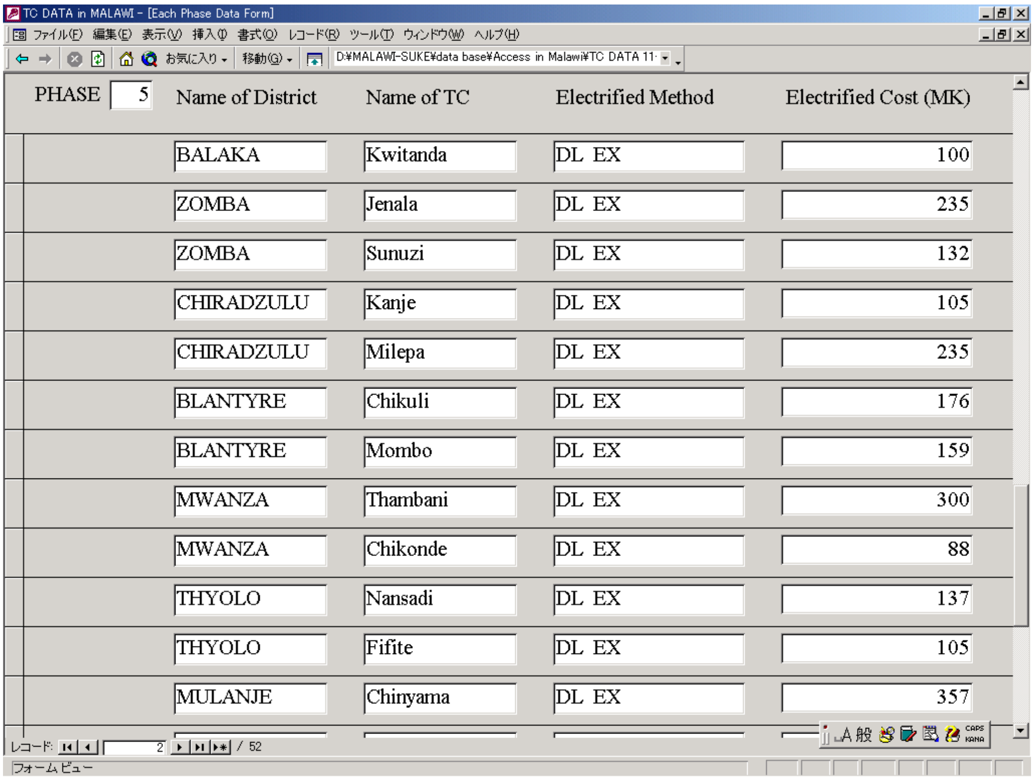
Fig. 9-3-6 Each District's Priority Data



TC DATA in MALAWI - [Each Phase Data Form]

PHASE 5	Name of District	Name of TC	Electrified Method	Electrified Cost (MK)
	BALAKA	Kwitanda	DL EX	100
	ZOMBA	Jenala	DL EX	235
	ZOMBA	Sunuzi	DL EX	132
	CHIRADZULU	Kanje	DL EX	105
	CHIRADZULU	Milepa	DL EX	235
	BLANTYRE	Chikuli	DL EX	176
	BLANTYRE	Mombo	DL EX	159
	MWANZA	Thambani	DL EX	300
	MWANZA	Chikonde	DL EX	88
	THYOLO	Nansadi	DL EX	137
	THYOLO	Fifite	DL EX	105
	MULANJE	Chinyama	DL EX	357

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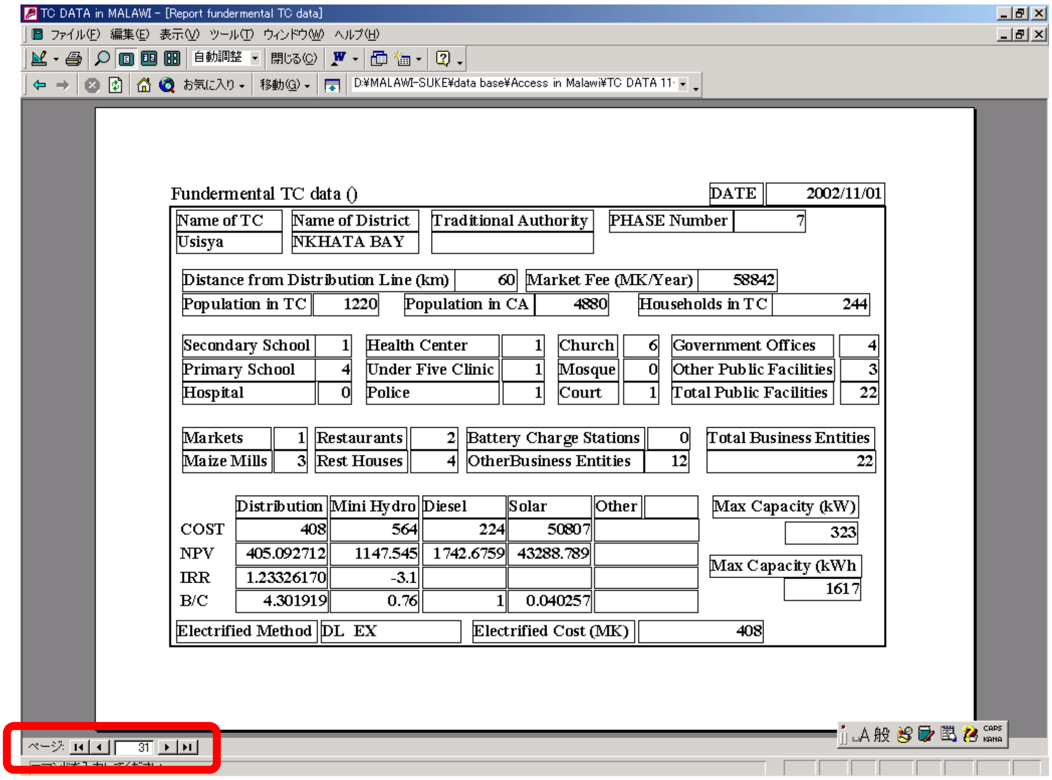
Fig. 9-3-7 Each Phase's TC Data



TC DATA in MALAWI - [Report fundermental TC data]

Fundermental TC data () DATE 2002/11/01

Name of TC	Name of District	Traditional Authority	PHASE Number
Usisya	NKHATA BAY		7

Distance from Distribution Line (km)	60	Market Fee (MK/Year)	58842		
Population in TC	1220	Population in CA	4880	Households in TC	244

Secondary School	1	Health Center	1	Church	6	Government Offices	4
Primary School	4	Under Five Clinic	1	Mosque	0	Other Public Facilities	3
Hospital	0	Police	1	Court	1	Total Public Facilities	22

Markets	1	Restaurants	2	Battery Charge Stations	0	Total Business Entities
Maize Mills	3	Rest Houses	4	OtherBusiness Entities	12	22

	Distribution	Mini Hydro	Diesel	Solar	Other
COST	408	564	224	50807	
NPV	405.092712	1147.545	1742.6759	43288.789	
IRR	1.23326170	-3.1			
B/C	4.301919	0.76	1	0.040257	

Max Capacity (kW) 323

Max Capacity (kWh 1617

Electrified Method	DL EX	Electrified Cost (MK)	408

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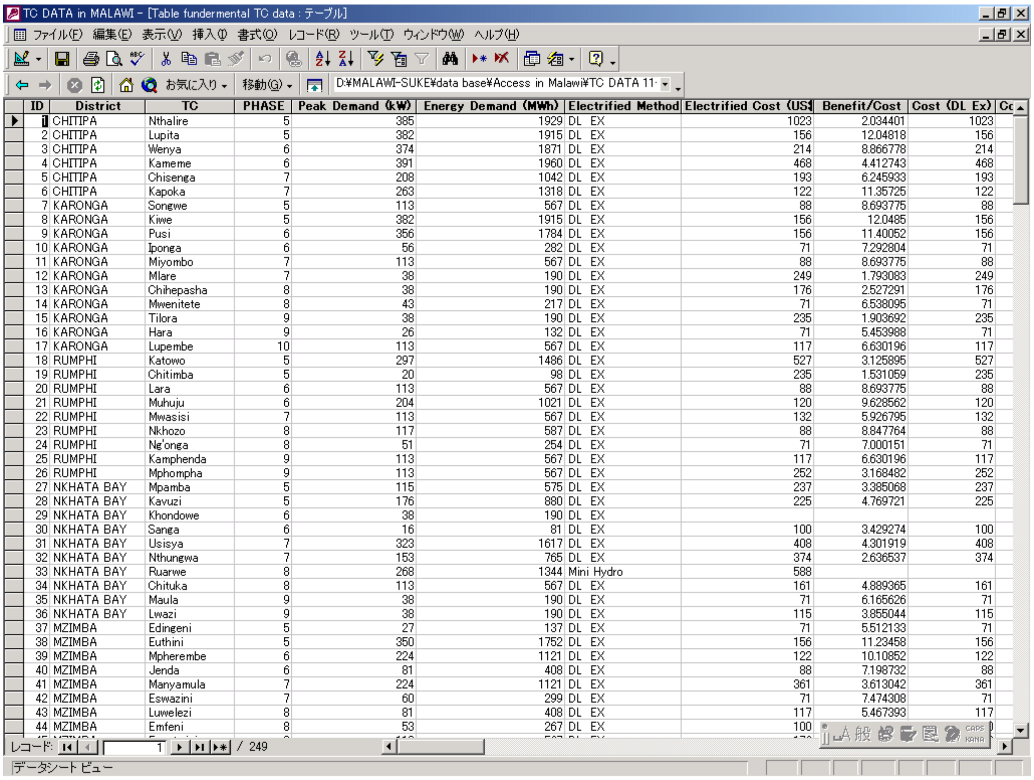
Fig. 9-3-8 Each TC's Basic Data Print



TC DATA in MALAWI - [Table fundermental TC data : テーブル]

ID	District	TC	PHASE	Peak Demand (kW)	Energy Demand (MWh)	Electrified Method	Electrified Cost (US$	Benefit/Cost	Cost (DL Ex)	Cc
1	CHITIPA	Nthalire	5	385	1929	DL EX	1023	2.034401	1023	
2	CHITIPA	Lupita	5	382	1915	DL EX	156	12.04818	156	
3	CHITIPA	Wenya	6	374	1871	DL EX	214	8.866778	214	
4	CHITIPA	Kameme	6	391	1960	DL EX	468	4.412743	468	
5	CHITIPA	Chisenga	7	208	1042	DL EX	193	6.245933	193	
6	CHITIPA	Kapoka	7	263	1318	DL EX	122	11.35725	122	
7	KARONGA	Songwe	5	113	567	DL EX	88	8.693775	88	
8	KARONGA	Kiwe	5	382	1915	DL EX	156	12.0485	156	
9	KARONGA	Pusi	6	356	1784	DL EX	156	11.40052	156	
10	KARONGA	Iponga	6	56	282	DL EX	71	7.292804	71	
11	KARONGA	Miyombo	7	113	567	DL EX	88	8.693775	88	
12	KARONGA	Mlare	7	38	190	DL EX	249	1.793083	249	
13	KARONGA	Chihepasha	8	38	190	DL EX	176	2.527291	176	
14	KARONGA	Mwenitete	8	43	217	DL EX	71	6.538095	71	
15	KARONGA	Tilora	9	38	190	DL EX	235	1.903692	235	
16	KARONGA	Hara	9	26	132	DL EX	71	5.453988	71	
17	KARONGA	Lupembe	10	113	567	DL EX	117	6.630196	117	
18	RUMPHI	Katowo	5	297	1486	DL EX	527	3.125895	527	
19	RUMPHI	Chitimba	5	20	98	DL EX	235	1.531059	235	
20	RUMPHI	Lara	6	113	567	DL EX	88	8.693775	88	
21	RUMPHI	Muhuju	6	204	1021	DL EX	120	9.628562	120	
22	RUMPHI	Mwasisi	7	113	567	DL EX	132	5.926795	132	
23	RUMPHI	Nkhozo	8	117	587	DL EX	88	8.847764	88	
24	RUMPHI	Ng'onga	8	51	254	DL EX	71	7.000151	71	
25	RUMPHI	Kamphenda	9	113	567	DL EX	117	6.630196	117	
26	RUMPHI	Mphompha	9	113	567	DL EX	252	3.168482	252	
27	NKHATA BAY	Mpamba	5	115	575	DL EX	237	3.385068	237	
28	NKHATA BAY	Kavuzi	5	176	880	DL EX	225	4.769721	225	
29	NKHATA BAY	Khondowe	6	38	190	DL EX				
30	NKHATA BAY	Sanga	6	16	81	DL EX	100	3.429274	100	
31	NKHATA BAY	Usisya	7	323	1617	DL EX	408	4.301919	408	
32	NKHATA BAY	Nthungwa	7	153	765	DL EX	374	2.636537	374	
33	NKHATA BAY	Ruarwe	8	268	1344	Mini Hydro	588			
34	NKHATA BAY	Chituka	8	113	567	DL EX	161	4.889365	161	
35	NKHATA BAY	Maula	9	38	190	DL EX	71	6.165626	71	
36	NKHATA BAY	Lwazi	9	38	190	DL EX	115	3.855044	115	
37	MZIMBA	Edingeni	5	27	137	DL EX	71	5.512133	71	
38	MZIMBA	Euthini	5	350	1752	DL EX	156	11.23458	156	
39	MZIMBA	Mpherembe	6	224	1121	DL EX	122	10.10852	122	
40	MZIMBA	Jenda	6	81	408	DL EX	88	7.198732	88	
41	MZIMBA	Manyamula	7	224	1121	DL EX	361	3.613042	361	
42	MZIMBA	Eswazini	7	60	299	DL EX	71	7.474308	71	
43	MZIMBA	Luwelezi	8	81	408	DL EX	117	5.467393	117	
44	MZIMBA	Emfeni	8	53	267	DL EX	100			

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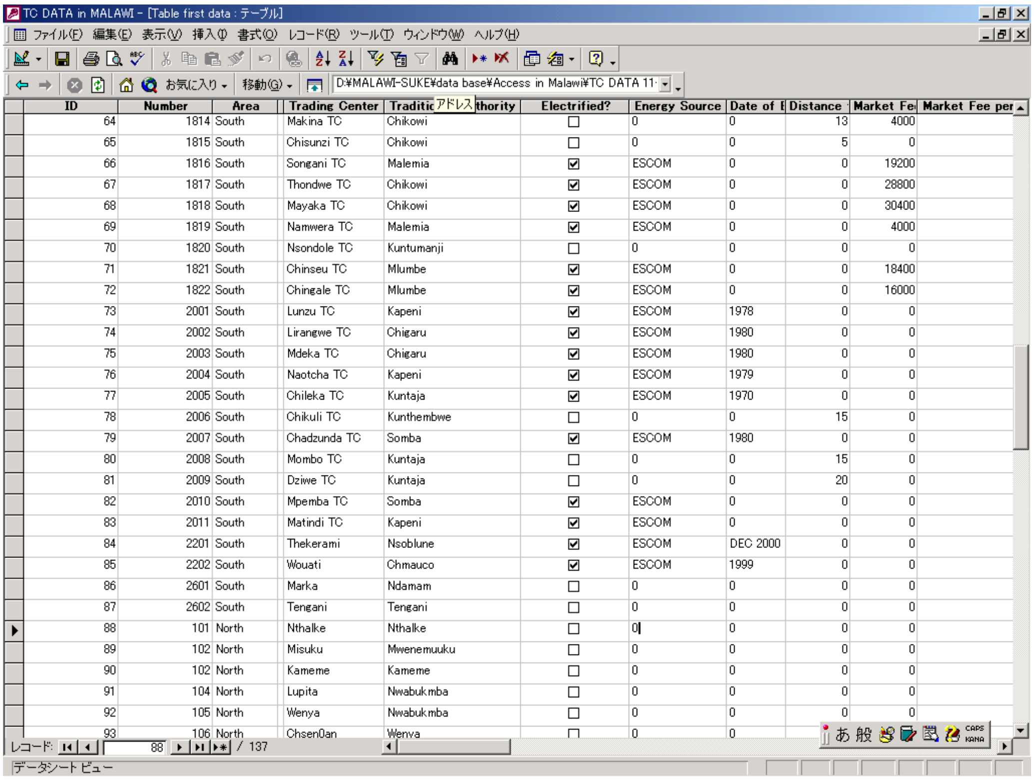
Fig. 9-3-9　Fundamental TC Table



TC DATA in MALAWI - [Table first data : テーブル]

ID	Number	Area	Trading Center	Traditic アドレス thority	Electrified?	Energy Source	Date of I	Distance	Market Fe	Market Fee per
64	1814	South	Makina TC	Chikowi	☐	0	0	13	4000	
65	1815	South	Chisunzi TC	Chikowi	☐	0	0	5	0	
66	1816	South	Songani TC	Malemia	☑	ESCOM	0	0	19200	
67	1817	South	Thondwe TC	Chikowi	☑	ESCOM	0	0	28800	
68	1818	South	Mayaka TC	Chikowi	☑	ESCOM	0	0	30400	
69	1819	South	Namwera TC	Malemia	☑	ESCOM	0	0	4000	
70	1820	South	Nsondole TC	Kuntumanji	☐	0	0	0	0	
71	1821	South	Chinseu TC	Mlumbe	☑	ESCOM	0	0	18400	
72	1822	South	Chingale TC	Mlumbe	☑	ESCOM	0	0	16000	
73	2001	South	Lunzu TC	Kapeni	☑	ESCOM	1978	0	0	
74	2002	South	Lirangwe TC	Chigaru	☑	ESCOM	1980	0	0	
75	2003	South	Mdeka TC	Chigaru	☑	ESCOM	1980	0	0	
76	2004	South	Naotcha TC	Kapeni	☑	ESCOM	1979	0	0	
77	2005	South	Chileka TC	Kuntaja	☑	ESCOM	1970	0	0	
78	2006	South	Chikuli TC	Kunthembwe	☐	0	0	15	0	
79	2007	South	Chadzunda TC	Somba	☑	ESCOM	1980	0	0	
80	2008	South	Mombo TC	Kuntaja	☐	0	0	15	0	
81	2009	South	Dziwe TC	Kuntaja	☐	0	0	20	0	
82	2010	South	Mpemba TC	Somba	☑	ESCOM	0	0	0	
83	2011	South	Matindi TC	Kapeni	☑	ESCOM	0	0	0	
84	2201	South	Thekerami	Nsoblune	☑	ESCOM	DEC 2000	0	0	
85	2202	South	Wouati	Chmauco	☑	ESCOM	1999	0	0	
86	2601	South	Marka	Ndamam	☐	0	0	0	0	
87	2602	South	Tengani	Tengani	☐	0	0	0	0	
88	101	North	Nthalke	Nthalke	☐	0	0	0	0	
89	102	North	Misuku	Mwenemuuku	☐	0	0	0	0	
90	102	North	Kameme	Kameme	☐	0	0	0	0	
91	104	North	Lupita	Nwabukmba	☐	0	0	0	0	
92	105	North	Wenya	Nwabukmba	☐	0	0	0	0	
93	106	North	Chsen0an	Wenya	☐	0	0			

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Fig. 9-3-10　First Data Table

9.4 Data Items

Information of each TC is arranged in this database according to the following items.

1. Fundamental Information
   District name / TC name / Traditional Authority name / Market Fee / Household number / Distance from the existing distribution line / Population （in the TC, in the Catchment Area (CA)） / Phase Number / Peak Demand / Energy Demand / Priority (Phase Number)
2. Public Facilities Information
   School (Primary, Secondary) / Hospital / Health Centre / Under Five Clinic / Police / Church / Mosque / Court / Government Office / Other Public Facilities
3. Business Entities Information
   Market / Maize Mill / Restaurant / Rest House / Battery Charge Station / Other Business Entities
4. Electrified Cost

The Cost, NPV, IRR, B/C of each method of electrification (Extension of distribution line, Micro Hydro, PV, Diesel)

CHAPTER 10 ECONOMIC AND FINANCIAL ANALYSIS

Chapter 10 Economic and Financial Analysis

10.1 Current State of the Malawi Economy

Malawi ranks as one of the least developed countries in the world. It's GDP in the year 2000 was US$9.4 billion. With a population of 1.05 million, GDP per capita is about US$900, which makes it only slightly above the LIC level.

Its economic base is predominantly agricultural. Ninety percent of the population lives in rural areas, and 86% of the labor force is engaged in agriculture. 37% of the GDP comes from the agricultural sector, and 85% of its export is agricultural products. Its main products are maize, tobacco, tea, sugarcane, groundnuts, cotton, wheat,, coffee, potatoes, cassava (tapioca), sorghum, pulses and others. Its main export products are tobacco, sugar and groundnuts.

Malawi economy relies heavily on aids from international and bilateral donors. As a country with a national revenue of US$ 490 million, the total amount of foreign aid received in 1999 amounts to US$427 million, 87% of the national revenue. The amount of foreign aid is US$2.9 billion in 2000. As a result, in late 2000, Malawi was approved for relief under the Heavily Indebted Poor Countries (HIPC) program.

As with other countries in the South African region, HIV/AIDS proliferation has become an increasingly serious issue. It is estimated that 15% of the whole population is HIV positive, which holds dark implications for the country.

The GDP growth in 2000 is about 3%, while inflation (CPI growth) is 29.5%, an extremely high figure.

National currency is the Malawian kwacha (MWK). Sub currency of Tambala is also used (1MWK=100 Tambala). The value of MWK is 80MWK per US$1 as of year end 2000. With the extremely high rate if inflation since 1998, foreign exchange rate is also showing a dramatic drop.

Table 10-1 Foreign Exchange Rate for Malawian Kwacha

	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2001 end**
MK/US$	15.3085	16.4442	31.0727	44.0881	59.5438	72.1973	67.3111
Change		7.4%	89.0%	41.9%	35.1%	21.3%	-6.8%

Sorce: WORLD FACT BOOK 2002

10.1.1 Power Sector

Total power generation in Malawi is 1.025 billion kWh. The generation relies predominantly on hydro. 97.57% of the total generation is hydropower, and 2.44% is generated using fossil fuel. The power used is 850 million kWh, and it also exports 300 million kWh to surrounding countries.

Because of its reliance on hydro power, the generation in Malawi is sensitive to rainfalls. It is said that the rainfall in the area shows a very long cycle of about 30 years, which could become a risk factor for future generation. Under low rainfall, it may become necessary to import the power, rather than serve as an exporter as it does today.

The main body responsible for power in Malawi is the Electricity Supply Corporation of Malawi Limited (ESCOM). ESCOM was originally the Electricity Supply Commission of Malawi. However, on November 30th 1998, Parliament passed the Electricity Supply Commission of Malawi (Repeal) Act, which received Presidential Assent in December 6, 1999. All assets, liabilities and trade of the Commission was acquired by the Electricity Supply Corporation of Malawi Limited (ESCOM).

The role of ESCOM in the field of rural electrification is to connect to the customers through the extension of the grid. Originally, ESCOM was also responsible for the electrification of rural areas. However, with ESCOM becoming a corporation, such unprofitable pursuit was considered to be out of the line of ESCOM's business. The current responsibility of rural electrification resides in the Department of Energy (DOE), although ESCOM often handles the actual installation and operations on behalf of DOE on a fee basis.

10.1.2 The Business Condition of ESCOM

ESCOM handles all aspect of power in Malawi, including generation, transmission and distribution. Its activities are extremely significant for the proper understanding of the power sector in Malawi. Also, it is important to understand the financial strength of ESCOM in order to determine the prospect of rural electrification through grid extension.

Several indicators that demonstrate the business situation of ESCOM are listed below;

	1989/90	**1990/91**	**1991/92**	**1992/93**	**1993/94**	**1994/95**	**1995/96**	**1996/97**	**1997/98**	**1998/99**
Consumers	39,504	43,339	45,712	51,000	52,293	57,270	61,482	65,786	71,990	77,383
Consumer growth (%)	-	10%	5%	12%	3%	10%	7%	7%	9%	7%
Generation (MkWh)	792.41	707.08	772.8	784.72	831.88	859.9	857.65	891.73	977.39	1021.09
Units Sold (MkWh)	655.2	598.08	648.64	654.98	702.27	723.03	724.91	741.66	801.63	846.05
Sold Unit Growth (%)	-	-9%	8%	1%	7%	3%	0%	2%	8%	6%
Revenue/Unit (Tambala	11.5	12.48	12.8	19.83	21.08	29.68	48.87	61.8	84.06	133.5
Cost/Unit (Tambala)	7.44	7.84	7.77	9.27	9.24	15.22	25.85	39.33	61.74	101.28
%of cost/revenue	65%	63%	61%	47%	44%	51%	53%	64%	73%	76%

In a country with a population of 10 million, the number of consumers below 80 thousand is an extremely low figure. Although there are some consumers who rely on independent electricity sources, the low level of electrification in Malawi is apparent in this figure. The number of consumers showed an annual growth rate of 7%. Considering the low number of consumers to begin with, this level of growth is not impressive. If this pace continues, it would take at least several decades before a modest share of the population would have access to power.

The amount of power sold shows growth, but its growth rate falls short of the customer growth. The growth rate for power sold fluctuates, but it is consistently below the customer growth, which implies diminishing returns for new customers that are connected to the grid.

Also, the ratio between the power sold and the power generated shows that the system loss is rather high at 18.2%. This figure is gradually increasing in recent years.

On the cost structure, the cost ration has increased significantly in the recent years. In 1992-1994, the overall cost was about 45% of the total revenue. In 1999, however, the overall cost occupied 76% of the total revenue, which leaves very little room for profit. This is a result of the cost increase caused by inflation. The tariff seems to have been increased at an average rate of 50% every year since 1994, but this was not sufficient to catch up with the cost increase. In 2000, ESCOM has managed to increase its tariff significantly to meet the long run marginal cost (LRMC), which is estimated for Malawi to be around 6US Cent/kWh in 1998. This should significantly improve its financial situation.

10.1.3 Financial Condition of ESCOM

The Profit and Loss (P/L) statement is shown below. Based on the P/L statement, ESCOM has managed to increase its sales at a steady pace since 1995, reaching 1.68 billion MWK in 1999/2000. It has also recorded accounting profits continuously since 1995, which reached 311 million MWK in 1999/2000. The operational profit that showed a decline up to 1998/99 also managed to recover in 1999/2000. Where as the cost increased at an annual rate of 60-70%, the revenue up to 1998/99 only grew at 40-70%, but this situation has improved significantly in 1999/2000.

Profit and Loss Statement (000K)

	1995/96	1996/97	1997/98	1998/99	1999/2000
Sales from Energy	354,550	458,892	674,067	1,130,265	1,675,378
Capital Contribution	5,849	6,087	6,845	28,052	10,171
Income from Operation	360,399	464,979	680,912	1,158,317	1,685,549
Generation & Transmission	30,502	45,733	55,858	100,404	190,231
Distribution	24,692	43,155	65,622	108,893	138,035
Administration	66,038	94,121	119,843	234,553	406,779
Transport	17,050	24,882	29,919	54,152	75,795
Depreciation	45,788	81,590	121,946	160,119	194,338
Interest on LT Loans	24,623	52,262	156,682	291,531	313,227
Interst on ST Loans	2,002	1,992	517	347	2,440
Total Operational Expenditure	210,695	343,735	550,387	949,999	1,320,845
Operationg Profit	149,704	121,244	130,525	208,318	364,704
Forex gain/loss	14,270	714	-78,760	-124,195	43,993
Training	-3,284	-4,106	-8,521	-6,979	-2,545
Interest received	1,568	694	4,703	4,873	7,215
Profit on Asset Sales	1,762	110	10,954	3,044	3,363
Sundry income	1,772	4,746	4,788	11,381	50,150
Total Sundry Income	16,088	2,158	-66,836	-111,876	102,176
Profit before Additional Depr	165,792	123,402	63,689	96,442	466,880
Additional Depriciation	44,829	27,090	0	0	0
Profit Before Tax	120,963	96,312	63,689	96,442	466,880
Tax	10	15	20	29,221	155,593
After Tax Profit	120,953	96,297	63,669	67,221	311,287

Another significant factor in recent years is the foreign exchange loss. Because of the devaluation of the MWK in recent years, the amount of foreign exchange loss has also mounted, pulling down the accounting profits. Although the situation improved in 1999/2000, the foreign exchange situation has worsened significantly since then, which leaves room for concern.

ESCOM was incorporated in 1998-1999, which also created some accounting changes. The most significant change is that ESCOM is now required to pay corporate tax. An amount of 29 million MWK has been paid in 1998/99, and 155 million MWK in 1999/2000.

As a result, the profitability of ESCOM operations showed a sharp decline initially. In 1995, the after-tax profits amounted to 1/3 of the total revenue. This has come down to only 6% in 1999, but since then, it has recovered to 18%, showing improvement.

The balance sheet of ESCOM is shown in the next table.

Balance Sheet (000K)

	1995/96	1996/97	1997/98	1998/99	1999/2000
Reserves	387,834	484,131	547,800	1,168,363	1,479,650
Long-Term Borrowings	1,873,285	2,326,058	3,375,273	6,349,754	7,974,253
Contribution to Capital Works	129,513	152,746	186,589	586,382	1,091,585
Total Funds Employed	2,390,632	2,962,935	4,109,662	8,104,499	10,545,488
Fixed Assets	1,025,181	2,485,177	3,238,173	4,718,669	4,869,601
Capital Works in Progress	1,641,446	419,166	1,313,424	4,141,748	6,599,044
Total Long Term Assets	2,666,627	2,904,343	4,551,597	8,860,417	11,468,645
Stocks	53,605	55,275	82,721	148,621	166,505
Debtors & Prepayments	102,812	391,152	466,691	494,314	795,797
Cash	9,117	65,589	121,042	133,438	116,386
Taxation Recoverables			1,212	1,997	2,347
Total Current Assets	165,534	512,016	671,666	778,370	1,081,035
Creditors	285,457	300,399	912,012	1,020,849	1,359,734
Consumer Deposits	3,104	3,941	4,835		
Short-Term Borrowings	4,334	0			
Current Portion of LT Loan	148,634	149,084	196,754	513,439	644,458
Total Current Liabilities	441,529	453,424	1,113,601	1,534,288	2,004,192
Net Current Assets/(Liabilities)	-275,995	58,592	-441,935	-755,918	-923,157
Total Employment of Funds	2,390,632	2,962,935	4,109,662	8,104,499	10,545,488
Total Assets	2,832,161	3,416,359	5,223,263	9,638,787	12,549,680
Total Liabilities	2,832,161	3,416,359	5,223,263	9,638,787	12,549,680

The total asset of ESCOM amounts to 12.55 billion MWK, with the permanent portion being 11.5 billion MWK. The amount of total asset has shown a dramatic increase in recent years, although in 1999/2000 this stabilized to an extent. This is in part due to the high inflation, but also to the aggressive level of investment that ESCOM has continued to carry out. One billion MWK amount of new fixed asset has been added to the balance sheet annually. The amount is lower in 1999/2000, but assets under construction still shows a high figure, which indicates a continuing high level of investment.

On the other hand, against the total asset of 12.55 billion MWK (with 11.5 billion MWK long term), long term liability amounts to 7.97K. This is 64% of the long term funds. This shows that ESCOM relies heavily on borrowing, although infrastructure firms such as power companies tend to show a higher debt ratio, and this figure does not seem to be excessive.

It should be noted that Malawi has experienced a very high level of inflation (about 30%), which causes the fixed assets and reserves to be undervalued. If this level of inflation continues, it should be advisable to introduce constant cost accounting, although it does not do so at the moment.

As for the proper value of the assets, the World Bank has made an estimate using an outside auditor for 1995-1997 in the year 1998, which is attached below. Similar figures for 1998 and 1999 are not available at the time.

Balance Sheet (with Reevaluation) (000K)

	1995/96	1996/97
Reserves	4,041,495	3,918,681
Long-Term Borrowings	1,873,285	2,326,058
Contribution to Capital Works	129,513	152,746
Total Funds Employed	6,044,293	6,397,485
Fixed Assets	4,678,842	5,919,727
Capital Works in Progress	1,641,446	419,166
Total Long Term Assets	6,320,288	6,338,893
Stocks	53,605	55,275
Debtors & Prepayments	102,812	391,152
Cash	9,117	65,589
Taxation Recoverables		
Total Current Assets	165,534	512,016
Creditors	285,457	300,399
Consumer Deposits	3,104	3,941
Short-Term Borrowings	4,334	0
Current Portion of LT Loan	148,634	149,084
Total Current Liabilities	441,529	453,424
Net Current Assets/(Liabilities)	-275,995	58,592
Total Employment of Funds	6,044,293	6,397,485
Total Assets	6,485,822	6,850,909
Total Liabilities	6,485,822	6,850,909

The following table shows the cash flow of ESCOM.

As mentioned in the description of the Balance Sheet, ESCOM is currently engaging in an aggressive investment plan. In 1999/2000, ESCOM, with a total asset of 12.55 billion MWK, has carried out an investment of 1.88 billion MWK, which is about 15%

of the total asset. The money required for investment amounts to about three times the internally generated cash. Therefore, ESCOM relies on long term borrowing to finance its huge investment every year.

The increase of long term borrowing naturally brings increased interest payments and principle repayment. At the moment, this has not caused any problem, and with the debt service coverage ratio under 2, it is at a manageable level. ESCOM has never defaulted on its obligations for loans that ESCOM took out itself. However, the interest payment and the principle repayment should increase dramatically in the following years, which should bring ESCOM a huge challenge in the future.

Cash Flow Statement (000K)

	1995/96	1996/97	1997/98	1998/99	1999/2000
Cash from Operations	284,113	-72,813	331,217	693,518	727,994
Interest Paid	-43,095	-46,385	-74,113	-143,931	-206,329
Taxation Recovered	-687	115	-228	-805	-550
Total	240,331	-119,083	256,876	548,782	521,115
Fixed Assets & Capital Works	-637,709	-296,391	-581,391	-1,888,468	-1,813,364
Disposed Fixed Assets	2,112	821	11,260	3,807	5,124
Interst	1,568	694	4,703	4,873	7,215
Cash from Investment	-634,029	-294,876	-565,428	-1,879,788	-1,801,025
Short Term Borrowing	4,334	0	0	0	0
Long Term Borrowing	428,171	496,371	362,202	1,347,532	1,228,334
Repayment of LT Borrowing	-62,065	-55,260	-38,885	-92,059	-298,977
Grants, Contributions	19,060	29,320	40,688	87,929	333,501
Cash from Financing	389,500	470,431	364,005	1,343,402	1,262,858
Change in Cash Position	-4,198	56,472	55,453	12,396	-17,052
Cash at Begininng	13,315	9,117	65,589	121,042	133,438
Cash at Year End	9,117	65,589	121,042	133,438	116,386

10.1.4 Conclusion

ESCOM is engaged in an extremely aggressive investment program, which amounts to 15% of its total assets every year. Even with this level of investment, however, it has not managed to adequately meet the need for new capacity and rehabilitation for the existing facilities. The number of customers still remains low. ESCOM would have to continue a high level of investment for a considerable time.

The revenue that ESCOM collects, however, is insufficient to cover the massive investment. Even with the tariff increased 40-50% every year, the cost increase more than offsets this, decreasing profitability and leaving less money for investment. The situation has somewhat improved in fiscal 1999/2000, and in 2000, the tariff has been raised to 6 US Cent/kWh, which is recommended from the long term marginal cost estimate. This should lead to much financial improvement in the coming years, although the figures have not been released yet.

Therefore, most of the investment relies on long term loans. However, ESCOM is already heavily in debt, which makes it difficult to take on more loans that are necessary for future investment. The debt service is expected to rise sharply, which would also undermine the financial health of ESCOM.

Considering the future of Malawi, the investment in the power sector needs to continue. Also, considering this situation, it would be difficult for ESCOM to foot the bill for the huge investment and operational costs incurred by the coming programs for rural electrification.

10.2 Economic and Financial Analysis of the Rural Electrification Master Plan

10.2.1 Economic Analysis

The Benefit/Cost ratio and the Economic IRR for the electrification of various TCs have been undertaken at the time of the selection of the electrification method for each of the TCs in Phase V/VI.

In most regions, B/C is over 2, and where applicable, IRR generally exceeds 20%. It can be said that there are high economic returns for the electrification of these TCs.

In this master plan, most TCs are electrified through grid extension. Malawi is a thin strip of land that extends from north to south, and the transmission lines from north to south is already in existence. Therefore, all TCs can be reached by relatively short stretch of the grid. This allows relatively low level of investment, which allows for higher returns.

10.2.2 Financial Analysis

The analysis of the last section shows that the master plan is economically feasible. However, in order to be feasible, the plan must make financial sense. This section will look into that aspect, focusing on the tariff level.

10.2.3 Existing Cost and Tariff Analysis

On June 2002, Likoma Island was electrified using a diesel generator. ESCOM has conducted an analysis of the costs and its impact on the tariff level. Since Likoma Island is located in Lake Malawi, it cannot be electrified by grid extension. It must rely on an independent generator. Such generators will have a high operation cost, especially for the diesel generators that are used, since the transportation cost for the diesel fuel will be extremely high. Therefore, it is interesting to examine this analysis as an indicator of one of the most costly example of electrification.

In the scheme for Likoma Island, the government pays for a large portion (80 percent to 100 percent) of the capital investment. ESCOM will take over this facility and put it on their balance sheet. ESCOM will pay for any remaining investment cost, financed by debt (20% interest), and operates the facility. Most of the operation cost will be the diesel fuel cost. The tariff is the sum of the operation cost, depreciation (15 year straight line depreciation), interest, capital cost.

ESCOM used this analysis to see the relation between the government assistance and its effect on the tariff. The analysis looks at 4 alternatives;

- Alternative 1: Gov pay 80% Capital Contribution
- Alternative 2: Gov pay 100% Capital Contribution
- Alternative 3: Gov pay 80% Capital Contribution & 50% of Ops Cost
- Alternative 4: Gov pay 100% Capital Contribution & Offset 50% Ops Cost

For each of these alternatives, the tariff for Likoma only and the tariff where the whole cost is spread out for all of ESCOM is calculated.

Table 10-2-1 Likoma Island Cost Analysis

Alternative 1

IMPACT ANALYSIS OF ELECTRIFICATION OF LIKOMA ISLAND (MGov pay 80% Capital Contribution)						
	2003 Budget	Likoma Island	Likoma Island Included	Increase(%)	2002 Forecast	2001 Actual
Units Sold(kWh '000)	920,000	876	920,876	0.10	876,454	904,356
Ops(K/kWh)	1.48	12.90	1.49	0.89	1.46	1.24
Interest(K/kWh)	0.69	2.28	0.69	0.22	0.70	0.60
Depreciation(K/kWh)	0.25	3.81	0.25	1.36	0.25	0.21
Capital & Loans(K/kWh)	1.50	0.76	1.50	-0.05	1.50	0.83
Average Price(Kwacha)	**3.91**	**19.75**	**3.93**	**0.45**	**3.91**	**2.88**

Impact	**241**	**K'million**
Government Contribution	**40**	**K'million**

Alternative 2

IMPACT ANALYSIS OF ELECTRIFICATION OF LIKOMA ISLAND (MGov pay 100% Capital Contribution)						
	2003 Budget	Likoma Island	Likoma Island Included	Increase(%)	2002 Forecast	2001 Actual
Units Sold(kWh '000)	920,000	876	920,876	0.10	876,454	904,356
Ops(K/kWh)	1.48	12.90	1.49	0.89	1.46	1.24
Interest(K/kWh)	0.69	0.00	0.68	-0.10	0.70	0.60
Depreciation(K/kWh)	0.25	3.81	0.25	1.36	0.25	0.21
Capital & Loans(K/kWh)	1.50	0.00	1.50	-0.10	1.50	0.83
Average Price(Kwacha)	**3.91**	**16.71**	**3.92**	**0.37**	**3.91**	**2.88**

Impact	**201**	**K'million**
Government Contribution	**50**	**K'million**

Alternative 3

IMPACT ANALYSIS OF ELECTRIFICATION OF LIKOMA ISLAND (MGov pay 80% Capital Contribution & 50% of Ops Cost)						
	2003 Budget	Likoma Island	Likoma Island Included	Increase(%)	2002 Forecast	2001 Actual
Units Sold(kWh '000)	920,000	876	920,876	0.10	876,454	904,356
Ops(K/kWh)	1.48	6.45	1.48	0.40	1.46	1.24
Interest(K/kWh)	0.69	2.28	0.69	0.22	0.70	0.60
Depreciation(K/kWh)	0.25	3.81	0.25	1.36	0.25	0.21
Capital & Loans(K/kWh)	1.50	0.76	1.50	-0.05	1.50	0.83
Average Price(Kwacha)	**3.91**	**13.30**	**3.92**	**0.26**	**3.91**	**2.88**

Impact	**140**	**K'million**
Government Contribution	**125**	**K'million**

Alternative 4

ACT ANALYSIS OF ELECTRIFICATION OF LIKOMA ISLAND (MGov pay 100% Capital Contribution & Offset 50% Ops Cost to Debt Arr						
	2003 Budget	Likoma Island	Likoma Island Included	Increase(%)	2002 Forecast	2001 Actual
Units Sold(kWh '000)	920,000	876	920,876	0.10	876,454	904,356
Ops(K/kWh)	1.48	6.45	1.48	0.40	1.46	1.24
Interest(K/kWh)	0.69	0.00	0.68	-0.10	0.70	0.60
Depreciation(K/kWh)	0.25	3.81	0.25	1.36	0.25	0.21
Capital & Loans(K/kWh)	1.50	0.00	1.50	-0.10	1.50	0.83
Average Price(Kwacha)	**3.91**	**10.26**	**3.92**	**0.19**	**3.91**	**2.88**

Impact	**100**	**K'million**
Government Contribution	**50+6pa**	**K'million**

Source: ESCOM

Spreading the cost for Likoma Island to all of ESCOM is in effect a cross-subsidization scheme. It allows the current ESCOM customers (mostly urban

users) to effectively pay for the residents in Likoma Island. For example, in Alternative 1, if all the cost were borne by the Likoma residents, the tariff must be as high as 19.75 Kwacha/kWh, where the current ESCOM tariff is only 3.91 Kwacha. The tariff at the Island will be 5 times as much as the ESCOM tariff. If, however, this cost is spread out to all of ESCOM, the ESCOM tariff will increase from 3.91 to 3.93 Kwacha/kWh.
Also, comparing the alternatives, the more the government pays, less the tariff change.

The level of capital contribution does not change the depreciation cost. This is because all the alternatives are properly taking into account the replacement cost after 15 years. Also, it is interesting to notice that the tariff level in alternative 1 is exactly the level that achieves 8 percent internal rate of return. Below is the estimate of the cash flow that ESCOM would have had in mind. The currency has been converted to US dollars in order to allow easier comparison.

Table 10-2-2 Likoma Island Electrification Cash Flow Estimate

Likoma

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Energy Demand (000 kWh)		876.0	876.0	876.0	876.0	876.0	876.0	876.0	876.0	876.0	876.0	876.0	876.0	876.0	876.0	876.0
Tarrif (cent/kWh)		24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7
Revenue (000 US$)		216.3	216.3	216.3	216.3	216.3	216.3	216.3	216.3	216.3	216.3	216.3	216.3	216.3	216.3	216.3
O&M (000 US$)		141.3	141.3	141.3	141.3	141.3	141.3	141.3	141.3	141.3	141.3	141.3	141.3	141.3	141.3	141.3
Investment (000 US$)	625															
Total	-625.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0

IRR= 8%

10.2.4 The Tariff Level of the Master Plan

Here, we attempt a similar analysis of the required tariff level for the proposed master plan.

At the time of this analysis, however, the exact scheme to be used for the master plan implementation has not been determined. Therefore, it is not possible to consider the impact of government intervention, as in the Likoma Island study. Even if some level of subsidy was decided, how to carry that out should become a large problem, since the power sector of Malawi is planned to go through a large structural reform in the near future. Under the current structure where ESCOM handles all of the electrification, government subsidy is straightforward, and cross subsidy within the power sector will become a matter of ESCOM's internal accounting. If, however, other operators will enter the market, the scheme to provide a fair subsidy will be necessarily complicated.

At this point, the study limits itself to a purely cash flow based analysis. It estimates the level of tariff without any subsidy. This should clarify the ease or difficulty of the electrification of each area, enable discussions about the appropriate project schemes for them.

(1) Assumptions

Here we assume that a separate organization will undertake the electrification of each TC, using its own resources without any borrowing. The organization will purchase electricity from ESCOM (current ESCOM or possibly the generation/transmission portion of the unbundled ESCOM in the future) at a wholesale price, and resell the power to the end users.

Based on the power sector reform plan of the government, the participation of the private sector will be encouraged in these schemes. Since no private party will participate without a certain level of expected profit, the study will assume some positive return (8% in this case).

Other conditions are as follows:

- Demand forecast:

Future power demand for each TC has been estimated when calculating the EIRR. Here, it is assumed that each TC will reach that estimated demand after 20 years, with annual demand growing at 7%. To simplify the simulation, households and businesses are not considered separately. The simulation simply looks at the total demand of the TC.

- Wholesale price of power: 3.5cent/kWh

This is estimated based on the current ratio between the generation cost and the distribution cost of ESCOM.

- Operation Cost

Includes administrative and other overheads. Since most TCs will rely on grid extension, the O&M cost will be proportional to the initial investment. Here, we assume 3 percent of the initial outlay every year.

Under these conditions, the tariff level required to achieve 8% IRR is calculated for each TC. IRR of 8% has been chosen since it is the figure that is assumed by ESCOM in their Likoma Island estimate, and also because it is the figure often used by various donors as the conditionality of their loans. Also, the level of tariff is expressed in terms of multiples of the current ESCOM tariff (6.5cent/kWh).

(2) Results

Based on these assumptions, the tariff level has been estimated. Shown below is a sample estimate for Mkaia.

Table 10-2-3 Electrification Tariff Analysis of Mkaia

Mkaia

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Energy Demand (000 kWh)		637	685	736	792	852	916	985	1,059	1,138	1,224	1,316	1,415	1,522	1,636	1,759	1,892	2,034	2,187	2,352	2,529
Tarrif (cent/kWh)		6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
Revenue (000 US$)		42.5	45.6	49.1	52.8	56.7	61.0	65.6	70.6	75.9	81.6	87.7	94.3	101.4	109.0	117.3	126.1	135.6	145.8	156.7	168.5
Energy Cost (3.5 cent/kWh)		22.3	24.0	25.8	27.7	29.8	32.0	34.5	37.1	39.8	42.8	46.1	49.5	53.3	57.3	61.6	66.2	71.2	76.6	82.3	88.5
O&M (000 US$)		8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
Investment (000 US$)	277																				
Total	−277.0	11.8	13.4	15.0	16.7	18.6	20.7	22.8	25.2	27.7	30.4	33.3	36.5	39.8	43.5	47.4	51.6	56.1	60.9	66.1	71.7

IRR= 8%

Tarrif Multiple 1.025

The total investment is US$277,000, while the power demand will reach 2,529 MWh. For this project to yield an 8% IRR, the tariff level must be 1.025 times the current ESCOM tariff. This means that Mkaia can be electrified at virtually the same tariff level, and thus it is a relatively attractive area for a potential operator.

An example of the other extreme is Chitimba.

Table 10-2-4 Electrification Tariff Analysis of Chitimba

Chitimba

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Energy Demand (000 kWh)		24.7	26.5	28.5	30.7	33.0	35.5	38.2	41.0	44.1	47.4	51.0	54.8	59.0	63.4	68.2	73.3	78.8	84.8	91.1	98.0
Tarrif (cent/kWh)		72.6	72.6	72.6	72.6	72.6	72.6	72.6	72.6	72.6	72.6	72.6	72.6	72.6	72.6	72.6	72.6	72.6	72.6	72.6	72.6
Revenue (000 US$)		17.9	19.3	20.7	22.3	24.0	25.8	27.7	29.8	32.0	34.4	37.0	39.8	42.8	46.0	49.5	53.2	57.2	61.6	66.2	71.2
Energy Cost (3.5 cent/kWh)		0.9	0.9	1.0	1.1	1.2	1.2	1.3	1.4	1.5	1.7	1.8	1.9	2.1	2.2	2.4	2.6	2.8	3.0	3.2	3.4
O&M (000 US$)		7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
Investment (000 US$)	235																				
Total	−235.0	10.0	11.3	12.7	14.2	15.8	17.5	19.3	21.3	23.4	25.7	28.2	30.9	33.7	36.8	40.1	43.6	47.4	51.5	56.0	60.7

IRR= 8%

Tarrif Multiple 11.173

The total investment is US$235,000, which is similar to that of the Mkaia above. The demand after 20 years, however, is only 98 MWh, which is extremely low compared to 2,920 in Mkaia. With this low level of demand, the tariff level necessarily becomes high at 11.2 times the current ESCOM rate. This is not a level that ordinary

Malawians can afford. From this analysis, it is clear that it is impossible to electrify this TC separately. Some form of subsidy will be necessary.

Similar analysis for each TCs are shown in the Appendix. The results are summarized in the following tables;

10.3 Conclusions

Of the 52 TG that are planed to be electrified in Phase V, about five can be feasibly electrified at the current tariff level. There are 16 TCs that can be sustained at less than 1.5 times the current tariff level. It may be possible to electrify these TCs without any subsidy through cost reduction efforts and aggressive sales.

For the remaining TCs, however, it is quite clear that they could not be electrified with the current tariff level. On average, 26 TCs in Phase V-1 require 2.4 times the current tariff level, and for Phase V-2, the average is 3.2 times the current level in order to maintain operation.

Region-wise, TCs in the Northern region and the Central region see relatively low multiples, where as the TCs in the Southern region seems more expensive.

Since we have already compared the various electrification methods and chosen the most cost effective ones, switching to another method will not solve the problem. Any solution must therefore be at the institutional level. We can consider the following options;

- Allow separate tariff levels for various areas

The simplest way to deal with this issue is to simply acknowledge the difference in feasibility, and allow different tariff to be set for each area or electrification body. Each area or body will set the tariff that will make it feasible.

This, however, will not work in practice. If the difference in required tariff level is minor, this may be an option. However, as the above analysis shows, the difference is quite large, ranging from less than 1 times to more than 12 times. The above simulation does not take the price elasticity of demand into consideration. A tariff level over five times the current level will not be affordable for most Malawians, which means there will be no demand at that price level. There will be no operators in those areas, which will remain unelectrified.

The tariff level also has a political dimension. The current policy of Malawi is to have a uniform tariff. It will require significant time and effort to change this.

- Combine TCs to make it feasible

By combining the TCs with high feasibility and low feasibility in concessioning the operation rights, it may be possible to prevent cherry picking by the operators, and enable steady electrification at the current tariff level. It may also be possible for the government to take charge of the most expensive regions, and make commercial operators do the others.

While this is possible, it may not work with the current scheme. Since the average required tariff is above twice the current level, no combination can make the operation feasible at the current tariff level.

- Lower the profitability

Current estimate is based on IRR = 8%. There is, however, no fixed reason that it must be 8%. If the operation organization can live with a lower return, it will enable a lower tariff and/or lower level of subsidy. For example, the government may create a public private partnership for rural electrification and provide 50% equity that expects now return.

No organization, however, can continue producing negative return. Unless it provides a positive return, the operation is not feasible. And within this bounds, a slight change in the required IRR does not change the picture very much. In the case of Chitimba that was sited before, for example, lowering the required IRR from 8% to 4% will result in a tariff level of 9.6 times the current level. Although this is better than 11 times, it does not significantly change the situation.

- Increase the tariff level for the whole country, and fund rural electrification from within that increase

Practically, it is impossible to make rural electrification pay for itself under the current level of tariff. Subsidy is required in one form or another, which will most likely come in the form of a cross subsidy from the national tariff from to the rural electrification.

In order to assess the level of such subsidy, we can think of a scheme similar to that of Likoma Island. Suppose the government will pay for all the capital costs and hands them over to ESCOM, the current tariff level of 3.91 Kwacha/kWh must be increased to 4.1 Kwacha/kWh. The increment will be 4.7 percent of the current tariff. This will be the maximum level of subsidy required. The ESCOM tariff has already been raised significantly in recent years. Additional increase may meet resistance. However, this need not be done at once. Tariff can be increased in increments. A total increase of about 5 percent over several years is not unthinkable.

Another issue would be how to distribute the collected fund. This will be especially be difficult, once ESCOM will become unbundled. The amount of subsidy to be provided to the operators will also be difficult to determine.

It is likely that some form of a rural electrification fund be established, and ESCOM will be asked to be in charge of the collection of that fund as a percentage of the electricity tariff. The energy fund, currently used as source of funds for rural electrification is exactly such a fund, and the law has already been amended to allow the fund to be charged to electricity tariff to achieve exactly the same effect.

10.4 Funding

The amount of investment required for Phase V-1 of the rural electrification master plan is US$7,494,000. The amount for Phase V-2 is US$5,216,000.

The main source of funds for the current rural electrification is the energy fund, based on taxes from gasoline. This fund collects about US$1 million annually. This fund has been amended so that now it is possible to collect the fund from electricity tariff also. One of the most stable sources for rural electrification is this Energy fund. At the current rate, it should be possible to electrify 4 to 5 TCs annually using this fund (although this figure will become lower when an expensive TC is included in the plan). It will take 8 years to complete Phase V-1 at the current ratio, and another 5 years to complete Phase V-2. If additional revenue from the electricity tariff will be introduced, this will become faster.

Recently, funds from the HIPC debt relief program has been applied to the field of rural electrification. This, however, is temporary, and cannot be expected to continue.

Aid from international donors will also help. At the moment, however, funds from other donors seems to be unpromising. The majority of TCs will be electrified through grid extension, and most donors will not finance grid extension project, even if they were for rural electrification.

- The World Bank and the UNDP is providing funds through the Malawi Social Action Fund (MASAF). This fund provides necessary capital for community based projects, such as school construction, road construction, and water systems. The community will organize a project body for such a project and apply for the fund. The fund is provided as a grant, although the Malawi government must pay back the World Bank and UNDP. In principle, this scheme can be applied to rural electrification. However, unlike independent grids and solar home systems, the operation and maintenance of a high voltage grid is not within the usual capabilities of a community-based organization. Also, there is a limit to the amount of funds that can be provided to a single community, which is about US$10,000. This amount is too low to be of any help to the current electrification scheme.

- The European Union currently does not fund grid extension projects. Their priority is in agriculture and roads. It will be difficult for them to provide funds to the current master plan.

CHAPTER 11 INSTITUTIONS AND ORGANIZATIONS

Chapter 11 Institutions and organizations

For the Republic of Malawi, the promotion of rural electrification (RE) has an important role to play as a support for socioeconomic advancement to improve levels of education, medical services, and the standard of living in rural areas. One of the major purposes of RE programs is to create employment opportunities and alleviate poverty by stimulating the rise of industry on a small scale or based on agriculture in these areas through the supply of electricity.

While the advancement of rural areas cannot be achieved solely through it, there can be no doubt that RE is a vital means to this end. The resolution of various problems stemming from poverty in these areas requires coordination between programs of social or industrial development and RE, in order to induce synergistic effects.

The Malawi government has been executing an RE program through the Electricity Supply Corporation of Malawi Limited (ESCOM) in order to get district centers which have thus far been without power connected to the grid (transmission and distribution system). Nevertheless, RE has not been making much headway; even at present, power is available to less than 0.5 percent of the rural population.

11.1 RE Program Implemented by ESCOM Thus Far

To date, ESCOM has implemented an RE program in three phases. The work in these phases extended the network of 66-kV transmission lines and 33/11-kV distribution lines, and the program has already been completed. There has not been much progress in extension of the network of 400-V transmission lines, however. This is because ESCOM has been asking customers to make a capital contribution for connection to distribution lines. As an electric utility, ESCOM must be operated on a commercial basis and have sound finances. As a result, there arose a conflict between the need for supply of electricity even to districts that are linked to loss and its duty as a corporation to secure earnings and keep its debt service ratio on a sound level. ESCOM was unable to resolve this conflict, and consequently abandoned its mission of promoting RE.

11.1.1 Phase 1

Over the years 1980 - 1989, ESCOM electrified a total of 13 district centers[1]. The purchase of imported items was funded with soft loans from the African Development Fund (ADF), and

[1] Bangula/Sorjin/Fatima/Nsanje, Chiradzulu, Mtendere campus, Namwera, Dowa, Mchinji, Nkhota-kota, Nkhata-Bay, Mzimba, Ekwendeni/Rumphi, Chitipa, Machinga, Ntchisi

ESCOM used its own funds to procure items from domestic sources. The phase installed about 600 kilometers of high-voltage lines.

11.1.2 Phase 2

The major undertakings in Phase 2 were the construction of a small hydropower plant with an output of 4.5 megawatts in Wovwe in the northern part of the country, and installation of about 212 kilometers of transmission and distribution lines. The plant was completed in 1996 and supplies power to Livingstonia, Chilumba, Rumphi, Karonga, and Chitipa. It is also used as a source of back-up power for the Mzuzu area. The project was executed with funding from Germany's Kreditanstadt fur Wiederanfbau (KfW) and ESCOM

11.1.3 Phase 3

The subjects of the RE program in Phase 3 were trading centers and tobacco-growing districts, which, although situated in the central part of the country, had not been electrified (i.e., Phalombe, Lirangwe, Nsanama/Ntaja, Lizulu, Linthipe, Mtakataka/Chipoka/Mua, Mlangeni-Golomoti-Monkey Bay, Bolero, and Kasungu-Mchinji). The work consisted of the installation of high-voltage lines and distribution lines, including some low-voltage ones. It was funded with soft loans from Spain.

11.2 Promotion of Further RE by the DOE

To promote further RE, the government removed RE programs from the scope of ESCOM business in 1995 and transferred the responsibility for them to the Department of Energy Affairs (DOE). The DOE is currently attached to the Ministry of Natural Resources and Environmental Affairs (MNREA).

By assuming direct responsibility for RE in this manner, the government manifested its firm commitment to pursue RE as part of its policy for socioeconomic advancement and alleviation of poverty. Upon transfer of the RE programs to the DOE, it instituted an ad-hoc organization (the Rural Electrification Unit) within the DOE, set up an "energy fund" for RE, and began the task of establishing criteria for selection of subject districts.

11.2.1 Prospective RE means in the DOE's view

The DOE believes that RE can be promoted through the two orientations of extending the ESCOM grid (transmission and distribution network) and developing off-grid sources making use of renewable energy.

11.2.1.1 Extension of the grid

The DOE views extension of the grid owned by ESCOM as the first option for RE promotion and assigns a supplemental role to the off-grid supply of power.

Because the DOE does not have enough personnel for construction of facilities, the task of extending transmission and distribution lines currently takes the form of consignment of the construction work to ESCOM. Upon the completion of the facilities, the property is to be transferred to ESCOM, while the Government of Malawi (GOM) holds an equivalent share.

11.2.1.2 Off-grid systems

Essentially, the off-grid approach is to be applied for districts in which extension of the grid is not feasible, for reasons of cost. The main candidate technology for off-grid electrification is photovoltaic (PV) systems. The DOE has already initiated a project entitled the National Sustainable Renewable Energy Program (NSREP) and is encouraging the installation of PV systems in that context. The United Nations Development Programme (UNDP), Danish International Development Agency (DANIDA), and the World Bank have pledged financial aid for the Program.

11.2.2 Institution of an energy fund

An energy fund was established to ensure a supply of funds for promotion of RE projects[2]. The fund wherewithal comes from taxes imposed on gasoline and diesel fuel. These taxes are collected by the Petroleum Control Commission, which makes monthly remittances of these revenues to the government's account.

Instituted in 1995, the fund was temporarily suspended in June 2000 and was excluded from the fiscal 2000/01 budget. This was because of the extremely tenuous relation between sales of petroleum products and supply of power. In 2001, however, the fund resumed. At present, it receives revenue from taxes of 0.50 Malawi kwacha (MK) per liter of gasoline and 0.40 MK per liter of diesel fuel. The revenue from these taxes is estimated to range between 9 and 10 million MK per month.

To eliminate ambiguity about the status of the energy fund, an RE bill now being prepared by the government stipulates the establishment of an official RE fund which will supersede the existing energy fund. Besides the revenues from the aforementioned taxes on petroleum products, the sources for this new RE fund are to include revenue from taxes on power tariffs (i.e., use charges) and fines provided for in the RE bill.

The government's determination to promote RE with domestic funds raised through the RE fund will presumably have a positive influence on efforts to obtain RE funds from international institutions and developed countries.

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[2] The use of this fund is not limited to RE, but RE is, in effect, the sole subject of funding from it.

11.2.3 Phase-4 program for extension of distribution lines

On the heels of the distribution line extension work carried out by ESCOM in the first three phases, the DOE is now promoting a Phase-4 program of distribution line extension. Six trading centers[3] and five middle schools[4] were chosen as subjects for grid extension in fiscal 1999/2000.

For fiscal 2001/02, a corresponding selection was made of a total of 42 growth centers, trading centers, and other centers. An expenditure of 595million MK was made for the work (see Table 11-1). Of this total, 315 million MK was to be obtained from non-domestic sources, and relief grant aid from the Japanese government was applied for this purpose. In contrast, cost in local currency is being met by the Malawi government's own funding from the energy fund.

Table 11-1: Subjects of the Phase-4 RE program

	Center	District	HV Line (kV)
Rural Growth Centers			
1	Chikwina	Nkhatabay	11
2	Mbalachanda	Mzimba	33
3	Mwansambo	Nkhotakota	33
4	Mkhota	Kasungu	33
5	Phalula	Balaka	33
6	Thekerani	Yhyolo	33
7	Tsangano	Ntcheu	11
8	Neno	Nwanza	33
Trading Centers			
9	Abunu	Mulanje	33
10	Cape Maclear	Mangochi	33
11	Champhira	Mzimba	33
12	Chimwankhuku	Dedza	33
13	Kafukule	Mzimba	33
14	Kamphata	Lilongwe	11
15	Khombedza	Salima	33
16	Lisungwi	Mwanza	33
17	Malembo	Mangochi	33

[3] M'deka, Nkhamenya, Chisemphere, Zaone, Kampepuza, and Champhira

[4] Madzanje in Ntcheu, Jalasi in Mangochi, Mpiri in Manchinga, Nasomba in Mulanje, and Chingale in Zomba.

18	Malingunde	Lilongwe	11
19	Malomo	Ntchisi	33
20	Marka	Nsanje	33
21	Mchenge	Rumphi	33
22	Mwamphanzi	Chikwawa	33
23	Mwanje	Chiradzulu	33
24	Nkhamenya	Kasungu	33
25	Chisemphere	Kasungu	33
26	Chulu	Kasungu	33
27	Dwangwa	Kasungu	33
28	Kasisi Hqs.	Chikwawa	33
29	Nyungwe	Karonga	33
30	Vuwa	Karonga	33
31	Ngara	Karonga	33
32	Nchezi	Lilongwe	11
33	Njereza		33
34	Nambuna	Lilongwe	33
35	Villa Mitekete	Chikwawa	33
36	Wovwe	Karonga	33
37	Majaro	Karonga	33
38	Misuku Hills	Chitipa	33
Other Centers			
39	Biriwiri Border	Ntcheu	11
40	Songwe Border	Karonga	33
41	Michinji Orphanage	Mchinji	11

Source: MNREA

11.2.4 National Sustainable Renewable Energy Program (NSREP)

The NSREP is a comprehensive program for the development and utilization of renewable energy. It encompasses various fields, including everything from the diffusion of technology through biogas and biomass briquette projects to the preparation of institutional schemes and technical centers. Promotion of RE making use of renewable energy is therefore only a part of its agenda. It is furnished with funds from a diversity of institutions, including the UNDP, DANIDA (which withdrew in February 2002), Global Environmental Facility (GEF), and Japan International Cooperation Agency (JICA). The different projects moving ahead under the NSREP consequently have different funding sources, and are not directly interlinked.

The program is operated by the NSREP steering committee. The committee is not a governmental entity with a specific organization; the DOE serves as its secretariat, and it is run with the participation of representatives from concerned aid institutions, governmental agencies, educational institutions, and private enterprises. In other words, it exists to provide a venue for coordination in the interest of overall benefit.

Many RE projects utilizing renewable energy are promoted by the Interim Supporting Unit (ISU) with DANIDA funding, but the Government of Denmark (GOD) withdrew from the project in February 2002. In addition, there are other projects under way for the construction of technical centers based on GEF funding and for World Bank plans.

11.2.4.1 DANIDA

The ISU is conducting activities to support the utilization of renewable energy. Its basic role lies in leading implementation of pilot projects for renewable energy, and accumulation and provision of the experience necessary for planning and development of systems for future installation. As such, the ISU focuses on the following four items in its activities.

- Construction of scheme models for the diffusion of renewable energy
- Development of skills needed for the development of renewable energy
- Preliminary preparations for organization of the market
- Standardization of renewable energy technology

At present, one of the biggest projects is aimed at the preparation of the legal framework for promotion of solar home systems (SHS). DANIDA withdrew from the project, but the staff of the DOE has taken over the project activities.

11.2.4.2 GEF

In January 2001, an agreement was reached between the UNDP and the government of Malawi on promotion of a project, funded by the GEF, for removal of barriers to renewable energy in the country.

This was followed by the organization of a task force composed of members of the NSREP, UNDP, and DANIDA for mutual coordination with the activities of the GEF, NSREP, and DANIDA. But the structure of the project completely changed largely due to the withdrawal of DANIDA.

The project entitled the "Barrier Removal to Malawi Renewable Energy" started officially in February 2002; however, the project office was not set up until June because of delay of the project operation. Until now, major progress has not been achieved, except for recruitment of the staff and planning for the annual work schedule.

11.2.4.3 New aid projects

DANIDA II

- DANIDA promised aid totaling some 3.5 million dollars for the areas of solar power, measurement and mapping of wind resources, biogas, etc., through the DANIDA II project. Subsequently, the GOD determined the withdrawal from the project, but not all of the technical assistance (TA) has been terminated. While wind mapping and projects related to biogas were terminated, TA for solar power continued. Under these TA projects, new PV systems will be installed in 14 clinics and existing damaged systems will be repaired. All of these TA projects are expected to be completed by around the end of September 2002.

World Bank

The World Bank has proposed a project entitled "Rural Energy for Rural Transformation," and has shown interest in furnishing assistance for the NSREP. The project is aimed at provision of energy services for the revitalization of economic activities in rural areas. Its main features are as follows:

- Support for awareness and more efficient supply of energy and utilization of technology
- Support for power supply making use of the RE fund (through both grid extension and off-grid systems) in parallel with the RE Master Plan Study
- Provision of technology for energy conversion and alternative energy
- Support through provision of microcredit for improvement of capabilities for supply of highly energy-efficient equipment by domestic manufacturers
- Support for related activities rooted in rural areas and communities
- Technical support and assistance for training

The World Bank, however, decided to review the terms of reference of the project and has not yet disclosed how they will change the project scheme.

11.3 The Movement for Power Sector Reform

In Malawi, ESCOM's monopolistic setup is thought to pose a problem to the future growth of electric enterprises. In parallel with the privatization of other state enterprises, there is consequently a movement under way for structural reform revolving around unbundling and privatization of ESCOM.

Although the RE role was transferred to the DOE in 1995, ESCOM remains in charge of the supply of power, inclusive of maintenance and management of the extended portion, once the DOE extends the grid to districts that had previously been without power. In this respect, the progress of the power sector reform led by ESCOM's privatization is going to have various effects on the deployment of RE policy by the government.

11.3.1 Assessment of the Malawi power sector by the World Bank and orientation of reform

The results of the financing projects implemented by the World Bank thus far have not been entirely satisfactory. This triggered the ongoing power sector reform. In light of these circumstances, the World Bank asked the government to pursue a reform encompassing improvement of ESCOM's management.

In its report on the results of Power V Project, which was concerned mainly with the construction of a hydropower plant at Kapichira, the World Bank noted the low management capabilities of ESCOM and pointed out the need for commercialization through its reorganization and ultimate privatization.

11.3.2 Problems at ESCOM

The business performance and weak financial position of ESCOM are, at present, substantial issues, and the Government of Malawi intends to resolve these problems through ongoing power sector reform.

11.3.2.1 Business operation

The performance of ESCOM is low as compared to other electric utilities in neighboring countries, and the following problems have been pointed out:

- Technical problems:
  - High technical and non technical loss
  - Unreliable power supply, load shedding, and reductions in voltage
  - Low labor productivity (35 customers per employee)
  - Low rate of new connections (3,000 per year)
  - Low availability rates of power plants (86%)
  - High incidence of distribution faults (40 per 100 consumers)
- Economic problems
  - Inadequate investment in transmission and distribution
  - High default rates by governmental and large consumers
  - Large accounts receivable (85 days' worth of billing)
  - High capital contributions and connection fees for new customers
  - Dependency on government subventions

11.3.2.2 Finances

ESCOM's weakness in the financial aspect derives from the low level of governance capabilities in the political and corporate management aspects, excessively low tariff levels, and weaknesses on the administrative front. More specifically, the aforementioned report on the Power V Project submitted by the World Bank in December 2000 mentioned the following points:

- The internal cash flow rate, which stood at 26 percent at the time of the 1991 project assessment, slipped to 20 percent at the time of project completion in June 2000, and has since ranged from -1 percent to 33 percent. The targeted 30-percent level was maintained only in fiscal 1997/98, after the debt reconstruction.
- The indicator for debt service coverage declined from 2.5 at the time of assessment to 1 at the time of completion. After the debt reconstruction, the targeted 1.5 level was maintained only in fiscal 1997/98. Before the reconstruction, however, it reached this level in all years except fiscal 1994/95 and 1996/97.
- The rate of return on assets (ROA) declined from 2.4 percent at the time of assessment to -0.9 percent at the time of completion. It had a minus value almost constantly during the period of project implementation.
- The target of 60 days for retrieval of accounts receivable was attained for two years, but the average length at the time of completion had increased to 88 days.
- The rate of network loss rose from 15 percent at the time of assessment to 18 percent.

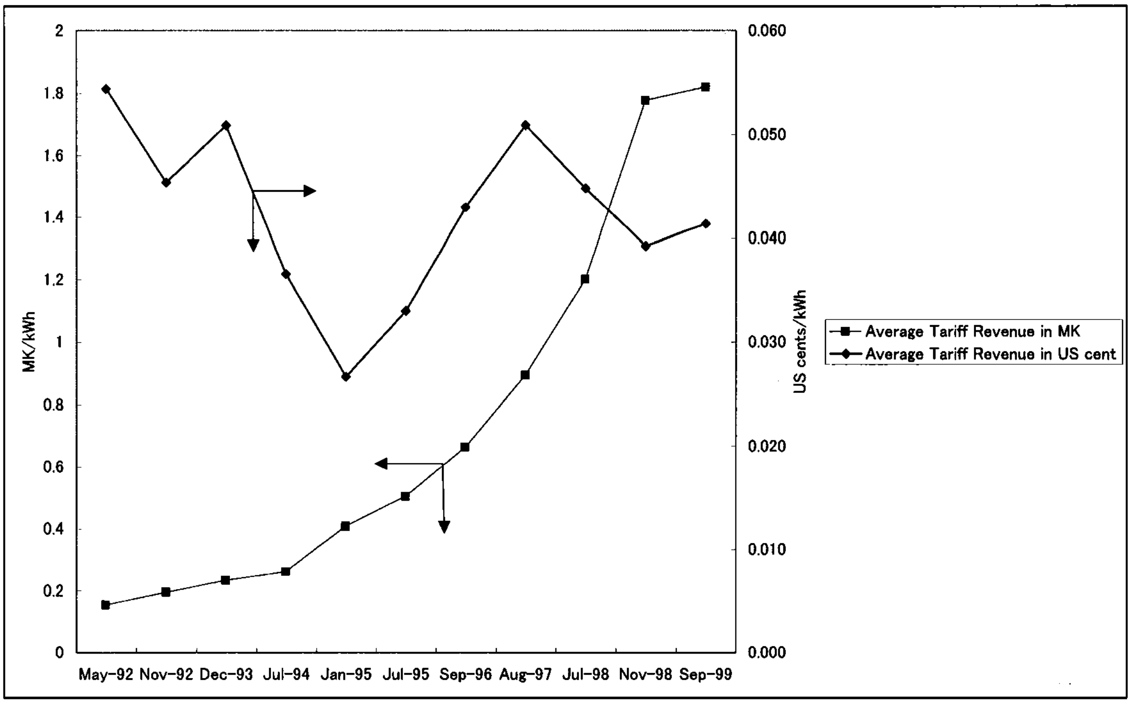
Tariff levels

In September 1999, the overall unit tariff rate came to 4.1 cents per kWh, lower than the World Bank estimate of 6 cents per kWh for the long-run marginal cost. This tariff scheme has been a major cause of the low incentive for additional investment and customer expansion at ESCOM. Based on its agreement with the World Bank, the government revised the power tariffs. At present, the unit rate has reached the level of 4.20 MK per kWh (or 6.7 cents per kWh at an exchange rate of 62.4 MK per dollar), and this will make it possible to retrieve the long-run marginal cost.

ESCOM is now making a study of new tariff levels taking account of the cost of the Kapichira hydropower plant, which was just built, and the cost of the international system interconnected with SADC, which is planned for the future. It intends to instate a new rate schedule in October 2002, when this study is slated for completion.

It should be added that the current ESCOM rate schedule consists of five rate categories. In the category of the residential lighting category, ESCOM applies a capacity charge of 73 MK, and an energy charge of 1.57 MK per kWh up to 30 kWh and a higher one for use beyond that level (see Table 11-2).

Rate hikes must be approved by the National Electricity Council (NECO). NECO basically has a cost-plus perspective and recognizes a certain level of return. In 2000, it became permissible to make automatic adjustments for the cost escalation component due to exchange rate fluctuation and inflation.



Source: ESCOM

Fig. 11- 1: Trend of ESCOM's overall unit tariff rate

Table 11-2 : Tariff table (as of August 1, 2001)

Scale I - Domestic Tariff	MK
Fixed charge per month	72.9549
For each kWh of the first 30kWh per month	1.5652
For each kWh in excess of 30kWh but less than 750kWh	2.2901
For each kWh in excess of 750kWh per month	3.2468
Scale II - General Tariff	MK
Fixed charge for single-phase supply per month	239.2088
Fixed charge for three-phase supply per month	333.4469
Charge per kWh	4.2923
Scale III - Maximum Demand Tariff (Low Voltage Consumers)	MK
Fixed charge per month	882.8261
Maximum demand charge per kVA per month	798.0681

Charge per kWh	1.3254
Scale IV - Maximum Demand Tariff (Medium Voltage Consumers)	MK
Fixed charge per month	851.2279
On peak demand charge per kVA per month	749.4507
Charge per kWh	1.2567
Maximum demand (off-peak, at customer's option)	
Fixed charge per month	851.2279
Off peak demand charge per kVA per month	374.7253
Charge per kWh	1.2567
Scale V - Export Tariff (Medium Voltage)	US$
Fixed charge per kVA per month	NA
Demand charge per kVA per month	18.36
Energy charge per kWh	0.014

Source: ESCOM

Uncollected charges and high level of accounts receivable

ESCOM applies a scheme of deposits to prevent non-collection of charges. On the occasion of concluding a supply contract, customers must make a deposit in the amount specified in their rate category.

Although the amount of uncollected charges in the case of small customers is therefore comparatively low, non-payment by large customers and official institutions (e.g., military, police, and government employee housing) is a major problem. In addition, ESCOM now has more than 85 days' worth of accounts receivable, which have also come to constitute a financial problem.

11.3.3 Proposal for restructuring

The Malawi government has presented a draft plan for structural reform of the power sector as a fundamental means of resolving the various problems surrounding ESCOM as described above. In its present form, however, the plan does no more than present a general vision for the future; it does not extend to details such as the reform timetable and specific problems.

The DOE, which presented the plan, is now pursuing a coordination of opinion with ESCOM, NECO, and other concerned entities. Essentially, the government has set forth the basic orientation for the reform but has not made a final determination on its implementation.

The plan for reform presented by the DOE thus far may be outlined as follows.

11.3.3.1 Background

Thus far, ESCOM has been in charge of investment in the power infrastructure and promotion of electrification. Nevertheless, as is clear from its management situation, ESCOM is saddled with substantial difficulties in that, while having high levels of accounts receivable and debt, it is not allowed to take a return fully sufficient for the conduct of its business. In light of these circumstances, it appears that ESCOM will not be able to make the investments needed for future electrification in Malawi unless the state takes over its debt.

ESCOM is also facing numerous problems in the technical aspect. These include frequent outages[5], worsening loss (both technical and non-technical), low system availability, and low system stability.

The draft plan for reform is the government's proposal for solution of these structural problems saddling the power sector. It is grounded in incorporation of the competitive mechanism to increase the efficiency of the sector as a whole by inducing investment from the private sector. As a concrete step in this direction, the government is planning to amend the 1998 Electric Power Law[6] with a view to stimulating private-sector investment. While the 1998 law accorded recognition to private-sector investment in the power sector and led to the establishment of NEC, it is not in itself sufficient to encourage investment from private companies. It does not contain any explicit provisions as regards the issuance of licenses and setting of power tariff rates, and there remain problems concerning NEC's autonomy. A new bill and power sector reform strategy paper are being prepared for the resolution of these problems, and the final draft versions have already been finished. The new (draft) measures include the vertical unbundling of ESCOM, construction of generation facilities by independent power producers (IPP), and consignment of transmission and distribution business on the basis of concession contracts.

11.3.3.2 New power sector structure

In the restructured power sector, the ESCOM generation, transmission, and distribution divisions will be unbundled. The existing generation facilities will continue to be owned by the government, and a newly established national utility will run them. In addition, IPPs will be permitted to build new facilities.

For the transmission system, the new setup will recognize natural monopoly and the division will survive as the sole entrant owned by the state, but the management of its business will be consigned

[5] In an interview conducted by the study team, personnel at the hospital operated by the Christian Health Association of Malawi in the Mua district expressed deep dissatisfaction with ESCOM because of frequent outages.

[6] ESCOM was transformed into a joint-stock company by this law

to the private sector in accordance with a concession contract lasting for up to 20 years. To keep the market fair, the transmission operator will not be permitted to participate in the generation or distribution divisions.

In the distribution subsector, customers currently number only about 104,000, and it would therefore be difficult to partition the service territory over the short term. As such, the existing distribution network is to be owned by a single distribution company. The management of this company, too, will be consigned to the private sector in accordance with a concession contract lasting for 20 years at the maximum. IPPs with a facility capacity of no more than 2 MW will be allowed to build new distribution networks in specified districts, upon obtaining the approval of the regulatory authorities. Over the longer term, however, the service territory will presumably be partitioned to give fuller play to the competitive mechanism.

As for rural electrification, responsibilities for generation and distribution will be delegated to the local level. In addition, the Rural Electrification Unit within the DOE will be in general charge of RE programs.

Generation subsector

To promote the workings of the market mechanism and investment from the private sector in the generation subsector, contracting for construction of additional generation facilities will be based on competitive bidding. To this end, the government is going to take the following three measures in the program for power sector reform.

- Over the short term, the existing generation facilities will be owned and operated by a state-run national utility company. Thereafter, the government will make a review of the operation and ownership of this company with the assistance of external advisors.
- New facilities are to be added through competitive bidding with the participation of private-sector IPPs.
- The power tariff scheme is to be revised with a view to supporting the construction of additional power sources (including cogeneration systems in the industrial sector) and providing incentive for sale of power from these sources to transmission operators.

International interconnected systems

The government also regards the import of power from other countries as an option for preserving its power supply security, and is considering participation in the South Africa Power Pool (SAPP). The proper degree of dependence on international interconnected systems is to be assessed with reference to the number of connections and the risks attending them.

Transmission subsector

The existing transmission network is simple, and is being extended only to those districts that are more economically advanced. Regarding reform and the pattern of ownership in this subsector, the plan is to recognize a natural monopoly for transmission lines of 66 kV or more, which will be owned by the government as national assets. However, their operation is to be consigned to a private company in accordance with a long-term (up to 20 years) concession contract. To avoid a conflict of interests in the market, the transmission operator will be prohibited from participating in the generation and distribution subsectors. The role of this transmission operator will consist of the following items:

- Safe and efficient operation and maintenance (O&M) of transmission systems
- Preparation of plans for extension of the transmission system (including international interconnection) to realize a cost minimum matching the forecast power demand
- Contracting with other private companies for construction of additional transmission lines
- Load dispatching
- Power transaction and wheeling within the SAPP framework
- Management of power purchase agreements (PPA)

Third-party access

There are a fair number of auto-generation facilities in Malawi, and recognition will be accorded to third-party access by these sources to transmission lines. The tariff scheme should be prepared so that it provides incentive for power sales by auto generators and other generation sources to the transmission operator. Although generation companies will not be allowed to sell directly to large-scale customers for the time being, the conclusion of contracts between the two for direct power purchasing would be a prospect further in the future, once the power transaction market has grown to a certain degree.

Distribution and sales subsectors

Owing to the small scale of the current distribution market and the delicate problems with a political dimension in the power sector, only a single distribution company will be allowed to exist. The operation will be executed by a private firm in accordance with a concession contract extending for up to 20 years. The business with this concession will be under an obligation to make additional investments and attain targets for connection to additional customers.

The distribution company will purchase power on a wholesale basis from the transmission operator and retail it to the final consumers.

Over the longer term, it could become possible to allow the establishment of additional (plural) distribution companies. However, limitations would be imposed on the makeup of distribution company shareholders in order to stimulate competition in the market.

11.3.3.3 Promotion of RE in the plan for reform

Implementation of RE

Implementation of RE must contribute to poverty alleviation, economic development in rural areas, and improvement in productivity. Because the rate of electrification in rural areas is still less than 0.5 percent, the government will proceed with RE by the two approaches of extending the grid and building off-grid systems. In districts which have a low demand density and are not installed with transmission and distribution lines, it will encourage the use of alternative energy such as photovoltaic panels and small-scale hydropower.

The RE perspective is based on curtailment of costs and power tariffs to the minimum level, and implementation with local participation and leadership. The DOE's Rural Electrification Unit is in general charge of RE planning, and its role is as follows:

- Development of a RE master plan
- Determination of criteria for selecting sites
- Determination of operational modalities
- Advice on technical, commercial, and institutional issues
- Administration of the RE fund
- Access to donor funding and soft loans
- Management of RE project
- Publicity campaign on the new approach to RE and opportunities it provides

In addition, the overall RE strategy will be to:

- Ensure that RE schemes are appropriately engineered and that costs are minimized;
- Establish an institutional framework to enable plants and equipment to be made available to projects at low cost;
- Establish a dedicated and sustainable funding mechanism (the former Energy Fund);
- Develop a legal framework to support the new arrangement for RE; and
- Remove bureaucratic obstacles to investment through simplification of contracting and licensing procedures, and clarify the roles of regulator in order to appropriately implement RE projects.

Subsidies for RE

By nature, RE yields low returns on investment and provides little incentive to private investors. The GOM takes the position that RE is a social measure to support poverty alleviation, economic development, and productivity improvement in rural areas, and, therefore, some level of subsidization is necessary. To this end:

- The GOM will subsidize plant and equipment costs necessary for RE, but not electricity consumption; all RE beneficiaries must pay their own monthly bills.
- The GOM will provide funding support for capital cost through the Energy Fund (i.e., RE Fund).

On-grid system

The on-grid option will involve extension of low-voltage distribution lines (up to 66kV) to the target areas that are identified in the RE Master Plan. Site selection must be in accordance with the criteria that will be established by the DOE. The DOE's policy affecting grid extension is as follows:

- Expansion of the distribution networks to rural growth centers, trading centers, public institutions (e.g., health centers, schools, police units, immigration and custom border posts) and other related institutions working for the common welfare (e.g., orphanages).
- Distribution assets developed with public funds under the RE programs will be owned by the public but leased to independent power distributors (IDPs).

Off-grid system

There are a number of sites where grid extension is too expensive and difficult due to small demand density. The GOM will take a complementary strategy to electrify these areas and support both public and private programs as follows:

- Electrification of areas which lack good access to the grid using off-grid and stand-alone systems such as solar PV and mini-hydropower.
- Ownership of off-grid facilities developed with private funds by the developer, i.e., local communities and entrepreneurs.

Due to lack of mechanisms for delivering equipment and raising funds, there are substantial barriers to promotion of off-grid systems using renewable energy sources. To solve these problems, the GOM undertakes trials of delivery models and financing arrangements. Lessons and learns obtained from these trials will be reflected in the development of the overall master plan for commercializing renewable energy sources aimed at removing technical, political, and economic risks and barriers of the market.

11.3.3.4 Outlook for the future

The present plans are no more than basic outlines indicating the orientation of reform; determination of the detailed agenda still lies ahead. In this sense, the next step that must be taken by the government is a decision in favor of executing the reform.

In the estimate of the DOE, the period of roughly two years following the official decision will have to be devoted to tasks such as assessment of ESCOM's existing assets, preparation of the legislative framework required for proceeding with privatization, and conditioning of the climate to encourage private investment. Once these tasks have been executed, the actual reform will be able to commence. The current schedule for the reform is shown in Table 11-3.

Table 11-3: Schedule for the Power Sector Reform

Activity	Timetable	Lead Agency
Employment of Change Managers	Jul. 2001 – Dec 2002	MNREA
Establishment of Business Units, i.e.,		
• Generation Business Unit	Jul. 2001 – Dec. 2002	ESCOM
• Transmission Business Unit	Jul. 2001 – Dec. 2002	ESCOM
• Distribution Business Unit	Jul. 2001 – Dec. 2002	ESCOM
ESCOM Asset Evaluation Study	Jan. 2002 – Dec. 2003	Privatization
Electricity Tariff Study	Jan. 2002 – Dec. 2003	Electricity Council
Regulatory Legislation		
• Repeal of the Electricity Act, 1998	Jun. 2000 – Dec. 2002	MNREA
• New Electricity Bill	Apr. 2002 – Dec. 2002	MNREA
• New Energy Regulatory Bill	Apr. 2002 – Dec. 2002	MNREA
• New Rural Electrification Bill	Apr. 2002 – Dec. 2002	MNREA
ESCOM Performance Evaluation	Jan. 2003	MNREA
Employ Transaction Adviser	Aug. 2003	MNREA
Tender for Distribution Concession	Jan. 2004	Privatization
Tender for Transmission Concession	Jan. 2004	Privatization
Establishment of National Generation Company	Jan. 2004	MNREA

Source: DOE

11.4 Rural Electrification Bill

A rural electrification (RE) bill was proposed to provide legal backing for the promotion of RE and the related procurement of funds, management, and regulation. The bill contains the following provisions on RE.

11.4.1 Definition of rural electrification

The term "rural electrification" shall refer to electrification by means of extension of the distribution lines (grid) and use of renewable energy resources, through projects with an internal rate of return (IRR) in the range of 1-15% per year. RE shall have a distribution line capacity of no more than 66 kV and generation capacity of no more than 5MW.

The concedante for the operation of RE projects may be a city, township, or district assembly, or the Electricity Supply Corporation of Malawi Limited (ESCOM).

11.4.2 Institution of the Rural Electrification Management Committee

11.4.2.1 Membership

The Rural Electrification Management Committee shall be composed of the following members.

- Director of Energy Affairs, Department of Energy Affairs
- Head of the Rural Electrification Unit, Department of Energy Affairs
- Director of ESCOM
- Head of Engineering, Electricity Council
- Principal Secretary of the National Economic Council
- Comptroller of statutory corporations
- Principal Secretary of the Ministry of Local Government

11.4.2.2 Role of the Committee

The Committee shall raise funds for and manage the Rural Electrification Fund, and make preparations for yearly RE programs. For these purposes, it shall prepare and update periodic RE master plans, acquire funds from aid institutions, administer the fund, and oversee projects promoted by RE enterprises.

11.4.2.3 Rural Electrification Unit

The Rural Electrification Unit of the Department of Energy Affairs (DOE) shall serve as the Committee secretariat and execute requisite routine procedures.

11.4.3 Institution of the Rural Electrification Fund

The Rural Electrification Fund shall be instituted to raise funds needed for RE promotion. The Fund shall draw on the following resources.

- Expenditures from the national treasury approved by the national assembly
- Power sales tax revenue (with a ceiling of 1% of the total sales proceeds of the enterprises)
- Various funds and assets from the government and other sources
- Assistance from foreign governments and international institutions
- Funds from 50% of the total amount of fines levied under the Rural Electrification Act

- Revenue from sales taxes imposed on petroleum products

11.4.3.1 Uses of the Fund

The Fund shall make expenditures for the following uses.

- Initial investment (capital) cost of grid extension for RE and off-grid electrification
- Capital cost of solar home system (SHS) facilities to be acquired by the concedantes or on their behalf
- Provision of credit guarantees for concedantes or concessionaires
- Financial contributions to RE projects promoted by aid institutions

11.4.3.2 Ordering of the priority of RE project candidates

The Committee shall assess project possibilities in the aspects of technology, funding, economic feasibility, environmental impact, and social impact. Those projects confirmed to be feasible shall be eligible to receive funding from the Fund.

Among these projects, first priority shall be accorded to that with the highest IRR.

Additional priority shall be accorded to those projects in which the concedante or the consumers will provide at least 20% of the (initial) capital cost.

11.4.4 RE-related regulations

11.4.4.1 License

Parties executing RE must obtain a license from the Electricity Council. Such licenses may be granted for only generation, transmission, or distribution business taken separately, or for any combinations thereof.

With regard to solar home system, a separate license will be issued concurrently with another license.

11.4.4.2 Tariffs

The setting of electricity tariffs must be approved by the Electricity Council.

11.4.4.3 Concession agreements

To execute RE projects, the concessionaire must conclude a concession agreement with the concedante.

In this agreement, the concedante must specify the regional scope of the concession and give the concessionaire exclusive authority for operation of RE business in it. The tariffs set by the concessionaire must be on the level approved by the concedante, and also must obtain the approval of the Electricity Council as the regulator.

The agreement shall remain in effect for 20 years, provided that the concessionaire honors its provisions.

11.4.4.4 SHS agreement

In the case of RE utilizing SHS, an SHS purchase guarantee and service agreement must be concluded by the concedante, concessionaire, and system supplier.

11.4.4.5 Ownership of assets

The government shall own all of the facilities installed with expenditures from the Fund. In individual RE projects, the concedante shall represent the government.

11.5 Advisable Setup for RE Promotion

The passage (enactment into law) of the proposed RE bill now under deliberation would provide the legal framework for RE. Fig. 11-2 shows the prospective setup for future RE promotion premised on passage of the Act.

The Committee instituted under the Ministry of Natural Resources and Environmental Affairs would have the following two roles.

- Supervision and support for ESCOM and local (city, town, or district) assemblies[7] as concedantes with the authority to approve RE projects on behalf of the government
- Management of the RE Fund

Parties intending to promote RE projects (i.e., prospective concessionaires) are allowed to do so only after concluding an agreement with the concedante to obtain the concession. The conclusion of the concession agreement requires the approval of the Electricity Council.

There are two types of concession agreement. One is for on-grid RE projects (i.e., those for RE through extension of the grid), and the other, for off-grid RE projects (i.e., those for RE through use of SHS).

For SHS-based RE projects, an SHS agreement must be concluded instead of the concession

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[7] Until the passage of the Rural Electrification Bill, ESCOM will be the only concedante; the township, city, and district assemblies will not have any authority to grant concessions.

agreement. The concessionaire opting for SHS-based RE could acquire a double agreement for both on-grid and SHS projects. It would also be possible to conclude SHS agreements in a plural number of districts.

Regardless of the RE project type (off-grid or on-grid), concessionaires can collect charges from users for their supply of electrical power. The tariffs applied for these charges must be approved by the Electricity Council.

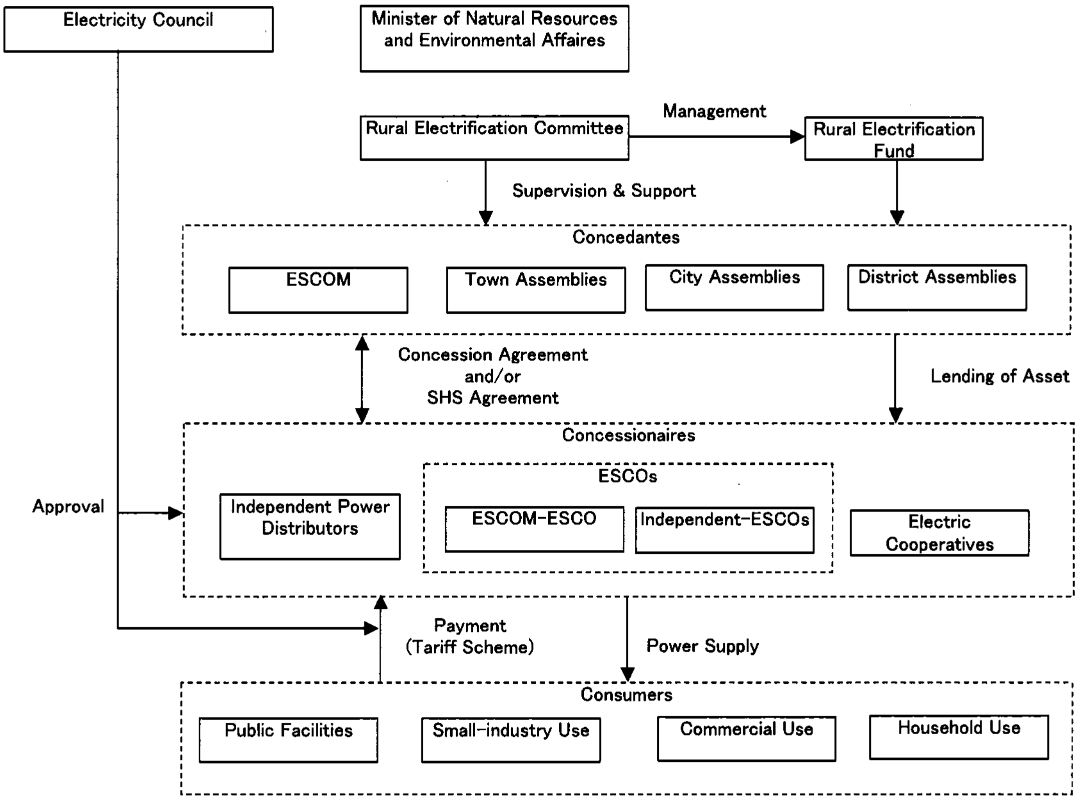

Fig. 11- 2: Institutional framework for promotion of RE projects

Source: JICA Study Team

11.5.1 Options for RE project models

The bill described above states that ESCOM and local governmental are to act as concedantes, but does not contain any detailed delineation of the identity of concessionaires.

Eventually, the project entities actually executing RE will presumably be the concessionaires. It must be noted, however, that the profitability of RE projects varies greatly depending on the demand density, total demand, and mode of electrification applied. This points to the need for operators to devise the most workable approach for the circumstances at hand as opposed to applying a single model for all RE projects. This section presents several options as prospective business models, based on the legal framework set forth in the RE bill.

At present, no parties in Malawi other than ESCOM are equipped with the technical capabilities to carry out RE projects, with the exception of small-scale photovoltaic (PV) system dealers. Nevertheless, the following non-ESCOM entities are thought to have the latent potential for participation in RE projects along with the progress of structural reform in the power sector.

- Independent power distributors (IPD) with business experience accumulated in other countries
- Energy service companies (ESCO) supplying energy in modes matching customer needs
- Membership-system electric cooperatives

The following sections present an account of the various prerequisites and tasks pertaining to the prospects for participation in RE projects by ESCOM and these potential principals.

11.5.1.1 ESCOM

In 1995, the government determined policy for removal of the RE program from the scope of ESCOM business and its transfer to the DOE as the party responsible for RE. Thereafter, in spite of being government-owned, ESCOM was equitized and required to turn a profit in its business.

In light of these RE-related policy determinations, it would be inconceivable for ESCOM to undertake RE projects in areas offering no prospects for retrieval of operating costs, even if the capital cost for facility construction would be met by the RE Fund and consequently impose no burden on its operation.

As such, ESCOM could not be expected to undertake RE projects in districts that did not offer a "certain amount of demand" capable of covering operating costs. This is to say that ESCOM's ability to operate RE projects in "low-demand" areas not capable of generating a profit would be highly dubious.

Naturally, ESCOM is currently operating even in areas where profits are not assured, but this is only because its overall balance of business payments is maintained through cross-subsidization, i.e., diversion of income from urban areas. Seeing that ESCOM was equitized in order to strengthen its financial health, however, it would have very little motivation for active participation in future RE projects premised on such cross-subsidization. In other words, ESCOM RE projects entailing cross-subsidization are not an easy business scenario.

It should be added that ESCOM is also under heavy pressure from the government to rationalize its business. For example, ESCOM now has an average of about 30 customers per employee, and this is much lower than the corresponding averages in the range of 100 - 130 for other members of the Southern African Development Community (SADC). This, too, suggests that ESCOM could not set about projects that would further worsen its business efficiency.

11.5.1.2 Independent power distributors

Liberalization of the power sector along with the progress of the structural reform being pursued by the government could pave the way for private investment in it. This raises the prospect of participation in the distribution division by independent power distributors in particular.

Nevertheless, it is extremely doubtful that such independent power distributors could also promote RE projects, for the following reasons.

In the first place, the independent power distributors that are the most probable future participants would be electric utilities in neighboring or developed countries. Needless to say, they would invest in projects in urban areas with promising demand potential. It would be out of the question for them to make purely business decisions in favor of investing in areas with poor prospects for return while ESCOM has an exclusive franchise for supply in urban areas with assured profits. If they decide to invest in Malawi, it would normally be as shareholders in ESCOM on the occasion of its initial public offering (IPO) or in accordance with a concession agreement with ESCOM for supply confined to an urban area yielding profit.

If foreign investors decide to invest in RE, it would probably be under the ESCO model (described below) instead of the power distributor business model.

11.5.1.3 ESCO

Generally speaking, ESCOs apply a business model of energy supply adapted to the needs of specific customers as opposed to the network business model of ordinary electric utilities. ESCO businesses serving rural areas are sometimes called "rural energy service companies" (RESCO). The major ESCOs are vendors of SHS and petroleum products.

ESCO-type enterprises therefore would be potential RE participants in Malawi. ESCO-style business would be especially suited to RE promotion by means of off-grid systems utilizing SHS.

The list of parties that could possibly enter the power sector for participation as ESCOs would by no means be limited to those with such business experience in other countries; ESCOM could very well launch new ESCO business by establishing a separate firm staffed with some of its current employees.

ESCO business by ESCOM

In Phase 4 of the RE program now under way, ESCOM is undertaking facility construction for RE in accordance with a contract for consignment (commissioning) from the DOE. Once this construction has been completed, control of the facilities will be transferred to ESCOM, which is to carry out the operation and maintenance (O&M) duties. This consignment of work for facility construction is kept separate from ESCOM's ordinary electric power business, and the cost burden is being met by a contracted amount of expenditure.

Be that as it may, in the eyes of ESCOM management, RE projects clearly compare unfavorably with business in urban areas in respect of return on cost, and provide little motivation for active pursuit. Obviously, it was to resolve this kind of management conflict that the government made the 1995 decision to remove RE projects from the scope of ESCOM business and assign them to the DOE.

This conflict notwithstanding, the undeniable reality is that ESCOM is the sole entity in Malawi with the technical and human resources needed for facility construction and O&M. It naturally follows that the government will be compelled to rely on ESCOM for the operation of RE projects.

In the flow of power sector reform, ESCOM has been asked by the government to rationalize its business and is now taking measures for improvement. Measures for surplus staff are, of course, a major issue in this context. As a part of the restructuring of its business under these circumstances, ESCOM has the option of establishing an ESCO as a separate firm under its umbrella for business exclusively in RE.

By adopting the ESCO model, the company could take full advantage of ESCOM's business resources and promote RE through either on-grid or off-grid projects. It would also have a relative edge on other entrants in respect of technology and personnel. It would even have the potential to come out on the top of the future ESCO market.

However, the detachment of ESCOM's RE division for reinauguration as a separate subsidiary would raise an additional question about employment and labor conditions. The detachment of ESCO business would naturally require rationalization to produce a cost structure in line with income, and a wage reduction would consequently have to be considered. Furthermore, aside from the question of pay, reposting from urban areas to rural ones would dampen incentives as far as employees are concerned. For these reasons, the establishment of a new company and concomitant transfer of personnel could trigger labor disputes.

Non-ESCOM ESCOs

The typical ESCOs in RE are the enterprises selling or leasing SHS. This business model is commonly found in developing countries. The ESCOs now doing business in neighboring countries could very possibly embark on business in Malawi, too, provided that the conditions in the market (including legislative and financial arrangements) are right.

These new entrants would first take aim at the customers offering the best prospects for retrieval of investment In other words, the primary circle of customers would be confined to merchants and tobacco farmers with relatively high income levels, and public institutions with guaranteed budgets, such as governmental facilities, health clinics, hospitals, and schools.

There is, of course, a latent market associated with ordinary households, but factors such as the current income levels and credit standing in rural Malawi suggest that actual customers would be extremely limited.

The cases of other developing countries, especially in Asia, show that diffusion of SHS by ESCOs can succeed as a business, and this could also be expected to apply for Malawi. For ESCO business to take root in Malawi, however, a business model must be established for sure retrieval of costs. Malawi does not yet have full financing provisions for ordinary consumers, and the instatement of a leasing system right from the start would still pose big risks to retrieval of costs by ESCO businesses. The model could be adjusted for Malawi by, for example, stipulating outright sales of SHS and conclusion of an O&M contract for maintenance service.

11.5.1.4 Electric cooperatives

Although there are not yet any in Malawi, electric cooperatives (ECs) are the principals of RE in many developing countries around the world. In Malawi as well, some businesses are run in the form of cooperatives in the fields of agriculture and fishery, and pertinent law (i.e., the Cooperative Law) has been enacted. In this sense, it would be legally possible to establish ECs in Malawi, too.

ECs are grounded in the idea of having local citizens pay membership dues, and using these dues as funding for establishment and of a cooperative association. Malawi's Cooperative Law does not recognize establishment as non-profit organizations; all cooperatives must have the status of limited-liability profit-making organizations. The supply of power is restricted to EC members.

Various problems stand in the way of RE promotion through ECs in Malawi, as follows.

<u>Fund-raising</u>

Capital must be collected to operate the EC, and this funding must be provided by membership dues. At present, however, income levels among the general public in rural areas are still extremely low, and it would, in practice, be nearly impossible to collect dues that are high. Conversely, unless sufficient dues are collected, the financial foundation of the EC would be very frail.

Human resource development

To run the EC as an electric power enterprise would require personnel in possession of the necessary expertise in the technical and management/administrative aspects. However, personnel with such expertise are not immediately available in rural Malawi, and development of the human resources needed to run the EC would be a big outstanding task.

Technology transfer

The EC would also require specialized knowledge and technology to perform O&M chores on the facilities. A scheme must be built for instruction and training to impart this know-how to rural personnel. Technology transfer and the grooming of technicians is all the more important because of the danger accompanying the high levels of voltage involved.

Although the establishment of ECs is saddled with many problems as outlined above, it also holds many latent benefits.

In the first place, one of the socioeconomic tasks now facing Malawi is development in rural areas. The establishment of enterprises based in rural areas could provide precious opportunities for employment, especially for the younger generation.

Secondly, economic advancement through RE demands stimulation of activity in the rural industries of farming and fishing. In many cases, agricultural and fishing cooperatives serve as the principals of production activities in rural areas. Coordination with them would help to increase productivity, expand the processing of primary products, and heighten value-added (VA) levels.

11.5.2 Business model application possibilities

None of the business models described above has an absolute superiority relative to the others. Each has its own particular strengths and weaknesses dependent on the characteristics of the subject area (e.g., number of customers and distance from the grid) and the electrification technology applied.

11.5.2.1 Cost recovery and tariff-setting standards

The scale of costs required for electrification in the subject area and the scale of revenue yielded by that area are major constraints on determination of the level of tariffs.

The final decision on tariffs is, of course, a matter of the tariff scheme design; the level is by no means decided with reference to the balance of payments for the subject area alone. Entities operating electrification projects, however, would obviously have little enthusiasm for attempting to do business in areas where profits cannot be assured.

In promotion of RE through extension of the grid, the government may possibly rule out a tariff disparity between urban and rural areas as a matter of policy in favor of "universal tariffs" that are uniform nationwide. This could create a need for cross-subsidization to compensate for interregional revenue differences or gaps. Unless this is done, enterprises would not be able to run the business.

It might be added that there would clearly have to be a tariff disparity between on-grid and off-grid systems. The two obviously differ in respect of the cost structure of power supply and the tariff scheme. This is especially true in the case of SHS as a stand-alone system, which require a tariff perspective completely different from that of on-grid systems.

Because of such factors, the current ESCOM tariff levels would be capable of application without modification only for electrification, by on-grid systems, of large trading centers in peri-urban areas with a substantial demand. In electrification of areas with a small demand through extension of the grid or installation of off-grid systems, the tariff levels required for recovery of costs would necessarily be higher than the current ESCOM ones. Conversely, if tariffs are not set on high levels, enterprises could not be expected to develop projects in such areas, which consequently would need subsidization to encourage project development.

11.5.2.2 Possibilities of RE project operation by concessionaires

ESCOM

In both the technical and institutional aspects, ESCOM has the capability to promote RE projects of either the on-grid or off-grid type. However, ESCOM is now a profit-making enterprise in the form of a limited liability company, and would realistically be able to promote electrification projects on its own resources only through on-grid systems in peri-urban areas enabling recovery of operating costs at the current tariff level. At present, when they are being pressed by the government to rationalize their business, ESCOM executives would necessarily be reluctant to expand operations in fields that could further worsen their balance of payments. From a management point of view, given equal resources, it would make more sense to put them into reinforcement of their business in areas offering higher revenue and assured profit, i.e., urban areas.

For such reasons, it is highly questionable whether ESCOM could, under its prevailing setup, become involved in electrification projects in areas with no sure prospects for retrieval of costs in long-term operation (even if the initial capital costs are funded by the government), and even more so if they are based on off-grid systems.

On the other hand, if such projects were to be undertaken with ESCOM's business resources, it would make more sense to detach them from ESCOM and conduct them under a separate entity with its own account, a slim organization, and a cost-saving operational setup.

Local governments

With the passage of the RE bill, local governemtns will be accorded the status of concedantes for RE projects, and legally empowered to carry out and operate such projects. However, local governments do not have any experience as project principals, and it is also uncertain whether it would really be desirable for governmental entities to manage projects. In actuality, the operation of projects directly by local governments would more properly be regarded as entailing too many technical difficulties.

11.5.2.3 Possibilities of operation of RE projects by concessionaires

Independent power distributors

Participation in the Malawi power sector by independent power distributors from other countries is a possibility with the progress of reform. As described above, though, they would by no means choose to become involved in RE projects themselves. As long as ESCOM has an exclusive franchise for supply in urban areas, it would be unthinkable, in business terms, for them to decide to invest solely in RE, with its poor profit prospects. If they invest in Malawi, it would be in urban areas; if they cannot obtain concessions in urban areas, they would probably look for countries offering better conditions than Malawi.

For projects based on off-grid systems, investors could not apply the model of independent power distributors.

ESCOM-ESCO

As an option, it would be fully possible for ESCOM to detach its RE division and reinaugurate it as a separate company (ESCO) for operation of RE projects. The major reason is that ESCOM has all of the necessary business resources in both the technical and staffing aspects.

Successful operation of ESCOM-ESCO would demand a slimmer organization capable of operating at lower cost than the current ESCOs. Otherwise, it would cause the same kind of financial problems as occurred in the promotion of RE projects by ESCOM up to Phase 3.

There is another potential problem associated with the labor union. The detachment of the RE division by ESCOM would be part and parcel of a program for rationalization of its own business. This program could grow into a major labor dispute about employment and treatment. The biggest issue confronting the establishment of ESCOM-ESCO is the high possibility of problems involving division of the organization and staff.

Other private-sector ESCOs

The basic ESCO model is grounded in dispersed supply of energy. There would be little possibility for ESCOs other than ESCOM-ESCO to promote electrification projects using on-grid systems.

The field of off-grid systems allows the best exercise of ESCO strengths. A prime example here is SHS sales. In Malawi, too, ESCOs will probably play the leading role in diffusion of SHS systems.

Electric cooperatives

Electric cooperatives (ECs) do not yet exist in Malawi, and their establishment would have to start from scratch. This would not be an easy task. Nevertheless, the job would hold considerable value for stimulating economic development in rural areas, and the attempt to promote RE through ECs could be worth the effort.

Regarding the order of priority in selection of principals, priority should be accorded to other entities (ESCOM, ESCOs, or other enterprises) in any areas where they want to participate. In RE areas, however, none of these other entities have a desire to participate, and means must be devised for project operation with local energies. These areas would also probably yield a low level of profit relative to cost.

Although execution of projects with on-grid systems right from the start would probably pose many difficulties, ECs should be able to operate simple off-grid systems.

Table 11-4: Possibilities of operation of RE projects

			On-grid		Off-grid		
			Relatively Large Demand	Relatively Small Demand	PV	Mini-hydropower	Other Renewables
Tariff Level Required for Cost Recovery (as Compared to Current ESCOM Tariffs)			○ (Possibly Abut the Same)	△ (Possibly Higher)			
Operation	Concedantes	ESCOM	○ (Probably Possible)	△ (High O&M Costs: Feasibility Difficult)			
		Local Assemblies	× (Technically Impossible)				
	Concessionaires	IPD	× (Low Profit Rate: Participation Doubtful)		not applicable		
		ESCOM-ESCO	○ (Probably Possible)				
		Other Private ESCOs	× (Probably Impossible)		Probably the Market with the Best Prospects)	△ (Participation Doubtful)	?? (Depends on the Individual Case)
		ECs	?? (Uncertain, but Worth Trying)		○ (Probably Possible)		

Source: JICA Study Team

11.6 Institutional conditioning required for promotion of RE

11.6.1 Toward establishment of business models

The effective functioning of the various rural electrification (RE) business models proposed herein depends on the progress of the structural reform now being promoted by the government in the power sector.

The provision of equal opportunity in the market is a prerequisite for encouraging participation by newcomers, i.e., entrants other than the Electricity Supply Corporation of Malawi (ESCOM). This, in turn, demands the breakup of ESCOM's current monopolistic setup through the structural reform. Conversely, the models for new entrants are not going to function if the reform does not progress.

11.6.1.1 In advance of the structural reform

As described above, unless the structural reform is executed, the conditions in the market could not be regarded as fair, at least when viewed from the standpoint of the newcomers. If the conditions are not put in order, it would be unreasonable to expect their participation.

These factors make it necessary to follow the business model applied in Phase 4 as the setup for RE promotion in the period until completion of the structural reform. In other words, there will be no choice but to have ESCOM ring-fence RE-related business and urban business, and to make a separation between the two in accounts. In addition, the government is to assume the burden of the initial investment and commission the facility construction to ESCOM. Upon their completion, the facilities will be transferred to ESCOM, and the government will hold ESCOM stock in a quantity equivalent to the asset value of the facilities.

11.6.1.2 After the structural reform

With implementation of the structural reform, a new business setup can be prepared in the distribution division.

As stated by the government in its official policy, it has been decided to reallocate franchises now monopolized by ESCOM among other operators in accordance with concession agreements. This kind of market climate will make it possible for ESCOM and the new entrants to compete for business under the same conditions. To obtain concessions, entrants would have to consider the size and profitability of the market under the contract terms established in each franchise, whether urban or rural, and build diverse new business models with operational configurations matching the market attributes.

For example, the independent power distributor (IPD) business model would probably be effective in franchises with a high proportion of urban markets, and the energy service company (ESCO) model, in franchises of a largely rural character.

11.6.2 Schedule for the RE program

The procurement of requisite funding is a key factor in the schedule for program promotion. The funding required for implementation of Phase 5 is estimated at about 1.1 billion MK. To promote the project, the government must procure this funding from the current energy fund (the future RE fund) and financial aid from donors. Judging from the scale of the energy fund as the domestic source, the government could obtain tax revenues of about 120 million MK per year at present.

The problem is that it is uncertain how much of the requisite funding can be procured from the energy fund and how much time it will take to obtain this funding. In light of the current scale of tax revenue, it would take about three years to obtain 30 percent (i.e., 333 million MK) of the requisite funding from the energy fund. Similarly, to obtain about half (550 million MK) from the same fund would take about five years.

Seeing that domestic funding accounted for 40 percent of the total in Phase 4, the energy fund must be considered as the source of about the same proportion.

In estimates of the RE project schedule from standpoint of funding procurement, it would probably take about five years to implement a single phase. To accelerate the project (and thereby shorten the schedule) would require quicker procurement of funds. This, in turn, would demand either an expansion of the sources of domestic funding or an increase in the rate of procurement from external sources.

11.6.3 Need for a subsidization mechanism for operations

In its current policy, the government has confined its assistance for RE to funding required for initial investment. There must be studies of the prospect of furnishing subsidies for operations.

As shown in the previous chapter, the RE cost for the trading center (TC) service envisaged in Phase 5 could in many cases not be met by the average power tariff of ESCOM. In other words, operators would fall into a situation of deficit that deepens as the operation continues.

To resolve this problem, it would be necessary either to instate a tariff scheme with levels that differ with the district in order to retrieve costs or some kind of mechanism for subsidization of the operation if tariff levels are to be uniform nationwide.

The instatement of district-specific tariffs (i.e., that vary with the district) would not be a realistic option. In some TCs, the RE cost would be from five to ten times as high as the current tariffs, and could not be passed on in its entirety to the customers. Furthermore, if the government's current policy of having all customers shoulder an equal tariff burden is to be upheld, some kind of mechanism for subsidization would have to be devised.

In connection with this prospective subsidization, there are two tasks for the government: assurance of funding sources for the subsidization and construction of the subsidization mechanism.

As described above, judging from its size, the existing energy fund would be capable of providing funds only for the RE program facility investment; it does not have the financial margin for subsidization of the balance of operating (business) payments. Therefore, this subsidization must be funded by the new financial sources planned in the Rural Electrification Bill.

As for the subsidization mechanism, the key point is assurance of transparency. This is why the government should not apply a mechanism based on cross-subsidization, which is liable to blur the relationship between the parties shouldering the cost burden and the beneficiaries. Here, the term "transparency" refers to a situation in which both the amount and source of the subsidies are clear and a third party can learn how much subsidization was received by which parties. The mechanism of the existing energy fund (the future RE fund) could be applied to assure such transparency.

The regulations proposed in the RE Bill would permit imposition of taxes on the sales of operators, and the revenue from these taxes would be pooled in the RE fund. At present, the aid from this fund is to be confined to facility investment. However, application of part of the fund to compensation for loss incurred in the operation of RE projects is an option that should be considered.

Fig. 11-3 envisions the establishment of a plural number of operators in the distribution subsector liberalized by the structural reform. It was assumed that some operators would provide service in franchises with both urban and rural areas, while others would operate RE projects only in rural areas. It was also assumed that the taxation funding the subsidization would be imposed on all operators alike, in correspondence with their sales, and that the revenue would first be pooled in the RE fund.

By the same token, subsidies would be furnished from the RE fund for deficits incurred by these operators in running the RE programs.

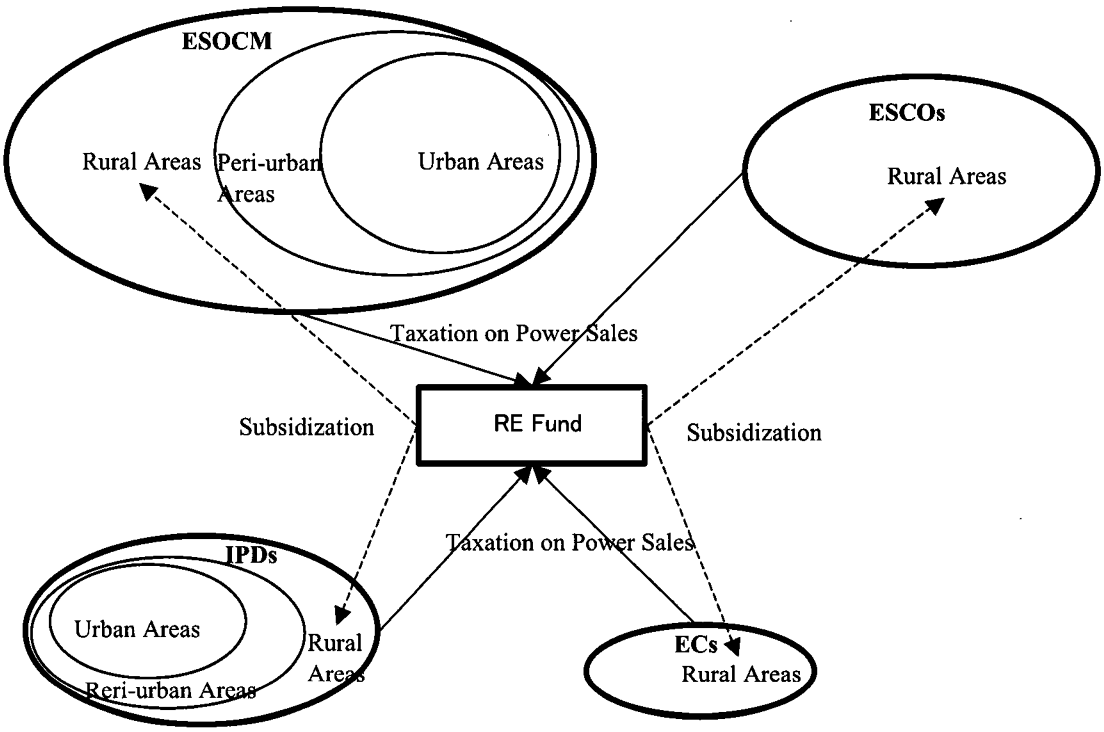

Fig. 11- 3: Mechanism of subsidization for the operation of RE programs

Source: JICA Study Team

Although the basic subsidization mechanism can be diagrammed as shown in Fig. 11-3, detailed studies would have to be made of matters such as the standard to be applied in determining the amount of subsidization for RE operations and the nature of the limitations to be imposed on the subsidies. The RE projects will presumably differ in respect of preconditions such as scale, type of operation, and economic merit. While these matters should be examined through a feasibility study conducted after determining the detailed RE districts and operation models, the general principles to be applied are as follows:

- Parameters for determining subsidies
  - Balance of operating payments
  - Number of customers and amount of sales
  - Conditions for discontinuation of the subsidies
- In franchises containing both urban and rural districts, there must be a clear separation for RE in the accounts. Otherwise, operators will be able to transfer a worsening of their earnings in urban districts to the RE program.
- The concession agreement must clearly define the ownership rights to the facilities constructed. The ownership rights to facilities constructed with governmental subsidies naturally should belong to the government. For those constructed with investments by the operators, the government would have to make buyouts at residual value upon the expiration of the concession agreement.

11.6.4 Need for expansion of the RE fund scale

Besides the provision of funds for initial investment in RE projects, the government must also consider the prospect of using the RE fund (the current energy fund) for subsidization of future RE project operations as described above.

At present, the fund is definitely not large enough to serve as a source for such subsidization. Among the variety of funding sources noted in the RE Bill, the taxation on power sales is expected to be the biggest after that on petroleum products.

The bill proposes a ceiling of 1 percent on the tax on power sales, but this would be too low to serve as a substantial financial resource. The rate should be high enough to produce revenue comparable to that from the current tax on petroleum products (about 120 million MK). For example, seeing that ESCOM's total power sales in fiscal 1998/99 came to about 1.1 billion MK, the tax revenue would amount to only about 11 million MK at a 1-percent rate as compared to 55 million MK at a 5-percent rate.

The cases of neighboring countries also exhibit higher rates; the tax rate on electricity has been increased from 3 to 7 percent in Zambia and from 1 to 6 percent in Zimbabwe.

In sum, the government must determine the advisable tax rate with reference to the requisite scale of funding and taxation level, and with consideration of precedents in other countries.

11.6.5 Emphasis on rural perspectives and the DOE role

The government has taken the policy line of promoting a regional devolution (decentralization of authority) over the long term. In the RE program as well, importance must be attached to the perspectives of the local beneficiaries, and the local side should play a role commensurate with its capabilities in the implementation of RE projects.

Nevertheless, the fact is that capabilities on the local side (including those of the local authorities) are severely limited at present. Although the program implementation probably must be transferred to the local authorities in the long run, the realities indicate that the Department of Energy Affairs (DOE) will have to lead the project promotion over the short and medium terms. For this reason, the DOE must prepare an organizational setup that will enable it to absorb local wants and needs, including the establishment of local offices.

In the future, i.e., in the course of the structural reform, the government is to reallocate franchises among new operators and conclude concession agreements with individual ones. On this occasion, the DOE should exercise leadership by, for example, encouraging entry by new operators and backing the implementation of the program. (The authority for approval of concessions resides with the National Electricity Council, but its role lies solely in decision, from an impartial standpoint, as to whether or not there is any violation of law. The DOE, in contrast, has the role of promoting the growth of the power sector inclusive of RE, in its capacity as an arm of national policy.)

11.7 Further Tasks

11.7.1 Coordination between on-grid and off-grid RE projects

The prospective subjects of RE in this master plan study are trading centers (TC) and their vicinities; it does not envision projects for agricultural demand or individual household customers. Furthermore, the study has already concluded that, for the majority of TCs, it would be economically preferable to promote electrification through extension of the grid, and that SHS would have a supplemental role confined to installation for certain public facilities.

It should also be noted, however, that the electrification rate in rural areas of Malawi is currently less than 1 percent, and that the demand density is extremely low in areas distant from TCs.

Electrification in such areas will obviously have to depend on dispersed sources, and especially SHS.

This is why SHS diffusion will rank alongside grid extension as a key pillar of RE strategy in Malawi. In other words, this strategy could be viewed as a combination of linear expansion of districts where TCs are electrified and plane-type expansion of dispersed points electrified by SHS for individual customers.

As mentioned in the preceding section, ESCO would definitely have a critical role to play in SHS diffusion. The Global Environment Facility (GEF) project is already laying down the legal framework for quality assurance and loan guarantees needed for the spread of SHS. This institutional conditioning in preparation for the promotion of SHS diffusion is a vital prerequisite for encouraging private-sector investment in ESCO projects.

Off-grid systems clearly cannot compete with on-grid systems in respect of cost and convenience. All parties must recognize that SHS and other dispersed sources will play a merely supplemental role relative to extension of the grid.

RE promotion in Malawi therefore must strike a mutual conformance between the plan for installation of dispersed sources applying renewable energy within the current NSREP framework and the plan for TC electrification in accordance with this master plan study.

11.7.2 ESCOM rationalization and participation in RE projects

RE promotion by ESCOM-ESCO is thought to be a valid option. Although it has not made an official statement on the matter, ESCOM itself has not rejected the idea. Nevertheless, there could be a big difference of perspective between the government and ESCOM on more concrete questions such as how ESCOM-ESCO should be established and go about promoting projects.

On the ESCOM side, there are apprehensions about being saddled with deficit business again if the government demands its deep involvement in operation of RE projects following the establishment of ESCOM-ESCO. As such, it is necessarily wary about operating RE projects itself.

At the same time, however, it has a positive attitude about offering technical support for RE programs. For example, it has stated that it would be prepared to cooperate fully with the establishment of ECs through activities including member instruction and training.

For ESCOM, the biggest agenda items at present are structural reform of the power sector and placement of its business on sound footing. Contribution to RE projects must be considered in this context. An attempt by the government to force RE projects on ESCOM against its will is liable to work against its own demands for self-funding management at ESCOM.

11.7.3 Need for diversification of RE project principals

Malawi does not yet have a principal which could undertake all RE. In other words, it would be impossible to carry out RE in Malawi with only a single methodology or business model.

Even ESCOM, for example, would have to limit its involvement with RE because of its need to strengthen its financial foundation. This is very understandable considering that, although its yearly profit is now less than 100 million Malawi kwacha (MK) as compared to the sum of 140 MK budgeted for Phase 4 of the RE program.

It is undeniable that ESCOM should play a leading role in some form, but arrangements must also be made for a more diverse array of principals by various measures. These include cultivation of ESCOs and promotion of electrification with extensive use of local human resources through the establishment of ECs as a remaining option.

11.7.4 Cooperation with other donors

The European Union (EU) is not very interested in the option of grid extension, which has not worked well in other African countries in the past. It is more interested in that of electrification by off-grid systems.

Because of its concern about global environmental problems, the GEF attaches importance to off-grid systems utilizing renewable energy. For Malawi, the implications of the global environmental problems emphasized by the GEF include a drop in the water level on Lake Malawi, risk of drought, and decline in the potential water-power resources of the Shire River under the influence of global warming. They would also present long-term problems for Malawi's power supply, which relies heavily on hydropower.

As described above (on coordination between on-grid and off-grid system RE projects), the on- and off-grid systems would lie in a relationship of mutual complementation. In RE promotion, they should complement, instead of competing against, each other.

Cooperation with the GEF, which assists the installation of dispersed sources, and the World Bank, which is making plans for rural economic development through RE, is absolutely essential for enhancing the actual effectiveness of all programs.

Abbreviation

AFD	African Development Fund
CHAM	Christian Health Association of Malawi
DANIDA	Danish International Development Agency
DOE	Department of Energy Affairs
EC	Electric Cooperative
ESCO	Energy Service Company
ESCOM	Electricity Supply Corporation of Malawi Limited
GEF	Global Environmental Facility
GOD	Government of Denmark
GOM	Government of Malawi
IPD	Independent Power Distributors
IPO	Initial Public Offering
IPP	Independent Power Producer
IRR	Internal Rate of Return
JICA	Japan International Cooperation Agency
KfW	Kreditanstadt fur Wiederanfbau
MNREA	Ministry of Natural Resources and Environmental Affairs
NECO	(National) Electricity Council
NSREP	National Sustainable Renewable Energy Program
O&M	Operation & Maintenance
PPA	Power Purchase Agreement
RE	Rural Electrification
RESCO	Rural Energy Service Company
SAPP	South Africa Power Pool
SHS	Solar Home System
TC	Trading Center
UNDP	United Nations Development Programme

MK	Malawi Kwacha
US$	United States Dollar

Weight and Means

kW	Kilowatt
kWh	Kilowatt-hour

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APPENDIX CHAPTER 3

Appendix 3-1 Existing Transmission Lines

(a) 132kV Transmission Lines

From	To	ckt	Length	Conductor Type	Pole or Tower	Commence-ment year
Nkula B	Salima	1	250.00	ELM	Pole	1981
Salima	Lilongwe B	1	75.00	ELM	Pole	1979
Salima	Chintheche	1	265.00	MULBERRY	Pole	1982
Tedzani 3	Kapichila	1	60		Tower	1999
Nkula B	Blantyre West	1	43.98	LYNX	Tower	1989
Nkula B	Tedzani	1	8.00		Pole	1995
Kapichila	Blantyre West	1	29.43		Tower	
Kapichila	Nchalo	1	39.45	TIGER	Tower	1989
Nkula B	Golomoti	1	161.80	PARAKEET	Tower	1993
Golomoti	Lilongwe B	1	87.00	PARAKEET	Tower	

(Source：ESCOM, Sep.2001)

(b) 66kV Transmission Lines

From	To	ckt	Length	Conductor Type	Pole or Tower
Mapanga	Zomba	1	38	ELM	Pole
Blantyre West	Chichiri	1	7	ELM	Tower
Lilongwe A	Lilongwe B	1	23	RACOON	Pole
Nkula B	Mapanga	1	44	DOG	Pole
Nkula B	Tedzani	1	8	ELM	Pole
Livingstonia	Bwengu	1	57.8	OAK	Pole
Lilongwe B	Lilongwe C	1	12	OAK	Pole
Nkula B	Mapanga	1	44	DOG	Pole
Balaka	Chingeni	1	8	RACOON	Pole
Chichiri	Mapanga	1	14	DOG	Pole
Chinyama	Nkhotakota	1	79	WILLOW	Pole
Chintheche	TELGRALL HILL	1	78	WILLOW	Pole
Fundis Cross	Mapanga	1	44	OAK	Pole
Nkula A	Lilongwe A	1	259	TIGER	Tower
Chichiri	Nkula A	1	43	DOG	Pole
Chichiri	Tedzani	1	59	LYNX	Pole
Blantyre West	Mapanga	1		ELM	Pole
Lilongwe A	Lilongwe C	1	10	ELM	Pole
Livingstonia	Karonga	1		WOLF	Tower

(Source：ESCOM, Sep.2001)

Appendix 3-2 Category of Consumers by ESCOM

Each category of consumers is defined as following table.

Category	Voltage	Contents
Domestic	-	Residential purpose (Including a total of up to 1.5kW of domestic motors)
General	-	Non-Domestic consumer Maximum demand is less than 25kVA
Power LV	400V	Maximum Demand is more than 25kVA
Power MV	11kV 33kV	Maximum Demand is more than 25kVA

(Source : Distribution Data, ESCOM, Oct. 2000)

And the consumers who have pre-paid system are classified as pre-payment.

APPENDIX CHAPTER 5

Appendix 5-1 Study of Distribution System

Northern Region

District	Distribution System		Remarks
	Existing (Main line)	Planning (Voltage)	
Chitipa	*33kV line Chitipa TC - Karonga district	*PhaseIV Misuku Hills TC (33kV)	
Karonga	*33kV line Karonga 33kV S/S - Chitipa district *11kV line Around Kagonga and Ulima 66kV S/S.	*PhaseIV Nyungwe TC (33kV) Chisemphere TC (33kV) Ngara TC (33kV) Wovwe TC (33kV) Majaro TC (33kV) Songwe Border (33kV) *ESCOM Karonga S/S - Border line (Tanzania:33kV)	A 33kV interconnection line from Karonga to Tanzania is planed, however, the source of funds is unclear.
Rumphi	*33kV line Bwengu 66kV S/S - Bolero TC Bwengu 66kV S/S - Phwezi TC Bwengu 66kV S/S - Nkhata Bay district *11kV line Around Livingstonia 66kV S/S	*PhaseIV Mchenga TC (33kV)	
Nkhata Bay	*33kV line Nkhata Bay TC - Mzimba district TELEGRALL HILL 66kV S/S - Rumphi district *11kV line TELEGRALL HILL S/S - Mbowe Estate	*PhaseIV Chikwina RGC (11kV)	There is a plan to install 66kV transmission line between TELEGRAW HILL 66kV S/S and Bwengu 66kV S/S. After this line is complete, 66kV transmission system of Northern region connects with Central system. Engneers of ESCOM ACC dissatisfied lifetime of wooden poles caused by termite attack in the areanear Lake Malawi. Especially, some poles for transmission line changed after 5 years from installation.
Mzimba	*33kV line Chikangawa 66kV S/S - Mzimba TC - Lundazi (Zambia)	*PhaseIV Mbalachanda RGC (33kV) Champira TC (33kV) Kafukule TC (33kV) *ESCOM Ekwendeni TC - Euthini TC - Mzimba TC (33kV)	Since the length of 33kV interconnection line between Malawi and Zambia is so long, about 100km, a recloser is installed near Mzimba TC. ESCOM join with the Zambia personell when the meter of the electric energy for power exchange is checked.
Likoma	Un-electrified	*PhaseIV Likoma TC (Diesel) Chizumulu TC (Diesel)	

Central Region

<table>
<tr><th rowspan="2">District</th><th colspan="2">Distribution System</th><th rowspan="2">Remarks</th></tr>
<tr><th>Existing (Main line)</th><th>Planning (Volatage)</th></tr>
<tr><td>Kasungu</td><td>*33kV line
Chinyama 66kV S/S - Kasungu TC
Kasungu TC - near Bua - Dowa district
Kasungu TC - Moyo(mission)
near Bua - Mchinji district</td><td>*PhaseIV
Mkhota RGC (33kV)
Nkhamenya TC (33kV)
Chisemphere TC (33kV)
Chulu TC(33kV)
Dangwa TC (33kV)</td><td>Some stays supported poles have been cut.
The condition of many wooden ploes are not good.
The position of the crossing of M1 road and M18 road differs from a map published in Malawi. The distribution lines are installed along actual road.</td></tr>
<tr><td>Nkhota-kota</td><td>*33kV line
Nkhotakota 132kV S/S - Dwanga TC
- Nthunga TC
*11kV line
Around Nkhotakota TC</td><td>*PhaseIV
Mwansambo RGC (33kV)</td><td>The route of a line from Nkhotakota TC to Dwanga TC is not along road. There is no TC on the way and route is like straight.
Some insulators of transmission line are sometimes broken.
The condition of poles for transmission line are not good comapared with distribution. The inside of some poles are rotten. This is as ESCOM engineers saying.</td></tr>
<tr><td>Ntchisi</td><td>*33kV line
Ntchisi TC - Dowa district</td><td>*PhaseIV
Malomo TC (33kV)</td><td>Although these area was electrified more than 20 years ago, the conditions of facilities are well.</td></tr>
<tr><td>Dowa</td><td>*33kV
Lilongwe district - Dowa TC - Salima district
Dowa TC - Ntchisi district</td><td>-</td><td>Some stays of supported poles of 132kV lines have been cut.</td></tr>
<tr><td>Salima</td><td>*33kV line
Salima 132kV S/S - Dowa district
Salima 132kV S/S - Mua
*11kV
around Salima town</td><td>*PhaseIV
Khombedza TC (33kV)</td><td>This area is located near Lake Malawi and there are a lot of marsh. In the rainy seasons, it is difficult to approach for an inspection of some facilities.</td></tr>
<tr><td>Lilongwe</td><td>*33kV line
Lilongwe city - Namitete TC - Mchinji TC
Lilongwe city - Dowa district
*11kV
Lilongwe city - Mintudu TC
Lilongwe city - Nkhoma TC
Lilongwe city - Likuni TC</td><td>*PhaseIV
Lamphata TC (11kV)
Malingunde TC (11kV)
Nchezi TC (33kV)
Nambuma TC (33kV)</td><td>In Bunda, outskirts of Lilongwe, most of 11kV ploes are old and reconstructed repeatedly.</td></tr>
<tr><td>Mchinji</td><td>*33kV line
Mchinji TC - Lilongwe district
Mchinji TC - Kasungu district</td><td>*PhaseIV
Mchinji Orphanage (11kV)
*ESCOM
Mchinji TC - Mkanda TC
- Chikon TC (33kV)</td><td></td></tr>
<tr><td>Dedza</td><td>*33kV line
Dedza 66kV S/S - Lobi RGC, Linthipe TC
Dedza 66kV S/S - Milonde</td><td>*PhaseIV
Chimwankhuku (Primary School:33kV)</td><td></td></tr>
<tr><td>Ntcheu</td><td>*33kV line
Ntcheu 66kV S/S - Balaka district
Mlanjeni 66kV S/S - Villa Ulongwe
(Mozambique)
*11kV line
around Ntcheu 66kV S/S</td><td>*PhaseIV
Trangangano RGC (11kV)
Biriwiri Border (11kV)</td><td></td></tr>
</table>

Southern Region

District	Distribution System		Remarks
	Existing (Main line)	Planning (Volatage)	
Mangochi	*66kV line (energized 33kV) Golomoti 132kV S/S - Monkey Bay TC *33kV line Mangochi TC - Namwera TC - Mandimba (Mozambique) Mangochi TC - Machinga district Mangochi TC - Malinde TC Mangochi TC - Monkey Bay TC	*PhaseⅣ Cape Maclear TC (33kV) Malembo TC (33kV) *ESCOM Nselema TC - Namwera TC (33kV: On-going)	Most poles near Lake Malawi are rotten. Near Namwera TC (it electrified by PhaseI), those are not damaged.
Machinga	* 66kV (energized 33kV) Liwonde 66kV S/S - Nsanama TC *33kV line Nsanama TC - Mangochi district *11kV Machinga TC - Zomba district	-	
Balaka	*33kV line Balaka 66kV S/S - Ntcheu district Balaka 66kV S/S - around Senzani *11kV line Balaka 66kV S/S - aound Kapire	*PhaseⅣ Phalula RGC (33kV)	
Zomba	*33kV line Zomba 66kV S/S - Chiradzulu district Zomba 66kV S/S - Imatiya Zomba 66kV S/S - Chingale TC Zomba 66kV S/S - around Magomero	*ESCOM Zomba TC - Lake Chirwa (33kV)	The ground wire is installed against lighting. ESCOM has had many lighting faults in this area.
Chiradzulu	*33kV Chiradzulu TC- Blantyre district Blantyre district - Zomba district Blantyre district - Mulanje district	*PhaseⅣ Mwanje TC (33kV)	
Blantyre	* 33kV Mapanga 66kV S/S - Chileka - Blantyre West 66kV S/S Blantyre West 66kV S/S - Thyolo district Mapanga 66kV S/S - Chiradzulu district (2) *11kV line Blantyre West 66kV S/S - Thyolo district	-	The project of 66kV transmission lines which configure the circle around Blantyre city is on-going.
Mwanza	*33kV line Nkula hydro station - Mwanze TC - Mozambique	*PhaseⅣ Neno RGC (33kV) Lisungwi TC (33kV)	
Thyolo	*33kV line Blantyre district - Thyolo TC - around Matamolo TC *11kV line Blantyre district - Thyolo TC - Mulanje district Thyolo TC - Nsanje distcrict Thyolo TC - around Khonjeni TC	*PhaseⅣ Thekerani RGC (33kV)	The 11kV lines near boarder with Mozanbique was already extended rather than the collected data. Some tea estates receive the electricity by 33kV or 11kV.
Mulanje	*33kV line Fundis Cross 66kV S/S - Milanje (Mozambique) Fundis Cross 66kV S/S - Chiradzulu district Fundis Cross 66kV S/S - Thyolo district	*PhaseⅣ Abunu TC (33kV)	
Phalombe	(On-going)	*ESCOM Mulanje district - Phalombe TC (33kV: On-going)	
Chikwawa	*33kV Kapichira hydro station - Chikwawa TC - SUCOMA - Nsanje district around SUCOMA *11kV line around Chikwawa TC	*PhaseⅣ Mwamphanzi TC (33kV) Kasisi TC (33kV), Njereza TC (33kV) Villa Mitekete TC (33kV)	SUCOMA is the largest sugar estate of Malawi.
Nsanje	*33kV line Nsanje TC - Bangula TC - Chikwawa district Bangula TC - Thyolo district	*PhaseⅣ Marka TC (33kV)	

Appendix 5-2 Investigated area

Northern Region

No.	District	Community		Electrification				Public Facilities	Remarks
				ESCOM		Off-Grid			
		Name	Category (Size)	Installed Year	Existing Voltage (kV)	Type	Use		
1	Nkhata Bay	Nkhata Bay	TC (Large)	Phase Ⅰ	33	-	-	Police Station, Hospital, Harbour etc.	
2	Mzimba	Champira	TC (Small)	(Phase Ⅳ)	-	Retail Shop (SHS:about 75W)	Light, TV, Iron, Radio	Police Station	SHS has been installed in 1999.
3		Chikangawa	TC (Middle)	Phase Ⅰ	33/11	-	-	Clinic	

Central Region

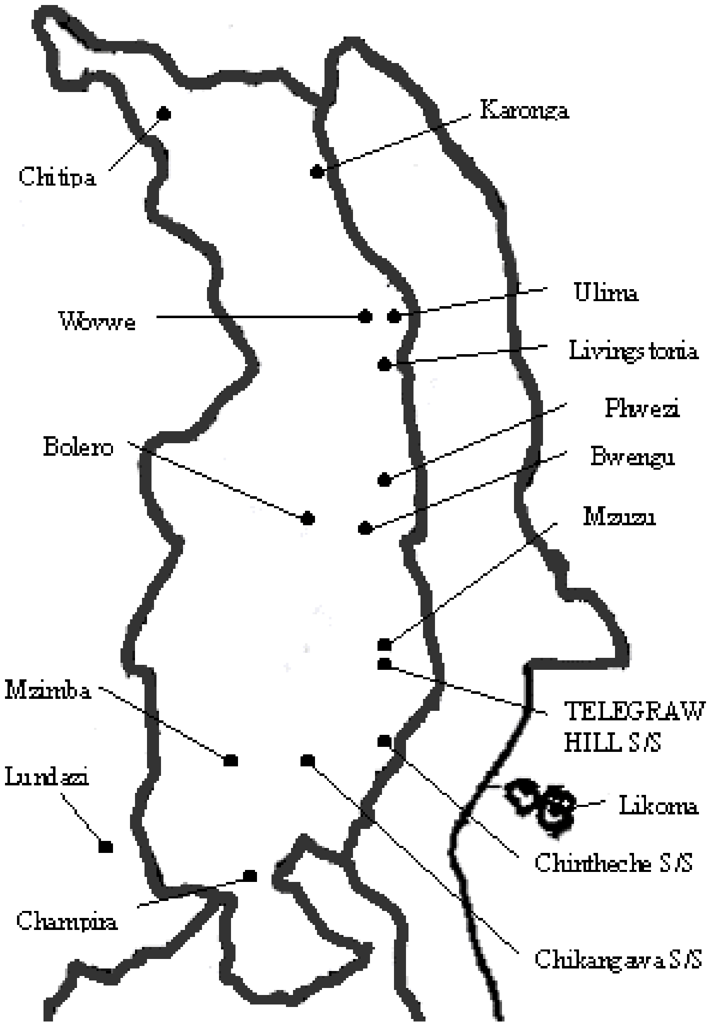
No.	District	Community		Electrification				Public Facilities	Remarks
				ESCOM		Off-Grid			
		Name	Category (Size)	Installed Year	Existing Voltage (kV)	Type	Use		
4	Kasungu	Kasungu	TC (Large)	Phase Ⅰ	33	-	-	-	In an interview with a citizen lived in un-electrified area near Kasungu TC, a lot of trees are cut for cultivation of tobacco in this area. As a result, the firewoods shortage are sometimes occurred. She said that she were waiting for electrification and she would like to have cooking heater.
5		Jenda	TC (Middle)	-	-	-	-	-	A distribution line extended by PhaseⅣ pass around this TC.
6		Moyo	Mission	Recent	33	-	-	Mssion	Main electrified equipements are Maize Mill, Light, Cooker and Sewing machine.
7		Chmwendo	Maize mill shop	Recent	33	-	-	-	Starting point of Phase Ⅳ Rated Capacity of Maize Mill is 24.6KVA
8		Lifupa	Lodge	-	-	Lodge (Diesel)	Light Cooking etc.	-	
9	Nkhota-kota	Dwanga	TC (Middle)	Unknown	33	-	-		Dwanga Sugar Estate(33kV Recieve)
10		Nthunga	TC (Small)	Unknown	33	-	-	Clinic	
11		Nkhotakota	TC (Middle)	Phase Ⅰ	33/11	-	-	Distric Assembly	
12	Ntchisi	Ntchisi	TC (Large)	Phase Ⅰ	33	-	-	Distric Assembly Primary Sch., Hospital	Altitude: 4500ft（1,350m） There is a hometown of Vice President in this region. The condition of poles are very well.
13		Nthesa	TC (Small)	-	-	-	-	Primary Sch., Secondary Sch., Post Office	Tobacco and paprika are main income in this area.
14		Khuwi	TC (Small)	-	-	-	-	Primary Sch., Secondary Sch., Post Office, Clinic, Gov.Office	Doctor sometimes come from other TC.
15	Dowa	Mponela	TC (Middle)	around 1990	33	-	-	Hospital	
16		Nthambwe	TC (Small)	-	-	-	-	-	33kV lines were already installed about 200m from this TC.

No.	District	Community		Electrification				Public Facilities	Remarks
		Name	Category (Size)	ESCOM		Off-Grid			
				Installed Year	Existing Voltage (kV)	Type	Use		
17	Salima	Chipoka	TC (Large)	Phase Ⅲ	33	-	-	Harbour, Custom, Police Station, Railaway Station	Harbour has been construcrted by USA Fund.
18		Mapanga	TC (Middle)	-	-	Clinic (SHS)	-	Primary Sch., Clinic	A primary school has been construcrted by Europe Development Fund. This area is located near Lake Malawi and it is easy to draw water from the well. Therfore, the electrical water pump is not always needed.
19		Mua	Mission Community (Large)	Phase Ⅲ	33	-	-	Mission Hospital Primary Sch. etc.	All public facilities in this area managed by mission. This area had been electrified by the diesel generator which is 3φ-380V-5.6kW. At present, ESCOM's distribution lines are extended, however, there are many shortages caused by thunder storm at rainy season. The doctor asked to some companies to repair the generator for emergency, but it was too old to re-operate. In this area, there are a lot of electric equipments are using, such as pump for water, air-conditionaers, computers and so on
20		Makanjira	TC (Small)	-	-	-	-	Primary Sch.	
21		Khombedza	TC (Small)	(Phase Ⅳ)	-	Clinic (SHS)	Light Refrigiator	Hospital	
22	Lilongwe	Nambuma	TC (Middle)	(Phase Ⅳ)	-	Barber (SHS: 220V, 20W)	Hair Clipper	Primary Sch., Secondary Sch., Post Office, Police Unit, Church, MCDE	Tobacco is a main income in this area. There is a plan to construct new church. That is bigger than present.
23		Kabudula	TC (Middle)	-	-	-	-	Community Hall	
24		Kasya	TC (Large)	-	-	-	-	Post Office, Telecom	Tobacco is a main income in this area.
25		Majiga	TC (Small)	-	-	-	-	Mission, Primary Sch.	Tobacco is a main income in this area.
26			Tobacco Estate						Only 50kVA, single phase transfomer is installed.
27		Nyanja	TC	-	-	-	-		
28	Mchinji	Mchinji	TC (Large)	Phase Ⅰ	33	-	-	Border Post, Hospital	
29		Ludzi	TC (Small)	1988	33	-	-	Mission, Hospital, Primary Sch.	
30	Dedza	Thete	TC (Middle)	Unknown	33	-	-	Primary Sch.	Tobacco is a main income in this area. The dried tobaccos are packed by electric machines.
31		Lobi	RGC (Large)	1998	33	-	-	Primary Sch., Post Office, Communiuty Hall, Telecom, Agriculture facility	
32		Maonde	TC (Small)	-	-	-	-	Post Office	
33	Ntcheu	Biriwiri	TC (Small)	(Phase Ⅳ)	-	-	-	Border Post	

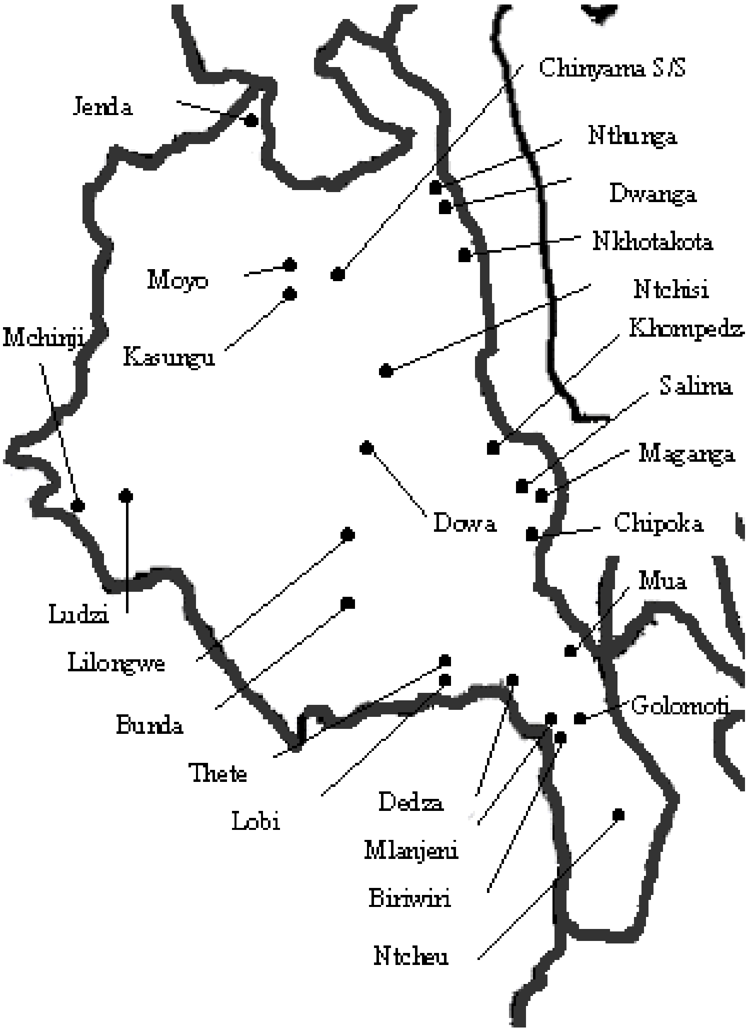
Southern Region

No.	District	Community		Electrification				Public Facilities	Remarks
				ESCOM		Off-Grid			
		Name	Category (Size)	Installed Year	Existing Voltage (kV)	Type	Use		
34	Mangochi	Namuwera	TC (Middle)	Phase Ⅰ	33	-	-	Primary School	
35		Malindi	TC (Middle)	Unknown	33	-	-	Mission Hospital Secondary Sch. Medical College	
36	Machinga	Ntaja	TC (Middle)	Phase Ⅲ	33	-	-	Post Office	
37		Nsanama	TC (Middle)	Phase Ⅲ	33	-	-		
38		Nselema	TC (Middle)	Phase Ⅲ	33	-	-	Secondary Sch.	The main road to Kenya via Mozambique are constructing. The distribution lines planned by ESCOM will be installed along this road.
39		Machinga	TC (Middle)		11	-	-	District Assembly Post Office	
40		Malosa	TC (Large)	Unknown	11	-	-	Mission, Hospital, Primary Sch., Post Office	
41		Chikweo	TC (Middle)	-	-	-	-	Primary Sch., Secondary Sch., Health Center, TDC, Church, Mosque	Rice is one of the income in this area.
42		Nampeya	TC (Small)	-	-	-	-	Church, Mosque	Rice is one of the income in this area.
43	Balaka	Chiendausiku	TC (Small)	-	-	-	-	Primary Sch., Church	Cotton is one of the income in this area.
44	Thyolo	Mtamolo	TC (Large)	Unknown	33	-	-	Mission, Secondary Sch., Mission Hospital Medical College	There are a lot of eucalyptus frorests managed by tea estates in this area. Most of them are fired to dry the tea leaves and a part of them are used for distribution poles. And it is useful to prevent the outflow of soil caused by rain.
45		Molelo	TC (Small)	1991	33	-	-	Mission Primary Sch., Water Pump	The tea and banana are growed around this area. Primary School is un-electrified.
46	Mulanje	-	Tea Estate	Unknown	33	-	-	-	The tea estate has some equipments to carry, select and pack the tea. These are 3φ400V eqipments and estate recieves 400V from ESCOM. The peak season is between December and February.

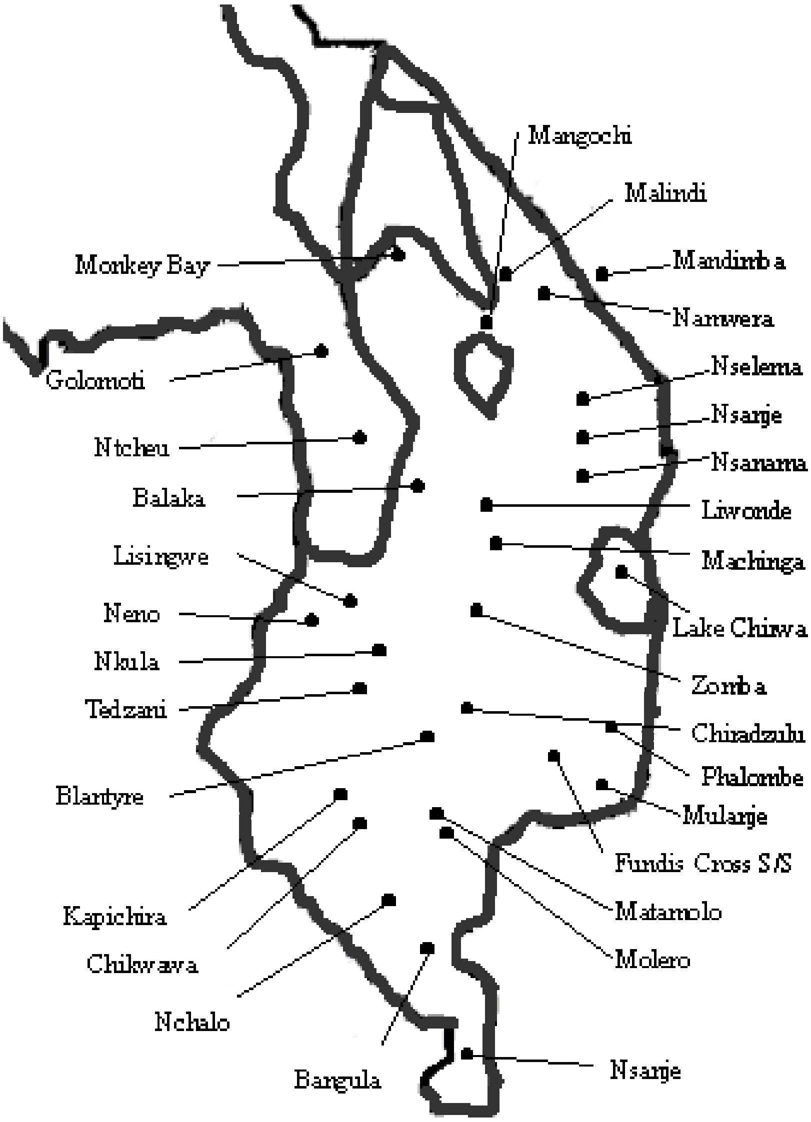
*TC : Trading Center
*RGC : Rural Growth Center
*SHS : Solar Home System
*Sch. : School
*MCDE : Malawi Colledge of Distance Education
*TDC : Teacher Development Center



Northern Region



Central Region



Southern Region

Appendix 5-3 Definition of "Low Voltage (LV)" and "Medium Voltage (MV)"

In Malawi, there are two definitions for "Low Voltage" and "Medium Voltage" as indicated below. Whenever possible use of the common definition is recommended.

Law, Manual etc.	Low Voltage	Medium Voltage
Law of Malawi	30V～250V AC 50V～250V DC	250V～650V
DOE	230V	400V, 11kV, 33kV
ESCOM	230V, 400V	11kV, 33kV

Appendix 5-4 Wooden Poles in Malawi

１． Rottenness of wooden poles in Malawi

The condition of wooden poles was investigated during the field surveys. Results are as follows:

(a) The surface of aged poles shows development of cracks.

(b) Termites nest into the cracks. Therefore the inside of the poles becomes more damaged. This condition is specially found close to the banks of the Lake of Malawi.

(c) The condition of poles is relatively better in the highlands.

The weather depends on the region and is very different between the dry and rainy season. Therefore the surrounding temperature and water content of the wood experience considerable changes. The rotting process dependant on these factors can be explained as follows:

(1) Expansion and contraction of the wood is caused by the seasonal change of water content in the wood. This causes the development of cracks that grow year by year.

(2) Termites enter through the cracks and spread into the inner part which starts rotting.

(3) The surface of wooden poles is difficult to get rotted because it has been treated with creosote (a preservative).

It is believed that a number of improvements including the change of type of timber and quality control would help the creosote to penetrate to the inner part of the poles.

2. Manufacturing process in Malawi

The manufacturing process of wooden poles made in Malawi is summarized as follows:

(1) There are three types of poles used as electrical poles, which are stout, medium and light. These are a made of local Eucalyptus timber. The poles are cut in six different lengths: 9, 10.8, 12.3, 13.5, 15 and 16.5 m. Only four sizes of poles up to 13.5 m are used as electricity distribution poles.

(2) After the cut poles are dry, they are treated with creosote, which is imported from South Africa and Zimbabwe. Creosote is infused not less than twice.

(3) Finally, the poles are left to dry again.

The time necessary to finish the poles is between three and five months, depending on the season (dry or rainy season). The equipment used to infuse the creosote is too aged and spare parts are no longer available. It was found that the creosote has not penetrated completely to the inside of some poles, as shown in the following figure.

Fig. Completed poles

Appendix 5-5 Applied Construction Cost of Distribution System

1. Line

(1) Material (Conductor)

Description	Unit Cost (MK/m)
AAAC 100mm^2 OAK	107.05
AAAC 50mm^2 HAZEL	55.42
AAAC 100mm^2 WASP	58.63
AAAC 50mm^2 ANT	29.01

(Source：ESCOM data)

(2) Material (Supporting Structure)

Description		Quantity per km	Unit Cost (MK) per km
Tee-Off	33kV	1	31,987.27
	11kV	1	31,902.05
	0.4kV	1	3,524.02
	0.23kV	2	7,048.04
Intermediates	33kV	8	157,721.92
	11kV	8	143,674.96
	0.4kV	8	71,875.20
	0.23kV	46	68,880.40
Section	33kV	1	69,723.71
	11kV	1	40,537.60
	0.4kV	2	14,070.96
	0.23kV	4	28,141.90
Terminal	33kV	1	47,934.23
	11kV	1	26,948.55
	0.4kV	2	8,755.80
	0.23kV	4	17,511.60

(Source：ESCOM data)

(3) Other

Description		Unit Cost (MK) per km
Labor	33kV, 11kV	64,535.32
	0.4kV	110,905.28
	0.23kV	122,927.44
Overhead	33kV, 11kV	33,904.20
	0.4kV	60,054.40
	0.23kV	69,811.20

(Source：ESCOM data)

Foreign Currency: All Materials

Local Currency: Labor

Overhead is divided proportionally by both ratios.

2. Distribution Transformer

(1) Material

Description	Voltage	Capacity (kVA)	Unit Cost (MK)
Distribution Transformer	33kV/0.4kV	50	253,405.44
		100	338,899.00
		200	438,337.55
	11kV/0.4kV	50	173,197.52
		100	280,654.79
		200	498,832.90
Structure	33kV/0.4kV	-	141,577.21
	11kV/0.4kV	-	114,888.31
Accessories	-	-	15% of Structure

(Source : Distribution Data, October 2000, ESCOM)

(2) Labor, Transport and Overhead

Description	Unit Cost (MK)
Labor and Transport	10,266.28
Overhead	6,750.00

(Source : Distribution Data, October 2000, ESCOM)

Foreign Currency: All Materials

Local Currency: Other

3. Feeder Bay

(1) Material

Description	Voltage	Unit Cost (MK)
Circuit Breaker	33kV	794,920
	11kV	604,272
Autorecloser	33kV	1,151,264
	11kV	1,092,704
Current Transformer	33kV	296,000
	11kV	236,800
Isolator	33kV	122,336
	11kV	97,869
Surge Arrestor	33kV	36,824
	11kV	27,618
Plinth	33kV, 11kV	50,500
Post Insulator	33kV, 11kV	30,000
Accessories	33kV, 11kV	50,000

(Source : ESCOM data)

(2) Labor, Transport and Overhead

Description	Voltage	Unit Cost (MK)
Labor	33kV, 11kV	40,863
Transport	33kV, 11kV	33,987
Overhead	33kV, 11kV	5%of Total

(Source : ESCOM data)

Foreign Currency: All Materials

Local Currency: Labor and Transport

Overhead is divided proportionally by both ratios.

4. Disconnecting Switch

(1) Material (Air Break Switch)

Description	Voltage	Unit Cost (MK)
Air Break Switch	33kV	94,497.40
	11kV	48,417.58

(Source: Price List June 2001 (DOE))

(2) Material (Structure)

Description	Voltage	Unit Cost (MK)
Supporting Structure *	33kV	69,723.71
	11kV	40,537.60
Accessories **	-	15% of Structure

* Referred to Section cost of line.

** Referred to cost of distribution transformer

(3) Labor, Transport and Overhead

5% of material referred to cost of distribution transformer is assumed.

Foreign Currency: All Materials

Local Currency: Others

5. Other

Estimation of construction cost was made based on the following conditions:

(a) Administration 3%

(b) Engineering Fee 8%

(c) VAT 10%

APPENDIX CHAPTER 10

APPENDIX FINANCIAL EVALUATION OF ELECTRIFICATION COST FOR EACH TRADING CENTER (1/3)

Region: Northern

Electrification Phase	Electrification Priority	Chitipa	Karonga	Rumphi	Nkhata Bay	Mzimba	Likoma
Phase V	1	Nthalire	Songwe	Katowo	Mpamba	Edingeni	
	Peak Demand (kW)	385	113	297	115	27	
	Energy Demand (MWh)	1,929	567	1,486	575	137	
	Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	
	Electrification Cost (x1,000US$)	1,023	88	527	237	71	
	Tariff Multiple	2.90	1.23	2.11	2.37	2.85	
	2	Lupita	Kibwe	Chitimba-chiweta	Kavuzi	Euthini	
	Peak Demand (kW)	382	382	20	176	350	
	Energy Demand (MWh)	1,915	1,915	98	880	1,752	
	Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	
	Electrification Cost (x1,000US$)	156	156	235	225	156	
	Tariff Multiple	0.90	0.90	11.17	1.67	0.93	
Phase VI	3	Wenya	Pusi	Lara	Khondowe	Mpherembe	
	Peak Demand (kW)	374	356	113	38	224	
	Energy Demand (MWh)	1,871	1,784	567	190	1,121	
	Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	Diesel	DL Ext.	
	Electrification Cost (x1,000US$)	214	156	88	110	122	
	Tariff Multiple	1.05	0.93	1.23	3.10	1.02	
	4	Kameme	Iponga	Muhuju	Sanga	Jenda	
	Peak Demand (kW)	391	56	204	16	81	
	Energy Demand (MWh)	1,960	282	1,021	81	408	
	Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	
	Electrification Cost (x1,000US$)	468	71	120	100	88	
	Tariff Multiple	1.60	1.66	1.06	6.06	1.50	
Phase VII	5	Chsenan	Miyombo	Mwasisi	Usisya	Manyamula	
	Peak Demand (kW)	208	113	113	323	224	
	Energy Demand (MWh)	1,042	567	567	1,617	1,121	
	Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	
	Electrification Cost (x1,000US$)	193	88	132	408	361	
	Tariff Multiple	1.36	1.22	1.57	1.65	1.98	
	6	Kapoka	Mlare	Nchenachena	Nthungwa	Eswazini	
	Peak Demand (kW)	263	38	189	153	60	
	Energy Demand (MWh)	1,318	190	948	765	299	
	Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	
	Electrification Cost (x1,000US$)	122	249	105	374	71	
	Tariff Multiple	0.95	6.35	1.03	2.70	1.59	
Phase VIII	7	Chisenga	Chibepasha	Nkhozo	Ruarwe	Luwelezi	
	Peak Demand (kW)	94	38	117	268	81	
	Energy Demand (MWh)	472	190	587	1,344	408	
	Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	Micro-hydro	DL Ext.	
	Electrification Cost (x1,000US$)	357	176	88	641	117	
	Tariff Multiple	3.90	4.65	1.21	2.62	1.81	
	8	Mulembe	Mwenitete	Ng'onga	Chituka	Emfeni	
	Peak Demand (kW)	35	43	51	113	53	
	Energy Demand (MWh)	174	217	254	567	267	
	Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	567	DL Ext.	
	Electrification Cost (x1,000US$)	159	71	71	161	100	
	Tariff Multiple	2.54	2.00	1.78	1.79	2.20	

Region: Central

Electrification Phase	Electrification Priority	Kasungu	Nkhotakota	Ntchisi	Dowa	Salima	Lilongwe	Mchinji	Dedza	Ntcheu
Phase V	1	Chamama	Mkaika	Nthesa	Thambwe	Kandulu	Chilobwe	Mkanda	Kabwazi	Ntonda
	Peak Demand (kW)	142	505	50	142	153	307	273	53	132
	Energy Demand (MWh)	711	2,529	251	710	768	1,536	1,366	264	663
	Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.
	Electrification Cost (x1,000US$)	345	277	159	134	120	484	122	235	208
	Tariff Multiple	2.70	1.03	3.36	1.37	1.23	1.93	0.94	4.50	1.92
	2	Mpepa	Dwambadzi	Khuwi	Bowe	Chitambula	Nyanja	Chiosya	Golomoti	Kasinje
	Peak Demand (kW)	63	350	70	205	43	59	190	111	264
	Energy Demand (MWh)	318	1,752	348	1,028	215	297	954	555	1,322
	Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.
	Electrification Cost (x1,000US$)	191	378	161	298	86	71	298	88	315
	Tariff Multiple	3.20	1.50	2.59	1.83	2.31	1.61	1.92	1.24	1.60
Phase VI	3	Matenje	Msenjere	Kamsonga	Chiseflo	Kambiri Sch.	Kasiya	Mikundi	Chimoto	Kadzakalowa
	Peak Demand (kW)	28	32	303	184	113	316	42	113	300
	Energy Demand (MWh)	141	159	1,519	920	567	1,581	208	567	1,504
	Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.
	Electrification Cost (x1,000US$)	176	71	226	359	88	139	191	88	139
	Tariff Multiple	6.06	2.52	1.20	2.26	1.23	0.93	4.62	1.23	0.95
	4	Simlemba	Kasitu	Chinguluwe	Bibanzi	Khwidzi	Chawantha	Nkhwazi	Chiluzi	Kandeu
	Peak Demand (kW)	116	32	128	17	113	39	27	192	111
	Energy Demand (MWh)	580	159	639	86	567	195	136	961	556
	Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.
	Electrification Cost (x1,000US$)	371	159	88	159	88	206	86	120	193
	Tariff Multiple	3.37	4.98	1.15	8.72	1.23	5.21	3.34	1.09	2.07
Phase VII	5	Kamboni		Bumphula	Msalanyama	Thavite	Malembo	Gumba	Mphati	Sharpvalle
	Peak Demand (kW)	57		163	47	113	110	113	113	518
	Energy Demand (MWh)	285		816	236	567	549	567	567	2,593
	Appropriate Electrification Method	DL Ext.		DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.
	Electrification Cost (x1,000US$)	249		210	115	266	146	222	208	309
	Tariff Multiple	4.43		1.68	2.70	2.63	1.72	2.28	2.17	1.07
	6	Kapheni		Malambo	Kachigamba	Makioni	Nsaru	Kazyozyo	Magomelo	Bilila
	Peak Demand (kW)	59		163	157	24	438	44	344	204
	Energy Demand (MWh)	294		816	788	122	2,192	222	1,722	1,021
	Appropriate Electrification Method	DL Ext.		DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.
	Electrification Cost (x1,000US$)	71		210	120	159	351	191	214	312
	Tariff Multiple	1.61		1.68	1.22	6.34	1.25	4.35	1.09	1.89
Phase VIII	7			Ng'ombe	Chinkhwiri	Michulu	Kabudula	Gumulira		Pengapenga
	Peak Demand (kW)			29	131	113	36	34		121
	Energy Demand (MWh)			145	656	567	181	172		608
	Appropriate Electrification Method			DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.		DL Ext.
	Electrification Cost (x1,000US$)			71	252	357	191	235		146
	Tariff Multiple			2.72	2.24	3.34	2.63	6.61		1.61
	8			Kasakula	Lipri	Chikombe	Hiunjiza	Kabzyala		Kaloga
	Peak Demand (kW)			122	126	70	198	11		284
	Energy Demand (MWh)			612	630	349	992	54		1,422
	Appropriate Electrification Method			DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.		DL Ext.
	Electrification Cost (x1,000US$)			132	161	88	508	130		244
	Tariff Multiple			1.50	1.67	1.66	2.82	11.20		1.30

Region: Southern

Electrification Phase	Electrification Priority	Mangochi	Machinga	Balaka	Zomba	Chiradzulu	Blantyre	Mwanza	Thyolo	Mulanje	Phalombe	Chikwawa	Nsanje
Phase V	1	Makanjira	Chikwewu	Chendausiku	Jenale	Kanje	Chikuli	Chikonde	Nansadi	Chinyama	Chilinga	Mitondo	Tengani
	Peak Demand (kW)	410	375	250	64	204	111	113	255	136	79	162	384
	Energy Demand (MWh)	2,054	1,876	1,253	322	1,021	555	567	1,275	683	394	809	1,923
	Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.
	Electrification Cost (x1,000US$)	1,265	349	242	235	105	176	88	137	357	208	149	156
	Tariff Multiple	3.28	1.36	1.39	3.79	1.00	1.95	1.23	1.02	2.86	2.88	1.36	0.90
	2	Chilipa	Nampeya	Kwitanda	Sunuzi	Milepa	Mombo	Thambani	Fifite	Nkando	Mlomba	Linvunzu	Mankhokwe
	Peak Demand (kW)	32	401	49	116	62	17	233	156	142	138	33	182
	Energy Demand (MWh)	160	2,006	243	583	312	84	1,165	783	711	689	165	910
	Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.
	Electrification Cost (x1,000US$)	340	363	100	132	235	159	300	105	149	225	191	105
	Tariff Multiple	5.56	1.34	2.36	1.54	3.44	8.93	1.68	1.13	1.40	1.99	5.67	1.05
Phase VI	3	Chiponde	Ngokwe	Phimbi	Zaone	Chimwawa	Dziwe	Ligowe	Lalakani	Nanthombozi	Phaloni	Kakoma	Mtowe
	Peak Demand (kW)	244	42	38	244	38	38	113	10	125	26	204	224
	Energy Demand (MWh)	1,221	208	190	1,221	190	190	567	49	624	132	1,021	1,121
	Appropriate Electrification Method	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.
	Electrification Cost (x1,000US$)	122	264	354	122	71	86	103	206	132	115	298	180
	Tariff Multiple	0.98	6.17	8.79	0.98	2.20	1.62	1.34	19.25	1.48	4.41	1.84	1.25
	4	Majuni	Mposa		Muwa	Ndunde	Mudi	Kanfumwamba	Thomasi	Chambe	Chitekesa	Tomali	Mbenje
	Peak Demand (kW)	113	33		67	51	101	91	204	263	113	32	107
	Energy Demand (MWh)	567	163		336	254	504	456	1,021	1,315	567	162	538
	Appropriate Electrification Method	DL Ext.	DL Ext.		DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.
	Electrification Cost (x1,000US$)	88	264		146	71	146	222	283	137	117	71	146
	Tariff Multiple	1.23	7.71		2.47	1.79	1.82	2.71	1.78	1.01	1.45	1.40	1.75
Phase VII	5	Mvumba	Nayuchi		Mpyupyu		Mlenje	Matope	Makapwa	Mathambi	Mpasa	Ndakwera	Masenjere
	Peak Demand (kW)	63	72		224		38	204	38	155	38	100	204
	Energy Demand (MWh)	313	358		1,121		193	1,021	190	777	190	499	1,021
	Appropriate Electrification Method	DL Ext.	DL Ext.		DL Ext.		DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.
	Electrification Cost (x1,000US$)	71	401		122		86	269	115	163	159	146	225
	Tariff Multiple	1.55	5.52		1.02		2.51	1.71	3.23	2.43	4.25	1.84	1.52
	6	Katuli	Msosa		Masaula		Domwe	Magaleta	Sandama	Chinakanaka	Nambazo	Kanyinda	Kampata
	Peak Demand (kW)	65	74		224		113	19	341	146	113	174	37
	Energy Demand (MWh)	327	371		1,121		567	97	1,708	732	567	873	185
	Appropriate Electrification Method	DL Ext.	DL Ext.		DL Ext.		DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.
	Electrification Cost (x1,000US$)	328	176		227		103	100	153	120	222	120	130
	Tariff Multiple	5.00	2.65		1.44		1.35	5.10	0.94	1.27	2.28	1.15	3.66
Phase VIII	7	Mkumba	Ngwepele		Nachuma		Chigwaja	Kanenekude	Chipho	Msakwanjala			Lulwe
	Peak Demand (kW)	287	133		113		113	53	152	48			59
	Energy Demand (MWh)	1,436	667		567		567	264	761	239			295
	Appropriate Electrification Method	DL Ext.	DL Ext.		DL Ext.		DL Ext.	DL Ext.	DL Ext.	DL Ext.			DL Ext.
	Electrification Cost (x1,000US$)	197	295		132		103	235	163	86			191
	Tariff Multiple	1.15	2.51		1.57		1.35	4.50	1.50	2.14			3.42
	8	Katema	Mangamba		Khonjeni		Linjidzi	Tulonkhondo		Namphundo			Chididi
	Peak Demand (kW)	176	60		38		113	145		59			224
	Energy Demand (MWh)	882	299		190		567	724		294			1,121
	Appropriate Electrification Method	DL Ext.	DL Ext.		DL Ext.		DL Ext.	DL Ext.		DL Ext.			DL Ext.
	Electrification Cost (x1,000US$)	298	206		130		146	283		86			166
	Tariff Multiple	2.04	3.61		3.57		1.69	2.28		1.84			1.20

APPENDIX FINANCIAL EVALUATION OF ELECTRIFICATION COST FOR EACH TRADING CENTER (2/3)

Electrification Phase	Region / Name of District / Electrification Priority	Northern						Central									Southern											
		Chitipa	Karonga	Rumphi	Nkhata Bay	Mzimba	Likoma	Kasungu	Nkhotakota	Ntchisi	Dowa	Salima	Lilongwe	Mchinji	Dedza	Ntcheu	Mangochi	Machinga	Balaka	Zomba	Chiradzulu	Blantyre	Mwanza	Thyolo	Mulanje	Phalombe	Chikwawa	Nsanje
Phase IX	9		Tilora	Kamphenda	Maula	Engutwini				Mzandu	Kasuntha	Mnema	Phirilanjuli	Kalulu		Masasa	Lungwena	Likhonyowa		Kachulu			Kasuza		Kambenje			Sankhulani
	Peak Demand (kW)		38	113	38	113				68	264	26	91	32		4	204	113		204			69		16			204
	Energy Demand (MWh)		190	567	190	567				340	1,322	132	458	159		18	1,021	567		1,021			345		81			1,021
	Appropriate Electrification Method		DL Ext.	DL Ext.	DL Ext.	DL Ext.				DL Ext.	DL Ext.	DL Ext.	DL Ext.	DL Ext.		DL Ext.	DL Ext.	DL Ext.		DL Ext.			DL Ext.		DL Ext.			DL Ext.
	Electrification Cost (x1,000US$)		235	117	71	176				208	242	176	281	130		249	210	88		105			88		86			193
	Tariff Multiple		6.04	1.45	2.20	1.92				3.24	1.36	6.47	3.27	4.18		62.04	1.45	1.23		1.00			1.67		5.25			1.38
	10		Hara	Mphompha	Lwazi					Nthondo	Chankhunga	Chitala	Kachale				Kwisimba	Malundani		Sakata					Kamwendo			
	Peak Demand (kW)		26	113	38					124	117	224	96				94	204		6					146			
	Energy Demand (MWh)		132	567	190					621	588	1,121	482				472	1,021		30					729			
	Appropriate Electrification Method		DL Ext.	DL Ext.	DL Ext.					DL Ext.	DL Ext.	DL Ext.	DL Ext.				DL Ext.	DL Ext.		DL Ext.					DL Ext.			
	Electrification Cost (x1,000US$)		71	252	115					146	146	180	176				222	210		115					105			
	Tariff Multiple		2.92	2.52	1.99					1.59	1.64	1.26	2.17				2.63	1.45		17.58					2.82			
Phase X	11		Lupembe							Kayoyo	Nalunga	Chinguluwe	Chimbalanga					Nanyumbu		Makina								
	Peak Demand (kW)		113							90	45	113	115					38		204								
	Energy Demand (MWh)		567							449	226	567	575					190		1,021								
	Appropriate Electrification Method		DL Ext.							DL Ext.	DL Ext.	DL Ext.	DL Ext.					DL Ext.		DL Ext.								
	Electrification Cost (x1,000US$)		117							193	176	88	281					71		134								
	Tariff Multiple		1.46							2.44	4.00	1.23	2.70					2.19		1.12								
	12										Dzoole	Siyasiya	Mtema					Molipa		Ngwelero								
	Peak Demand (kW)										105	113	170					113		224								
	Energy Demand (MWh)										526	567	851					567		1,121								
	Appropriate Electrification Method										DL Ext.	DL Ext.	DL Ext.					DL Ext.		DL Ext.								
	Electrification Cost (x1,000US$)										193	88	239					88		137								
	Tariff Multiple										2.16	1.23	1.79					1.23		1.08								
Phase XI	13										Kalonga	Matenje	Bisai							Chisunzi								
	Peak Demand (kW)										48	38	112							113								
	Energy Demand (MWh)										239	190	562							567								
	Appropriate Electrification Method										DL Ext.	DL Ext.	DL Ext.							DL Ext.								
	Electrification Cost (x1,000US$)										71	115	208							103								
	Tariff Multiple										1.86	3.23	2.19							1.35								
	14										Kalumbu	Chagunda	Mbong'ombe							Ngondole								
	Peak Demand (kW)										146	113	153							204								
	Energy Demand (MWh)										730	567	766							1,021								
	Appropriate Electrification Method										DL Ext.	DL Ext.	DL Ext.							DL Ext.								
	Electrification Cost (x1,000US$)										178	88	312							149								
	Tariff Multiple										1.63	1.23	4.16							1.19								
Phase XII	15										Mkukula	Pemba	Sinumbe															
	Peak Demand (kW)										124	224	26															
	Energy Demand (MWh)										621	1,121	132															
	Appropriate Electrification Method										DL Ext.	DL Ext.	DL Ext.															
	Electrification Cost (x1,000US$)										103	166	176															
	Tariff Multiple										1.28	1.20	6.46															
	16										Chakadza	Mphinzi	Kang'oma															
	Peak Demand (kW)										158	38	227															
	Energy Demand (MWh)										792	190	1,137															
	Appropriate Electrification Method										DL Ext.	DL Ext.	DL Ext.															
	Electrification Cost (x1,000US$)										120	235	210															
	Tariff Multiple										1.22	6.01	1.36															

APPENDIX FINANCIAL EVALUATION OF ELECTRIFICATION COST FOR EACH TRADING CENTER (3/3)

Electrification Phase	Region / Name of District / Electrification Priority	Northern						Central									Southern											
		Chitipa	Karonga	Rumphi	Nkhata Bay	Mzimba	Likoma	Kasungu	Nkhotakota	Ntchisi	Dowa	Salima	Lilongwe	Mchinji	Dedza	Ntcheu	Mangochi	Machinga	Balaka	Zomba	Chiradzulu	Blantyre	Mwanza	Thyolo	Mulanje	Phalombe	Chikwawa	Nsanje
Phase XIII	17										Chimungu		Chiwamba															
	Peak Demand (kW)										86		102															
	Energy Demand (MWh)										430		511															
	Appropriate Electrification Method										DL Ext.		DL Ext.															
	Electrification Cost (x1,000US$)										176		88															
	Tariff Multiple										2.35		1.31															
	18										Thonje		Chadza															
	Peak Demand (kW)										86		224															
	Energy Demand (MWh)										430		1,122															
	Appropriate Electrification Method										DL Ext.		DL Ext.															
	Electrification Cost (x1,000US$)										132		256															
	Tariff Multiple										1.90		1.56															
Phase XIV	19										Kayembe		Kalumbu															
	Peak Demand (kW)										115		189															
	Energy Demand (MWh)										575		946															
	Appropriate Electrification Method										DL Ext.		DL Ext.															
	Electrification Cost (x1,000US$)										252		163															
	Tariff Multiple										2.48		1.31															
	20										Simbi		Kalima															
	Peak Demand (kW)										86		45															
	Energy Demand (MWh)										430		226															
	Appropriate Electrification Method										DL Ext.		DL Ext.															
	Electrification Cost (x1,000US$)										146		100															
	Tariff Multiple										1.67		1.01															
Phase XV	21										Bweya																	
	Peak Demand (kW)										81																	
	Energy Demand (MWh)										407																	
	Appropriate Electrification Method										DL Ext.																	
	Electrification Cost (x1,000US$)										132																	
	Tariff Multiple										1.98																	
	22										Ntiti																	
	Peak Demand (kW)										115																	
	Energy Demand (MWh)										575																	
	Appropriate Electrification Method										DL Ext.																	
	Electrification Cost (x1,000US$)										88																	
	Tariff Multiple										1.98																	