No

Japan International Cooperation Agency

Department of Energy Affairs,

Ministry of Mines, Natural Resources and Environment, Republic of Malawi

The Feasibility Study Implementation Manual for Grid Extension

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1. Objectives

The Feasibility Study (hereinafter referred to as FS) at each candidate Trading Center (hereinafter referred to as "TC") is carried out for two objectives.

(1) To confirm an actual route and arrangement of equipment considering technical issues below:

(a) Selection of routes for middle voltage lines such as 33kV and 11kV lines

(b) Selection of routes to extend 400/230V distribution lines to public facilities in TCs

(c) Demand forecast if necessary

(d) To study if electricity supply is possible or not under the voltage regulation

(2) To estimate costs and viability in order to check the bill of constructor and analyze the possibility of enterprise.

2. Process on Implementation for Rural Electrification

The FS will be carried out after the Master Plan (Pre-Feasibility Study) which is based on a criterion as well as a demand forecast. Not viable sites (TCs) should be in the field of rural electrification to be managed by the Government of Malawi. The process of implementation is shown in the Figure 1.

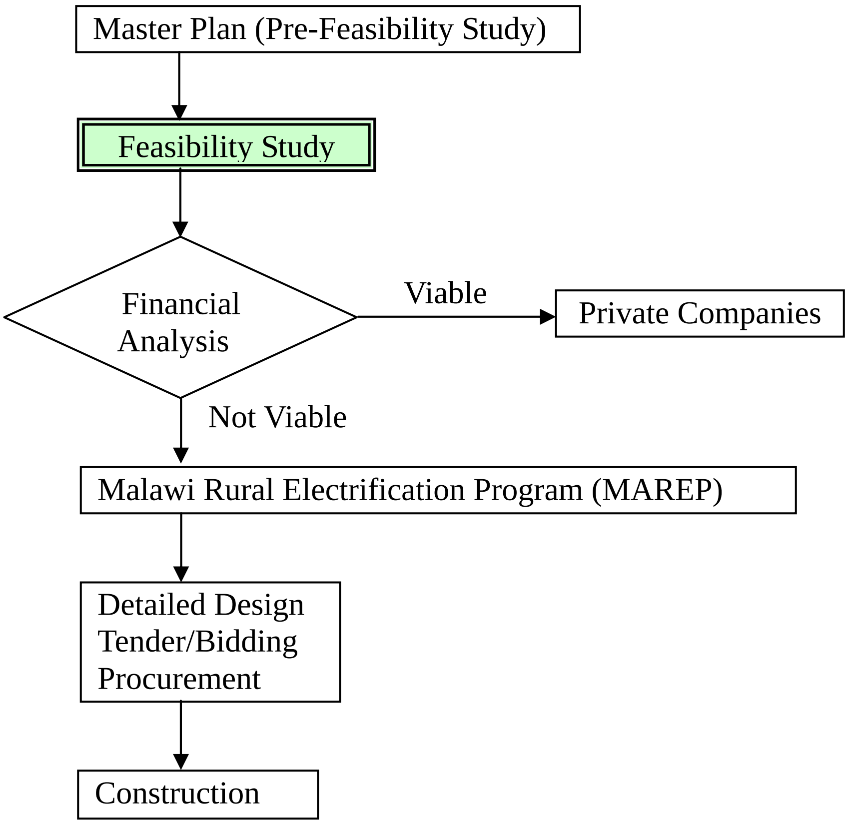


Figure 1 : Process for Implementation of Rural Electrification

3. Process on Feasibility Study

FS consists of five activities such as Preparation, Map Study, Field investigation, Voltage Drop Study, Cost Estimation and Economical Analysis. The process of FS is shown in the Figure 2.

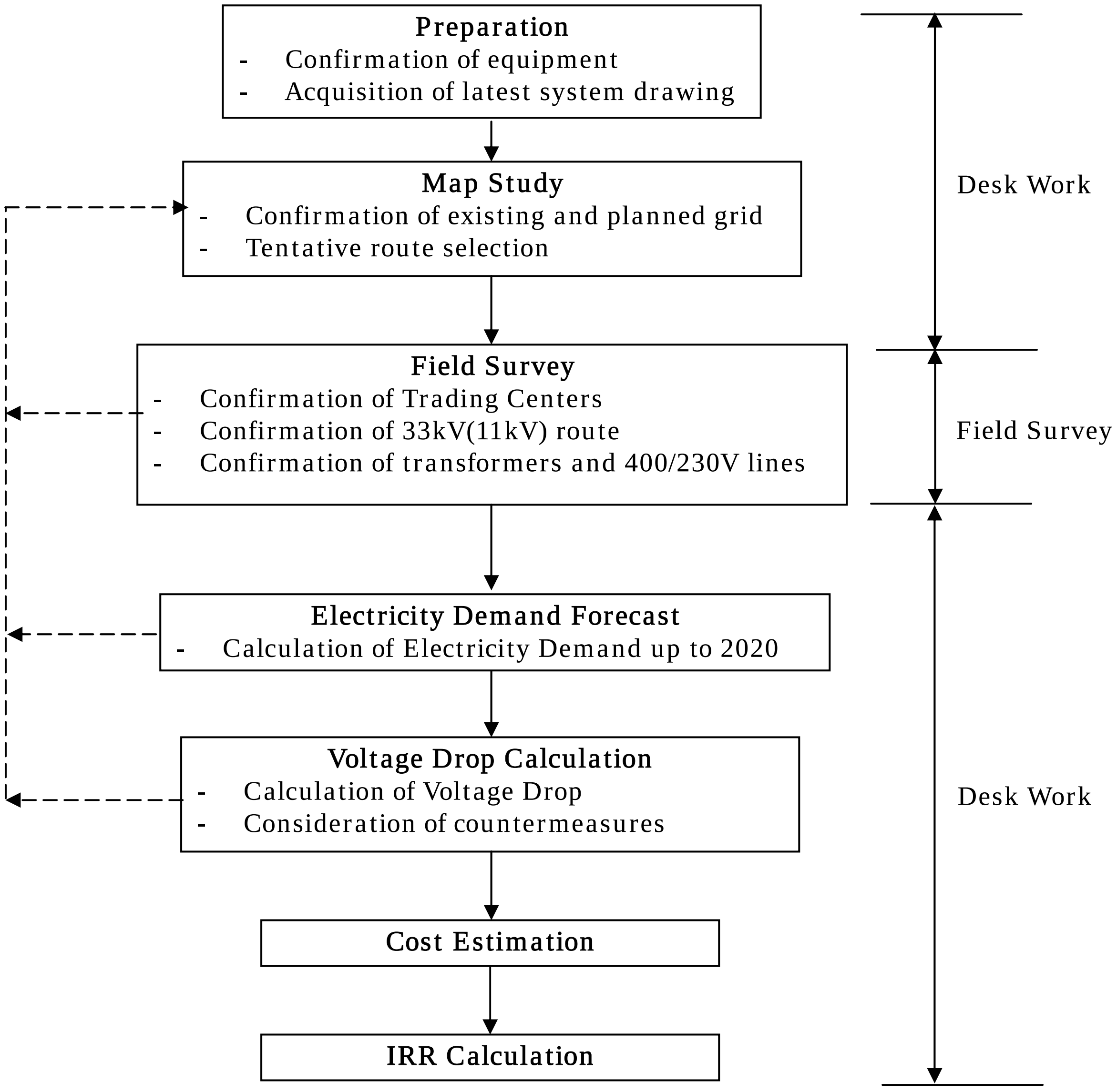


Figure 2 : Process on Feasibility Study

4. Review on the Master Plan (preliminary study) completed by JICA in March 2003

4.1 General

The cost of each Phase was estimated mainly based on map study at the Master Plan. Before carrying out the FS, some assumptions of the Master Plan listed below should be put in mind.

4.2 Voltage classes of distribution lines

- Class of the existing distribution line to trading centers shall be 33kV
- 3-phase 3-wire system

4.3 System configuration

- A radial system with no reserve line is adopted for cost reduction
- Disconnecting Switches (DS) shall be installed every 10km to separate faulty section
- A circuit Breaker (CB) shall be installed at each starting point of new lines

4.4 Distribution system facilities

Conductor	33kV	AAAC 100mm^2
	11kV	AAAC 100mm^2
	400V / 230V	AAC100mm^2
	Dip	5% of distance
Supporting Structure	Wooden poles	
Span Length	33kV	100m
	11kV	100m
	400V	50m
Distribution Transformer	3 phase, 100kVA, max load shall be 80% of rated capacity	

4.5 Construction cost

(a) Definition

- Lengths of 33kV and 11kV lines are estimated at 120% of straight distance of maps.
- Extensions must be planed in line with priority. Estimate does not incorporate all TCs.
- Number of 33kV/0.4kV transformers per TC

$$n = \frac{total\ load\ of\ TC(kVA)}{rated\ capaticity(kVA) * loading 80\%}$$

where

$total\ load\ of\ TC(kVA)$

$$= \frac{demand\ of\ maize\ mill(kW)}{power\ \ factor 80\%} + \frac{demand\ of\ others(kW)}{power\ \ factor 90\%}$$

*maximum loading is 80% of rated capacity

*standard power factors are 80% for maize mills and 90% for the rest

- 400V/230V lines
- Length between a transformer and a household plug of is 500m

  Two lines are extended from each transformer

- Circuit breaker

  A circuit breaker is installed at the starting point of new lines

- Disconnecting Switch

  Disconnecting switches are installed every 10km

(b) Unit cost and total cost

- Unit cost

  Unit cost of 33kV line, transformers and 400V/230V are calculated using (latest total cost / total quantity)

- Total cost

  A total cost was estimated to the sum of costs on 33kV lines, transformers, circuit breakers, disconnection switches and 400/230V lines. Then, 8% of an engineering service fee, 2% of an administrative fee for DOE and 10% of an surtax are added.

5. Description on each activity

5.1 Preparation

(a) Data collection

Before a FS, some data listed below should be collected in advance.

- Existing lines and future planning of ESCOM
- Cost data per km including local cost such as labors, transport, fuels, etc.
- Technical data for voltage drop calculation
- Tariff, energy cost, O&M cost per kWh

(b) Equipment/materials for the FS (Refer to Attachment 1-a)

For FS, some equipment/materials listed below should be prepared in advance.

- 1/250,000 scale maps, hopefully more detailed maps
- Roller measure
- Plane board for drawings
- White papers and section papers
- Rulers
- Calculators
- GPS
- Laser binoculars
- Magnet compass

And the objectives, directions of main equipment are shown in the Table 1.

Table 1 : Objectives, Directions of Main Equipment

Equipment	Objectives	Directions (how to use)
GPS	To confirm the current position during driving and drawing.	Push the "page" button after turning on the source switch.
Laser binoculars	To measure the long distance or distance with obstacle. Mainly vertical direction along the main load.	Depress the source switch after aligning the reticule with the target.
Roller measure	To measure the short distance exactly. Mainly horizontal direction along the main load.	Roll after pushing button to reset.
Magnet compass	To confirm the current direction during driving and drawing.	Put in the horizontal place.

(c) Scheduling on field survey

Time and cost effectiveness should be considered for scheduling on the field survey. However, long duration of survey trip is not practical. One-week field survey, one-week desk work and re-planning for the next trip would be recommended.

5.2 Map Study

An objective of carrying out map study is to decide the tentative routes for the 33kV or 11kV lines from the starting point to the candidate TC. The 1:250,000 maps that are already put information obtained by data collection will be used, and standard routes are drawn along the roads on these maps.

5.3 Field Survey (Refer to Attachment 1-b,1-c)

(a) Identification on starting point of 33kV or 11kV lines

An end pole, substation or power station selected in the map study will be identified. If other distribution lines are found to have been extended near the TC, the tentative routes decided by the map study will be revised.

(b) Identification on the of 33kV or 11kV lines

This survey is conducted to investigate a route from the identified starting point to TC. If any obstacles such as large rivers and/or steep terrain are identified during the survey, and the route of distribution has to be changed considerably, the map study will be repeated.

(c) Distribution transformer and 400V/230V lines

The tentative locations of distribution transformer and 400V/230V lines are studied. The procedure is the followings

a. Draw an outline map of the candidate-trading center.
b. Select the appropriate area sites where pole-mounted transformer will be installed with consideration of the position of maize mills.
c. Draw the most appropriate route between the distribution transformer and public facilities on the outline map. Route distances will be measured.

(d) Standard symbols

Standard symbols for making drawing are as shown in Table 2.

Table 2 Standard Symbols (1/2)

Item		Example	
Scale	Choose a suitable reduced scale fitting A4 size paper		1/500, 1/1000, 1/5000 etc
Symbol	Transformer	Tx100kVA	
	33kV HV line		33kV HV
		33 kV	Blue dotted-line means "proposed."
		33kV	Green dotted-line marked by fluorescent pen means "planned."
		33 kV	Green solid line marked by fluorescent pen means "existing."
	11kV HV line		11kV HV
		11 kV	Blue dotted-line means "proposed."
		11 kV	Red dotted-line marked by fluorescent pen means planned."
		11 kV	Red solid line marked by fluorescent pen means "existing."
	LV line		3φ: 3-phase 4-wire system (400V) 1φ: 1-phase 2-wire system (230V)
		1φ	Blue solid line means "proposed."
	Existing Extra High Voltage Line	66 kV	Red solid line
	Existing Telecommunication Line	Tele	Red solid line
	Direction	N	
	Maize Mill	MM Sh	Sh means "Maize Mill with Sheller"
	Shop	SH	
	House	H	H in square is not necessary to be shown.
	Secondary School	SS	
	Primary School	PS	
	Church	CH	
	Mosque	MO	
	Court	CO	
	Health Center	HC	
	Hospital	HO	
	Clinic	CL	

Table 2 Standard Symbols (2/2)

Item		Example	
Symbol	Police Station	POL	
	Police Unit	PU	
	Police Post	PP	
	Agriculture Office	AG	
	Government Office	GO	
	Post Office	PO	
	Admarc	AD	
	Teacher's Training Center	TTC	
	Government Office	GO	
	Agriculture Office	AG	
	Staff House	STA	
	Other Public Facility	OPF	Write the concrete type of facility
	Market	MA	Solid line means “the area.”
	Restaurant	RE	
	Rest House	RH	
	Battery Charge Station	BCS	
	Tree	Tree	Solid line means “the area.”

5.4 Electricity Demand Forecast Method (Refer to Attachment 1-d,2-a)

5.4.1 Preface

To electrify a non-electrified TC, a demand forecast is significant for designing appropriate distribution facilities and estimating accurate distribution costs because a demand forecast of a TC is a basic in a plan for electrification.

In the present condition in Malawi, however, the main role of the Government of Malawi is to raise the electrification ratio to the level that the nation can have access to electricity as at least basic human needs and the Government of Malawi is not responsible for power sector as business. Therefore, the targets to electrify that the Government of Malawi has a responsibility is public facilities and maize mills in TC and electrification of other facilities such as business entities and households are under the control of private power companies. In this circumstance, a demand forecast in each TC is only an indicator for reference or could be data for comparison with demand forecasts submitted by private power companies. In addition, an estimated distribution system for a TC in FS implemented by DOE is set to satisfy the present power demand in public facilities and maize mills in the TC. Although the present demand is calculated for determination of facilities for the distribution system, the demand forecast is not used in FS.

The demand forecast for each non-electrified TC was examined in "The Master Plan Study on Rural Electrification Plan in Malawi." In this FS Manual, the ordinary electricity demand forecast methods, the problems in the demand forecast in the Master Plan, and the new demand forecast method are explained. Since this is only a manual, however, the "how to" is focused on and the theoretical aspects are not deeply explained. Please refer the report of the Follow-up Study for the theoretical details.

5.4.2 Ordinary Electricity Demand Forecast Methods

In electricity demand forecast methods, there are two major approaches; the macro approach and the micro approach. These both have their characters, advantages and disadvantages. In Japan, we use both approaches to estimate future demand forecasts.

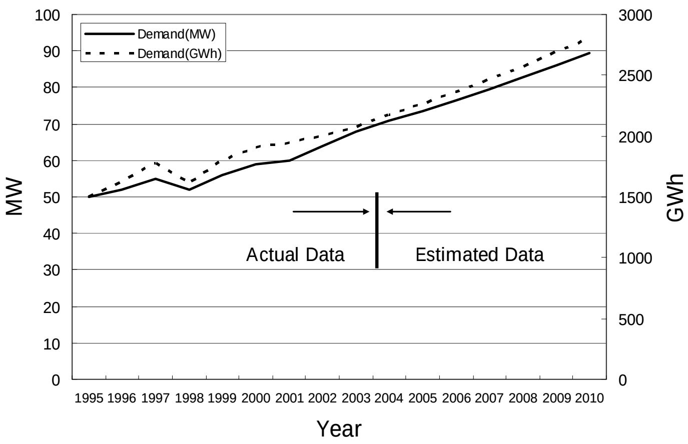


Figure 3 : The Example of the simplest demand forecast

(1) Macro Approach

The Macro Approach is a method in electricity demand forecasts using statistics of the macro economic data such as population growth, GNP growth, and IIP (Index of Industrial Production) growth. The simplest way is that, based on the actual data of demands in MW and GWh, we estimate the growth of both demands by the averages of these growths. The longer terms for calculation of the averages are, the better it is. The example is shown in Fig. V-1. These macro economic data can be obtained from organizations like a national statistic agency.

In addition that this approach is used for electrified areas since the past demand data is needed for estimation, however, it is usually used for estimation in grid system. The reason is that grid-connected areas usually have a good correlation with macro economic indicators because an electricity demand in industries excels in grid-connected areas comparing with other customers. However, the demand in non-electrified areas does not always fit with economic movements since electricity has not been needed for their life.

The advantages and the disadvantages of the macro approach are as follows;

<Advantages>

- Since macro economic indicators are considered, the results of demand forecast match to the national economic conditions.
- The calculation is not complicated comparing with the micro method.

<Disadvantages>

- The result depends on how long the terms of economic indicators are.
- In especially developing countries, it is difficult to acquire accurate economic indicators.
- The longer forecast terms, the worse accuracy since it is impossible to forecast future economic and political issues.

(2) Micro Approach

The Micro Approach (End-user Approach) is a method in electricity demand forecasts using unit demands which is estimated from power consumptions in customers such as households, business units, schools, and hospitals. The electricity demand is calculated with piling up these unit demands.

A unit demand is estimated from actual consumptions and its power usage hours referring already electrified areas. For example, when estimating a unit demand in a household, we research actual power consumption hour by hour through interviews in electrified houses and assume an ordinary power usage form as a unit demand. Then we pile up the unit demand multiplying the number of household in the area.

The end-user approach is especially good for the estimation in non-electrified areas which demands are difficult to estimate and are not along with macro economic movements like TCs.

The advantages and the disadvantages of the macro approach are as follows;

<Advantages>

- Since a unit demand which is a base of a demand forecast in micro approach is assumed based on actual power consumption, the forecasted demand is nearly right.
- Relatively accurate analyses can be expected because the unit demands in types such as households, industries, shops are calculated
- Not only quantitative data but also qualitative data in both electrified and non-electrified areas such as willingness to pay, capacity to pay can be acquired through socio-economic survey.

<Disadvantages>

- The needed data for assuming a unit cost is great in quantity and collecting data takes much time.
- The data analyses from interviews are complicated.
- A unit demand changes depending on the target year to forecast.

5.4.3 New Electricity Demand Forecast Method

Based on the demand forecast method in the Master Plan, the new demand forecast method was developed.

(1) Policies

The basic policies for the DOE demand forecast are as follows.

- The demand forecasts for non-electrified TCs in the Master Plan indicate electricity demand until 2020 according to the Master Plan.
- The micro method was adopted in order to grasp more accurate electricity demand in a non-electrified TC.

(2) Preconditions

(a) The facilities in each TC which DOE targets to are as follows.

- *Public Facilities*

1) Secondary School
2) Primary School
3) Teacher's Development Center
4) Staff House
5) Hospital

6) Health Center
7) Clinic
8) Post Office
9) Police Station
10) Police Post
11) Police Unit
12) Admarc
13) Other Government Offices
14) Church
15) Mosque
16) Court
17) Other Public Facilities

- *Business Entities*
  1) Maize Mill
  2) Shop
- *Households*
  1) Ordinary Household
  2) Rich Household

(b) The electricity demand forecasts are made based on the analyses of the Socio-Economic Survey in the Master Plan

(c) The electricity demand is calculated multiplying the unit demand in each facility and the number of the facility

(d) The power consumption of each electric device is calculated from average of the consumption data acquired through the Socio-Economic Survey.

(e) The preconditions for each facility are as follows.

- Public Facility
  1) Electric device(s) is (are) provided from ministries concerned every 3 years.
  2) After 17 years from electrification all assumed devices will have been set.

- Maize Mill
  1) After electrification, existing maize mills in a TC are immediately connected.
  2) Increase of the number of maize mill is along with the equation of the Master Plan.
  3) An electric device is bought every year.

- Business Entity
  1) The ratio that business entities connect to distribution lines is 50%.
  2) An electric device is bought every year.
  3) Increase of the number of business entity is to be calculated based on the correlation between the household population and the number of business entity.

- Household
  1) The ratio that ordinary households connect to distribution lines is 40%.
  2) Households are separated in two, ordinary household and rich household. The ratio between ordinary households and rich households is 95:5.
  3) An electric device is bought every three years in ordinary households and every year in rich households.
  4) The number of electric device matures 17 years after electrification.
  5) The total household demand in a TC considers the household growth rate indicated in the Master Plan. (1.27%)
  6) The growth rate of electric demand after 17 years depends on the household growth rate.

(3) Necessary Data

In order to calculate an electricity demand forecast in a TC, following data should be collected in FS.

- Number of each existing public facility
- Number of existing maize mill
- Number of existing business entity
- Number of existing household inside the TC

5.4.4 Check Sheet

In a FS, a check sheet is useful for a smooth implementation and an avoidance of oversights. Though all data is significant for calculation of a demand forecast in a TC, the data to acquire can be reduced depending on allowed time in a site survey. The least data that should be absolutely needed is written in bold. Also, since the check sheet made by DOE was based on the rural electrification database created in the Master Plan Study, the check sheet recommended in this FS Implementation Manual follows the format.

After inputting the necessary data to a check sheet, the electricity demand in a TC until 2020 is automatically calculated.

Note) Do not delete the file named "Unit Demand Forecast Sheet" since data in each TC is linked to the file. linked to the file.

5.4.5 Example of Demand Forecast Sheet

The unit demand in an ordinary secondary school is shown bellow as an example.

a) Daily Load in an Ordinary Secondary School

Basic Assumption:	Number of Classroom	4

Number of Usage

Electrical Devices	Number	Capacity (W)	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
1) Incandescent Light	4	100	2	2	2	2	2	2												4	4	4	2	2	2	2
2) Fluorescent Light	8	40																	8	8	8	8				
3) Cooking Device	0	1,600																								
4) Refrigerator	0	280																								
5) Radio	0	10																								
6) Cassette/CD Player	1	30							1	1	1	1	1	1	1	1	1	1	1	1						
7) Television	0	80																								
8) Video Cassette Recorder	0	20																								
9) Electric Iron	0	1,000																								
10) Electric Heater	0	1,200																								
11) Electric Fan	2	50											2	2	2	2	2	2	2	2						
12) Air Conditioner	0	1,000																								
13) Mill	0	20,000																								
14) Computer	2	200									2	2	2	2	2	2	2	2	2	2						
15) Others	0	200																								

Electrical Devices	Number	Capacity (W)	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
1) Incandescent Light	4	100	200	200	200	200	200	200	-	-	-	-	-	-	-	-	-	-	-	400	400	400	200	200	200	200
2) Fluorescent Light	8	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	320	320	320	320	-	-	-	-
3) Cooking Device	0	1,600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4) Refrigerator	0	280	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5) Radio	0	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6) Cassette/CD Player	1	30	-	-	-	-	-	-	30	30	30	30	30	30	30	30	30	30	30	30	-	-	-	-	-	-
7) Television	0	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8) Video Cassette Recorder	0	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9) Electric Iron	0	1,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10) Electric Heater	0	1,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11) Electric Fan	2	50	-	-	-	-	-	-	-	-	-	-	100	100	100	100	100	100	100	100	-	-	-	-	-	-
12) Air Conditioner	0	1,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13) Mill	0	20,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14) Computer	2	200	-	-	-	-	-	-	-	-	400	400	400	400	400	400	400	400	400	400	-	-	-	-	-	-
15) Others	0	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Max Capacity (W)		1,250	200	200	200	200	200	200	30	30	430	430	530	530	530	530	530	530	850	1,250	720	720	200	200	200	200
Total Consumption (Wh)		9,640	200	200	200	200	200	200	30	30	430	430	530	530	530	530	530	530	850	1,250	720	720	200	200	200	200

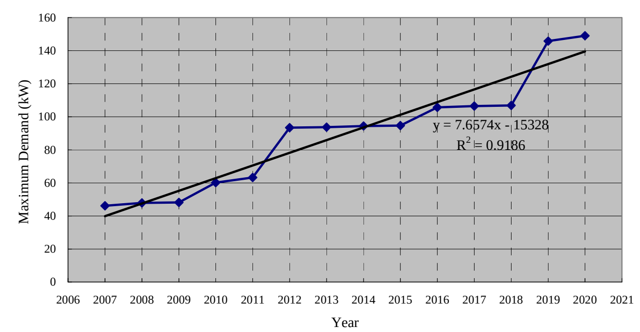
The electricity demand forecast until 2020 in Kapoka in Chitipa District is shown as follow.

Demand Forecast in TC

DISTRICT: Chitipa
TC NAME: Kapoka

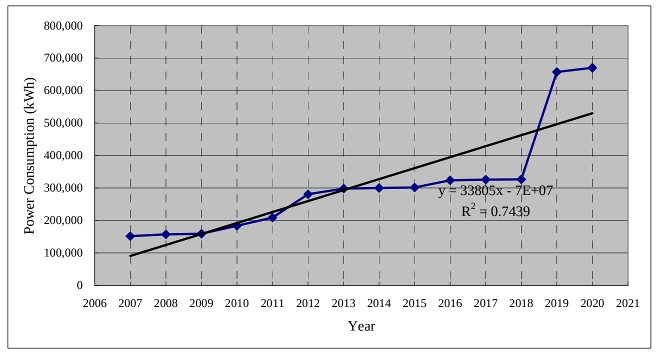
Max Capacity (kW)

Year	Secondary School	Primary School	Teacher's Development Center	Staff House	Hospital	Health Center	Clinic	Post Office	Police Station	Police Post	Police Unit	Admarc	Government Office	Church	Mosque	Court	Other Public Facilities	Public Facilities Total	Maize Mill		Business Entities		Business Entities Total	Ordinary Household		Rich Household		Household Total	TC Total
																			Number	kW	Number	kW		Number	kW	Number	kW		
2007	0.4000	0.4000	0.0000	0.0000	0.0000	0.3100	0.0000	0.0000	0.3000	0.0000	0.0000	0.0000	0.0000	0.1000	0.0000	0.0000	0.4000	1.9100	1	20.0100	3	0.2400	20.2500	114	22.8000	6	1.2000	24.0000	46.1600
2008	0.4000	0.4000	0.0000	0.0000	0.0000	0.3100	0.0000	0.0000	0.3000	0.0000	0.0000	0.0000	0.0000	0.1000	0.0000	0.0000	0.4000	1.9100	1	20.0100	3	0.8400	20.8500	116	23.2000	7	1.9600	25.1600	47.9200
2009	0.4000	0.4000	0.0000	0.0000	0.0000	0.3100	0.0000	0.0000	0.3000	0.0000	0.0000	0.0000	0.0000	0.1000	0.0000	0.0000	0.4000	1.9100	1	20.0500	3	0.8400	20.8900	117	23.4000	7	1.9600	25.3600	48.1600
2010	0.7200	0.8800	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000	0.0000	0.1400	0.0000	0.0000	0.4000	3.4300	1	20.0500	3	0.8400	20.8900	119	33.3200	7	2.5200	35.8400	60.1600
2011	0.7200	0.8800	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000	0.0000	0.1400	0.0000	0.0000	0.4000	3.4300	1	20.0500	3	1.6800	21.7300	120	33.6000	7	4.4800	38.0800	63.2400
2012	0.7200	0.8800	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000	0.0000	0.1400	0.0000	0.0000	0.4000	3.4300	2	40.1000	3	1.6800	41.7800	122	34.1600	7	14.0000	48.1600	93.3700
2013	0.7500	0.9100	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.5100	0.0000	0.0000	0.0000	0.0000	0.1400	0.0000	0.0000	0.4000	3.5000	2	40.1000	3	1.6800	41.7800	123	34.4400	7	14.0000	48.4400	93.7200
2014	0.7500	0.9100	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.5100	0.0000	0.0000	0.0000	0.0000	0.1400	0.0000	0.0000	0.4000	3.5000	2	40.1000	3	1.6800	41.7800	125	35.0000	7	14.1400	49.1400	94.4200
2015	0.7500	0.9100	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.5100	0.0000	0.0000	0.0000	0.0000	0.1400	0.0000	0.0000	0.4000	3.5000	2	40.1000	3	1.6800	41.7800	126	35.2800	7	14.1400	49.4200	94.7000
2016	0.8500	1.0100	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.5600	0.0000	0.0000	0.0000	0.0000	0.1400	0.0000	0.0000	0.4000	3.7500	2	40.1000	3	1.6800	41.7800	128	46.0800	7	14.1400	60.2200	105.7500
2017	0.8500	1.0100	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.5600	0.0000	0.0000	0.0000	0.0000	0.1400	0.0000	0.0000	0.4000	3.7500	2	40.1000	3	1.6800	41.7800	130	46.8000	7	14.1400	60.9400	106.4700
2018	0.8500	1.0100	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.5600	0.0000	0.0000	0.0000	0.0000	0.1400	0.0000	0.0000	0.4000	3.7500	2	40.1000	3	1.6800	41.7800	131	47.1600	7	14.1400	61.3000	106.8300
2019	1.2500	1.4100	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.7600	0.0000	0.0000	0.0000	0.0000	0.1400	0.0000	0.0000	0.4000	4.7500	2	40.1000	3	1.6800	41.7800	133	85.1200	7	14.1400	99.2600	145.7900
2020	1.2500	1.4100	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.7600	0.0000	0.0000	0.0000	0.0000	0.1400	0.0000	0.0000	0.4000	4.7500	2	40.1000	3	1.6800	41.7800	135	86.4000	8	16.1600	102.5600	149.0900



Power Consumption (kWh)

Year	Secondary School	Primary School	Teacher's Development Center	Staff House	Hospital	Health Center	Clinic	Post Office	Police Station	Police Post	Police Unit	Admarc	Government Office	Church	Mosque	Court	Other Public Facilities	Public Facilities Total	Maize Mill		Business Entities		Business Entities Total	Ordinary Household		Rich Household		Household Total	TC Total
																			Unit	Year	Unit	Year		Number	Year	Number	Year		
2007	884	884	0	0	0	1,099	0	0	1,820	0	0	0	0	473	0	0	1,560	6,720	1	57,229	3	175	57,403	114	82,992	6	4,368	87,360	151,484
2008	884	884	0	0	0	1,099	0	0	1,820	0	0	0	0	473	0	0	1,560	6,720	1	57,567	3	2,577	60,144	116	84,448	7	5,911	90,359	157,224
2009	884	884	0	0	0	1,099	0	0	1,820	0	0	0	0	473	0	0	1,560	6,720	1	57,587	3	2,719	60,306	117	85,176	7	6,676	91,852	158,879
2010	1,217	1,258	0	0	0	5,293	0	0	3,800	0	0	0	0	517	0	0	1,934	14,019	1	57,587	3	3,855	61,442	119	100,493	7	7,720	108,214	183,675
2011	1,217	1,258	0	0	0	5,293	0	0	3,800	0	0	0	0	517	0	0	1,934	14,019	1	57,587	3	11,193	68,780	120	101,338	7	24,843	126,181	208,980
2012	1,217	1,258	0	0	0	5,293	0	0	3,800	0	0	0	0	517	0	0	1,934	14,019	2	115,175	3	11,193	126,368	122	103,027	7	37,073	140,100	280,487
2013	1,303	1,344	0	0	0	5,584	0	0	3,888	0	0	0	0	517	0	0	2,028	14,663	2	115,175	3	11,193	126,368	123	117,303	7	39,621	156,924	297,955
2014	1,303	1,344	0	0	0	5,584	0	0	3,888	0	0	0	0	517	0	0	2,028	14,663	2	115,175	3	11,193	126,368	125	119,210	7	39,774	158,984	300,015
2015	1,303	1,344	0	0	0	5,584	0	0	3,888	0	0	0	0	517	0	0	2,028	14,663	2	115,175	3	11,193	126,368	126	120,164	7	40,284	160,448	301,478
2016	1,511	1,552	0	0	0	5,584	0	0	4,033	0	0	0	0	517	0	0	2,392	15,589	2	115,175	3	11,193	126,368	128	141,174	7	40,284	181,458	323,414
2017	1,511	1,552	0	0	0	5,584	0	0	4,033	0	0	0	0	517	0	0	2,392	15,589	2	115,175	3	11,193	126,368	130	143,380	7	40,284	183,663	325,620
2018	1,511	1,552	0	0	0	5,584	0	0	4,033	0	0	0	0	517	0	0	2,392	15,589	2	115,175	3	11,193	126,368	131	144,483	7	40,284	184,766	326,723
2019	2,551	2,592	0	0	0	5,584	0	0	4,834	0	0	0	0	517	0	0	2,392	18,469	2	115,175	3	11,193	126,368	133	472,017	7	40,284	512,301	657,138
2020	2,551	2,592	0	0	0	5,584	0	0	4,834	0	0	0	0	517	0	0	2,392	18,469	2	115,175	3	11,193	126,368	135	479,115	8	46,039	525,154	669,991



5.5 How to Revise Demand Forecast System

5.5.1 File Structure

File Structure is shown in Figure 4.

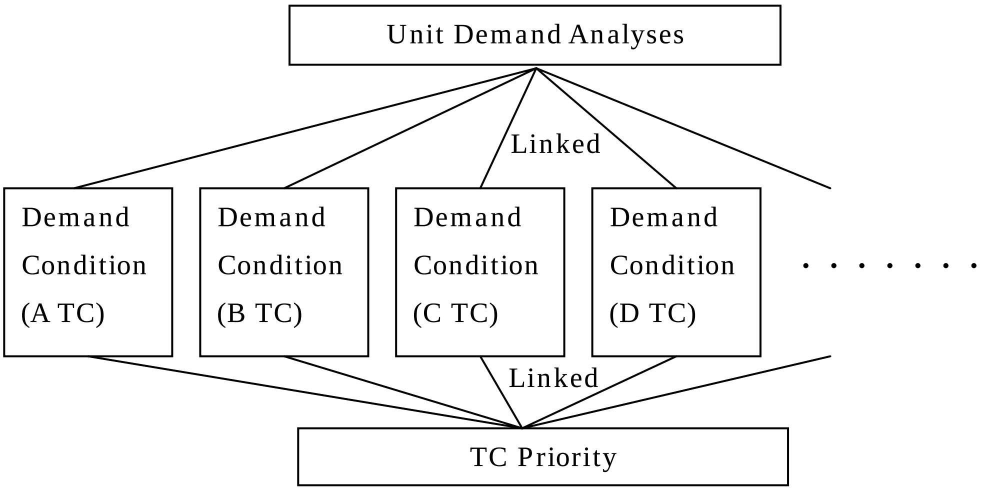


Figure 4 : File Structre (Demand Forecast System)

Unit Demand Analyses: Calculation of unit demand for facilities
Place: Desktop – JICA MP Followup Demand Forecast

TC Demand Condition files: Calculation of electricity demand from 2007 to 2020 in a TC
Place: Desktop – JICA MP Followup Demand Forecast – Phase 6

TC Priority: Prioritization of non-electrified TCs for Phase 6
Place: Desktop – JICA MP Followup Demand Forecast

5.5.2 Revision of Existing File

(1) TC Data Revision

If you want to revise number of facilities, following procedure shows how to revise.

(Step 1) Start up EXCEL

(Step 2) Open the file you want to revise

cf the file name, “Demand Condition Sheet for Phase6(Chitipa Kameme)”

(Step 3) In the “TC DATA FORM” sheet, revise corresponding cells such as “Number of Secondary School.” All you can revise is only pink cells.

(Step 4) The demand forecast results will be automatically revised based on your input.

(Step 5) Save the file.

(2) Unit Demand Data Revision

If you want to revise unit demand data of facilities, following procedure shows how to revise.

(Step 1) Start up EXCEL

(Step 2) Open “Unit Demand Analyses” file in “JICA MP Followup Demand Forecast” folder on Desktop.

(Step 3) Revise corresponding cells. (From D7 cell to AA21 cell)

Note)
- The data sheets you can revise are from “Demand Forecast in Sec. School” sheet to “Demand Forecast in Rich HH” sheet since each TC data file is linked to these “Demand Forecast ～” sheets. It does not make any sense if you revise “a) Secondary School” sheet to “u) Rich Household” sheet.
- On inputting number data in upper rows, power consumptions are automatically calculated.
- In from “Demand Forecast in Sec. School” sheet to “Demand Forecast in Rich HH,” yearly growth of electric device purchase is chronically expressed. Therefore, if you revise unit demand, you also have to revise chronicle data.

(Step 4) Save the file.

Note) Do not move the file to other directory because the file is linked to other TC data files.

5.5.3 Making of New TC File

If you want to add a new TC for demand forecast, following procedure shows how to add.

(Step 1) Start up EXCEL
(Step 2) Open a file in the same district in the directory "Phase 6"
(Step 3) Save the file as the new TC name
(Step 4) Input necessary data such as TC name, number of facility.
(Step 5) The electricity demands (kW and kWh) are automatically calculated.
(Step 6) Save the file.

5.6 Prioritization of Non-Electrified TCs

The prioritization method was also revised based on the Master Plan.

(1) Policies

The basic policies of the DOE prioritization method are as follows.

- DOE electrifies two non-electrified TCs in each District in every phase.
- After determination of two TCs in a district in a phase, the rest TCs are to be prioritized again for subsequent phases.

(2) Preconditions

1. The criteria used in the prioritization are as follows.
   - Amount of Electricity Demand
   - Distance from a tapping point, which is equal to distance from the existing distribution line
   - Public Electricity Demand Ratio (PEDR: Electricity demand in Public facilities in a TC divided by all electricity demand in the TC)
2. Regarding each criterion, a weight as follow was given. TCs are prioritized in each criterion and points in and a TC which gets higher total points is prioritized.

Criteria	Weight
Amount of Electricity Demand	10
Distance from a tapping point	2
PEDR	1

Although the weights of criteria were determined in the Follow-up Study as above, they should be changed by DOE depending on situation changes.

<Example>

Criteria		A TC	B TC	C TC
Amount of Electricity Demand	Value	200kWh	250kWh	180kWh
	Rank	2nd	1st	3rd
	Point	20 points (2 points × 10 = 20 points)	30 points (3 points × 10 = 30 points)	10 points (1 points × 10 = 10 points)
Distance from a tapping point	Value	12km	20km	3km
	Rank	2nd	3rd	1st
	Point	4 points (2 points × 2 = 4 points)	2 points (1 points × 2 = 2 points)	6 points (3 points × 2 = 6 points)
PEDR	Value	10%	12%	6%
	Rank	2nd	1st	3rd
	Point	2 points (2 points × 1 = 2 points)	3 points (3 points × 1 = 2 points)	1 points (1 points × 1 = 1 points)
Total Point		26	35	17
Priority		2	1	3

(3) Necessary Data

In order to prioritize TCs to electrify, distance from a tapping point in each TC should be collected in FS. Other data, amount of demand and public electricity demand ratio are calculated through the demand forecast in the TC.

(4) Prioritization Sheet

The prioritization sheet for Chitipa District is shown as follow. All data except distance from tapping point is automatically calculated through the demand forecast sheet.

DISTRICTS TC DATA COLLECTION

NAME OF DISTRICT: CHITIPA

TC Number	4			5			6			252			253		
1. Name of Trading Center	Kameme			Chesenan			Kapoka			Chisenga			Mwenemulembe		
	Number	kW at 2020	kWh at 2020	Number	kW at 2020	kWh at 2020	Number	kW at 2020	kWh at 2020	Number	kW at 2020	kWh at 2020	Number	kW at 2020	kWh at 2020
2. Traditional Aauthority		Kameme						Mwakulambya							
3. Distance from the Existing Distribution Line (km)		23			8			2			20			8	
4. Market Fee															
a) Monthly Market Fee per Person (MK/month)															
b) Total Collected Annual Market Fee in TC (MK/year)		45,000			35,000			35,000			0			0	
5. a) Population in TC		1,710			806			1,110							
b) Population in CA [inc. the TC]		6,840			3,223			4,440							
6. Number of Existing Public Facilities															
a) Secondary School	1	1.250	2,551				1	1.250	2,551						
b) Primary School	1	1.410	2,592				1	1.410	2,592						
c) Teacher's Development Center	0	0.000	0				0	0.000	0						
d) Staff House	0	0.000	0				0	0.000	0						
e) Hospital	0	0.000	0				0	0.000	0						
f) Health Center	1	0.790	5,584				1	0.790	5,584						
g) Clinic	0	0.000	0				0	0.000	0						
h) Post Office	0	0.000	0				0	0.000	0						
i) Police Station	1	0.760	4,834				1	0.760	4,834						
j) Police Post	0	0.000	0				0	0.000	0						
k) Police Unit	0	0.000	0				0	0.000	0						
l) Admarc	0	0.000	0				0	0.000	0						
m) Government Office	2	0.280	1,378				0	0.000	0						
n) Church	1	0.140	517				1	0.140	517						
o) Mosque	0	0.000	0				0	0.000	0						
p) Court	1	0.530	1,277				0	0.000	0						
q) Other Public Facility	4	0.400	2,392				4	0.400	2,392						
Total	12	5.560	21,124	0	0	0	9	5	18,469	0	0	0	0	0	0
7. Targeted Business Entities in 2020															
r) Maize Mills	5	100.250	287,937				2	40.100	115,175						
s) Business Entity	16	8.960	59,696				3	1.680	11,193						
Total	21	109.210	347,633	0	0	0	5	42	126,368	0	0	0	0	0	0
8. Targeted Household in 2020															
r) Ordinary Household	207	132.480	734,643	0.0			135	86.400	479,115	0.0			0.0		
u) Rich Household	11	22.220	63,303	0.0			8	16.160	46,039	0.0			0.0		
Total	218	154.700	797,946	0	0	0	143	103	525,154	0	0	0	0	0	0
Grand Total		269	1,166,703		0	0		149	669,991		0	0		0	0

		MP	Follow-up		MP	Follow-up		MP	Follow-up		MP	Follow-up		MP	Follow-up
kW		391	269		208	141		263	149		94	64		35	24
kWh		1,960,000	1,166,703		1,042,000	706,226		1,318,000	669,991		472,000	319,903		174,000	117,930

Ranking

Amount of Demand	1	2	3	4	5
Distance from Tapping Point	5	2	1	4	2
Public Electricity Demand Ratio	5	2	1	2	2

Points

Amount of Demand	15	12	9	6	3
Distance from Tapping Point	2	6	10	4	6
Public Electricity Demand Ratio	1	2	3	2	2
Total	**18**	**20**	**22**	**12**	**11**
Priority	**3**	**2**	**1**	**4**	**5**

[Points]

1) Input a value of distance from tapping point in the TC's cell "3. Distance from the Existing Distribution Line."
2) If there is no data of number of facility like Chesenan in the example, use the data in the Master Plan. From the analysis, a kWh calculated by the new demand forecast method is 32.2% less than that in the Master Plan.
3) If it is impossible to collect data such as distance from a tapping point and Public Electricity Demand Ratio of a TC, you can use an average data of other TCs in the district.
4) If there are the same total score TCs, Choose a TC which has a higher amount of electricity demand.
5) After determination of two TCs to electrify, delete the two and input new distances from tapping points since the distances may change because of expanding distribution lines.

5.7 How to Revise TC Priority System

5.7.1 Prioritization for Phase 7

If you want to prioritize non-electrified TCs for Phase 7, following procedure shows how to make.

(Step 1) Start up EXCEL
(Step 2) Open the “TC Priority” file
(Step 3) Save as TC Priority (Phase 7)
(Step 4) Go to the district sheet you want to make
(Step 5) Delete TC cells which are in Phase 6

Note) Do not delete all columns because there may be needed cells in down rows. Delete only corresponding cells.

(Step 6) Input new data of “Distance from existing distribution line”

Note) The distance from distribution line will be changed since if you expand lines, the distance may be changed.

(Step 7) New prioritized TCs are shown in “Priority”
(Step 8) Save the file

Note) Even if you want to make the Phase 8 and later, the procedure is the same.

5.7.2 Addition of New TCs

If you want to add non-electrified TCs and prioritize them, following procedure shows how to make. Please be careful since it is a little complicated.

(Step 1) Start up EXCEL
(Step 2) Open the corresponding “TC Priority(Phase ○)” file to the phase you want to make
(Step 3) Go to the district sheet you want to make
(Step 4) Copy the all columns of a TC data
(Step 5) Paste the data to the end of lines
(Step 6) Input necessary data to the new pasted columns

(Step 7) Expand the calculation range of the equations “=Rank(…)” of the first TC’s cells in Ranking section to the added TC.

cf =RANK(D54,$D$54:$R$54) → =RANK(D54,$D$54:$U$54)

Note) This is about “Ranking” section.

(Step 8) Expand the calculation range of the equations “=Rank(…)” of the first TC’s cells in Priority section to the added TC.

cf =RANK(D54,$D$54:$R$54) → =RANK(D54,$D$54:$U$54)

Note) This is about “Priority section.

(Step 9) Expand all data in Rank section and Priority section to right side

(Step 10) Replace the old TC file name to new TC file name in each cell

cf [Demand Condition Sheet for Phase6(Chitipa Kameme).xls]

↓ Encircled part has to be changed

[Demand Condition Sheet for Phase6(Chitipa ○○).xls]

Note) Do not input any data in cells in which there are equations.

(Step 11) New prioritized TCs are automatically ranked in the Priority part

5.8 Voltage drop calculation (Refer to Attachment 2-b)

5.8.1 General

Voltage drops after installation of lines are assumed based on a demand forecast, distance of distribution lines and the current voltage condition. The current voltage conditions are collected from ESCOM.

If any problems occur with respect to the voltage of 33kV lines, a discussion with ESCOM regarding the below listed issues related to voltage compensation is necessary.

- Re-evaluation of route (ex. new feeder from substation)
- Installation of facilities to compensate for voltage drop (ex. static capacitors, step voltage regulators, load ratio control transformer)

As for 400V/230V lines, the following measures are considered.

- Change of the pole-mounted transformer location

5.8.2 Calculation method

The voltage criterion under the regulation in Malawi is ±6% against rated voltages. The following table shows the range and limits of voltage for each voltage grade.

Rated Voltage	Range	Limitation
33 kV	±1.980 kV	34.98 kV – 31.02 kV
11 kV	±0.660 kV	10.34 kV – 9.34 kV
400V/230V	±24 (400V) ±13.8 (230V)	424V –376V 243V –216V

(a) 33kV and 11kV lines

A voltage of 33kV and/or 11kV lines is generally estimated using the following equation (1).

$$V_r = V_s - 1.732I(R\cos\varphi + X\sin\varphi) \qquad \text{equation (1)}$$

where

V_s	Voltage at sending point of distribution line
V_r	Voltage at receiving point of distribution line
I	Load current
R	Resistance of line
X	Reactance of line
$\cos\varphi$	Power factor of load at receiving point

The following parameters are applied in Equation (1)

V_s 35kV for systems with a rated voltage of 33kV and 11.5kV with 11kV system according to operation data from ESCOM

V_r Rated voltage (33kV or 11kV)

I Demand of public facilities in each TC

$cos\varphi$ 0.9 (including Maize Mill)

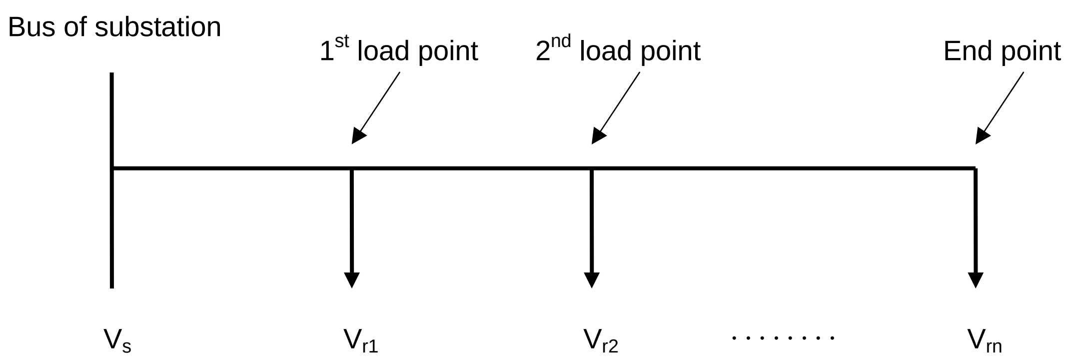
R, X

Conductor type	Resistance (Ω/km)	Reactance (Ω/km)
Hazel	0.616	0.380
Oak	0.311	0.358

Source: ESCOM, Pole type "A", None earth wire

The simplified calculation procedure is as follows.

- Calculation of V_{r1} (voltage at the first load point) using Equation (1)
- Replacement of V_s by V_{r1} of Equation (1) and calculation of V_{r2} (voltage at the second load point) by Equation (1)
- This procedure is repeated until the terminal point



(b) 400V/230V lines

In case of low voltage lines, Equation (2) is generally used for voltage drop calculation, since the load power factor at the receiving point is almost 1.0, except for motors.

$$V_r = V_s - 2IR \qquad \text{equation (2)}$$

A calculation procedure is the same as for the 33kV lines.

Equation (1) should be applied for this calculation in the case that a connection of a maize mill is expected. And 0.8 is applied for power factor because that of maize mills in Malawi is usually 0.8.
The following table shows the calculated voltage drop for 400V/230V by using equation (1) when a maize mill is connected to the end point of the line. "ANT" and "WASP" are the name of typical conductors in Malawi.

Conductor	**Resistance *1(Ω/km)**	**Reactance *1(Ω/km)**	**Voltage drop *2 (V)**
ANT	0.6638	0.2750	31.50
WASP	0.3309	0.2530	17.79

<table>
<tr><td rowspan="2">*1</td><td colspan="2">Equations are shown in reference2</td></tr>
<tr><td>Conductor temperature</td><td>75℃</td></tr>
<tr><td rowspan="3">*2</td><td>Capacity of maize mill</td><td>25kVA (20kW)</td></tr>
<tr><td>Power factor</td><td>0.8</td></tr>
<tr><td>Vs</td><td>Rated
(Equipment is selected such that the tap of the mole-mounted transformer maintains the voltage of the secondary at the rated value)</td></tr>
</table>

According to regulations in Malawi, the voltage criterion is ±6% against rated values. This means that ±24.0V (three phase), ±13.8V (single phase) are the limitation for 400V/230V line. The above table shows that any conductor cannot meet this voltage regulation for a length of 1.3km.

In case of maize mill, the limited lengths are approximately 700m for ANT and 1300m for WASP conductors. Therefore, when the length of 400V/230V lines is less than 700m and the demand is smaller than standard for a maize mill (20kW), voltage calculation is not always necessary.
In case of not maize mill, when the length of 400V/230V lines is less than 500m and the demand is smaller than 4.6kW, voltage calculation is not always necessary.

5.9 Cost Estimation (Refer to Attachment 2-c)

The scope of work for MAREP is the construction of distribution lines to public facilities in the TC. The installation cost of electrification for public facilities within each TC is estimated in this section.

The installation cost of grid extension to satisfy the total demand of each TC is estimated based on a field survey to public facilities, since the extension of distribution lines to private sectors, such as households, retail shops and maize mills, shall be done by other parties who will manage the distribution by their own financial resources. Economical and financial evaluations are carried out for the total demand of each TC. The equipment to be extended includes the pole-mounted transformer and 400V/230 V lines.

Cost data should be based on construction cost per km for 33kV lines and 400V/230V lines, and construction cost per unit for transformers using ESCOM's latest data including materials, labors, transportations and fuel together with coming up with Bill of Quantities (BOQ).

Total cost is estimated to the sum of costs on 33kV lines, transformers, and 400V/230V lines.

5.10 Calculation of an Internal Rate of Return(IRR) (Refer to Attachment 2-d)

There are two methods of calculating an internal rate of return. One is an economic internal rate of return (EIRR), and another is a financial internal rate of return (FIRR). In the feasibility study, users can calculate both IRRs using the EIRR and FIRR calculation sheets.

Difference of financial and economic analyses

Financial analysis of a project is similar in form to economic analysis because both appraise the profit of an investment. The concept of financial profit is, however, not the same as in economic analysis. The financial analysis of a project estimates the accrued profit of the project-owner (i.e., investor), while the economic analysis evaluates the effect of the project on the national economy.

Both analyses are conducted in monetary terms, but big differences exist in respect of the definition of cost and benefit. In financial analysis, all expenditures incurred in the project and revenues resulting from it are taken into account. In contrast, economic analysis attempts to assess the overall impact of a project for improving the economic welfare of the citizens of the country concerned.

For this reason, analysts use current value in monetary terms for financial analysis, but real value for economic analysis. Furthermore, they take account of government subsidies in financial analysis but not in economic analysis, because such subsidies increase the revenue for the project-owner but do not contribute directly to national economic growth.

Purpose of using the calculation sheet

To judge whether a project fulfills the legally required condition of rural electrification (RE), the EIRR sheet must be used because the EIRR of the RE project must not be more than 6% as stipulated in the Implementing Rules and Regulations of the Rural Electrification Act.

On the other hand, to evaluate project viability, the FIRR sheet must be used. Using this sheet, users can simulate not only the profitability of the project from a Concessionaire’s standpoint but also financial conditions including annual income and cash flow.

General conditions

- Monetary terms: The US dollar was used in both calculation sheets, because estimation of the current value of the Malawi kwacha during the project term would be too difficult, due to the country's high inflation. The only difference between the "Economic Analysis" and "Financial Analysis" sheets is that the former is in real terms and the latter is in nominal (current terms).
- Deflator: The GDP deflator for the USA is used (i.e, 1.7% p.a. between 1995 and 2002).
- Effective income tax: It is necessary to apply the common figure in commercial business operations of Malawi.
- Power retail price: The personnel using this spreadsheet may set it as a precondition of simulation.
- Annual power sales: The result of the demand forecast is used. On the "Economic Analysis" and "Financial Analysis" sheets, values calculated on the demand forecast sheet—"Transformer Calculation"—are automatically retrieved.
- Power loss: The personnel using this spreadsheet may set it based on the technical evaluation.
- Year of starting construction work: The personnel using these calculation sheets may decide this year.
- Project term: 20 years
- O&M cost: The personnel using these calculation sheets may set it based on the technical evaluation. Tentatively, 2% of the investment cost is used.
- Monetary value: It must be the year when the user estimates the project cost.
- Direct capital cost: Value is retrieved from the linked "Cost Estimation" sheet.
- Inventory & startup cost: Tentatively, 5% of the investment cost is used.
- Depreciation: Straight line method is used.
- Concession fee: The personnel using these calculation sheets may set it as a precondition of simulation.
- Equity portion of the concessionaire: Automatically calculated.
- Power wholesale price: For the time being, the rate applied by ESCOM is used, but in the future, the wholesale price in market transactions will be used.

5.10.1 Data sheet

Data input in the column of "Premises"

The personnel using the calculation sheet must input data for the following items: GDP Deflator, Effective Income Tax, Power Wholesale and Retail Prices, Year of Starting Construction Work, Project Term, and O&M Cost

Only the input data on the wholesale and retail prices are in terms of kwacha per kWh, but they are automatically converted into US cents per kWh using currency conversion rate in the "Cost Estimation Sheet."

Depreciation Base/Schedule

The user must input data for only three items: "Value in," "Inventory & Startup Cost," and "Concession Fee." Other values (i.e., data) are linked to other calculation sheets.

Data Sheet

Premises				
GDP Deflator	%/Yr	1.7		
Effective Income Tax	%	30		
Power Wholesale Price	US¢/kWh	2.6	2.9121	
Power Retail Price	US¢/kWh	6.0	6.6	
Power Loss	%	6		
Year of Start of Construction Work		2004		
Project Term	Year	20		
O&M Cost	%	2		
Depreciation Base/Schedule				
Value in	Year	2004		
Direct Capital Cost	US$	242,472		
Inventory & Startup Cost	US$	12,124	<=	5 % of direct capital cost, and paid by the concessionaire
Total Project Capitalized Cost	US$	254,596		
Depreciable Portion of Capitalized Cost	US$	242,472		
Concession Fee	US$	100	<=	<=paid by the concessionaire
Equity Portion of the Concessionaire	US$			

in MKW/kWh

5.10.2 FIRR sheet

Two types of project schemes are shown: One is applied to the program up to Phase 4 where ESCO take over the project, and another, to the concessionaire.

The only value to be input is "O&M Subsidy." The user changes the value and evaluates a reasonable FIRR. Tentatively, the value of the O&M subsidy is constant during the project life (i.e., it is not escalated.)

The user must be careful about the following points:

- If the value of cash flow of each year becomes minus, it means that the business operation faces a cash shortage, and an additional capital injection is needed.
- In this calculation, therefore, this situation must be avoided by increasing the O&M subsidy or decreasing the leasing fee.

FIRR Sheet

		Values /Costs of 2004	0 2004	1 2004	2 2005	3 2006	4 2007	5 2008	6 2009	7 2010	8 2011	9 2012	10 2013	11 2014	12 2015	13 2016	14 2017	15 2018	16 2019	17 2020	18 2021	19 2022	20 2023
Premises																						
GDP Deflator	%/Yr	1.7																				
Effective Income Tax	%	30																				
Power Wholesale Price	US¢/kWh	2.6																				
Power Retail Price	US¢/kWh	6.0																				
Annual Power Sales	kWh/Yr			404,551	409,023	413,544	418,115	422,737	522,357	527,081	531,858	536,687	541,570	546,507	551,498	651,492	656,595	661,753	666,969	672,242	677,516	682,789	688,063
Power Loss	%	6																				
Year of Start of Construction Work		2004																				
Project Term	Year	20																				
O&M Cost	%	2	<= An expected percentage share of the direct capital cost.																			

Depreciation Base/Schedule					
Direct Capital Cost	US$	242,472	242,472	<=paid by the government	
Inventory & Startup Cost	US$	12,124	12,124	<=	5 % of direct capital cost, and paid by the concessionaire
Total Project Capitalized Cost	US$	254,596	254,596		
Depreciable Portion of Capitalized Cost	US$	242,472	242,472		
Concession Fee	US$		100	<=paid by the concessionaire	
Equity Portion of the Concessionaire	US$		12,224		
Depreciation	%	5.00		<=straight line method	

Income Statement under the Current Scheme Applied to ESCOM

			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Power Sales	US$			24,273	24,967	25,681	26,416	27,171	34,157	35,064	35,996	36,953	37,937	38,947	39,985	48,054	49,271	50,520	51,802	53,118	54,464	55,840	57,248
O&M Subsidy	US$			8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000
Total Revenue	US$			32,273	32,967	33,681	34,416	35,171	42,157	43,064	43,996	44,953	45,937	46,947	47,985	56,054	57,271	58,520	59,802	61,118	62,464	63,840	65,248
Power Purchased	US$			11,394	11,719	12,055	12,399	12,754	16,033	16,459	16,896	17,346	17,807	18,281	18,769	22,556	23,127	23,714	24,315	24,933	25,565	26,211	26,872
O&M Cost	US$			4,849	4,934	5,019	5,106	5,195	5,285	5,377	5,470	5,565	5,662	5,760	5,860	5,962	6,065	6,170	6,277	6,386	6,497	6,610	6,725
Depreciation of Asset	US$			12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124
Taxable Income	US$			3,906	4,191	4,484	4,787	5,099	8,715	9,105	9,506	9,919	10,344	10,782	11,233	15,413	15,955	16,513	17,086	17,675	18,278	18,896	19,528
Income Tax	US$			1,172	1,257	1,345	1,436	1,530	2,615	2,731	2,852	2,976	3,103	3,235	3,370	4,624	4,787	4,954	5,126	5,302	5,483	5,669	5,858
Income After tax				2,735	2,933	3,139	3,351	3,569	6,101	6,373	6,654	6,943	7,241	7,547	7,863	10,789	11,169	11,559	11,960	12,372	12,795	13,227	13,670
Cash Flow	US$		-254,596	14,858	15,057	15,262	15,474	15,693	18,224	18,497	18,778	19,067	19,365	19,671	19,987	22,913	23,292	23,682	24,084	24,496	24,918	25,351	25,793
FIRR to Equity	**4.36%**																						

Note 1: Initial capital investment paid by the government is a sort of equity financing measure.

Income Statement under a New Scheme Applied to a Concessionaire

			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Power Sales	US$			24,273	24,967	25,681	26,416	27,171	34,157	35,064	35,996	36,953	37,937	38,947	39,985	48,054	49,271	50,520	51,802	53,118	54,464	55,840	57,248
O&M Subsidy	US$			4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100
Total Revenue	US$			28,373	29,067	29,781	30,516	31,271	38,257	39,164	40,096	41,053	42,037	43,047	44,085	52,154	53,371	54,620	55,902	57,218	58,564	59,940	61,348
Power Purchased	US$			11,394	11,719	12,055	12,399	12,754	16,033	16,459	16,896	17,346	17,807	18,281	18,769	22,556	23,127	23,714	24,315	24,933	25,565	26,211	26,872
O&M Cost	US$			4,849	4,934	5,019	5,106	5,195	5,285	5,377	5,470	5,565	5,662	5,760	5,860	5,962	6,065	6,170	6,277	6,386	6,497	6,610	6,725
Depreciation of Concession Fee	US$			5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Leasing Fee Paid Back to the RE Fund (= Depreciation of the Asset)	US$			12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124
Taxable Income	US$			1	286	579	882	1,194	4,810	5,200	5,601	6,014	6,439	6,877	7,328	11,508	12,050	12,608	13,181	13,770	14,373	14,991	15,623
Income Tax	US$			0	86	174	264	358	1,443	1,560	1,680	1,804	1,932	2,063	2,198	3,452	3,615	3,782	3,954	4,131	4,312	4,497	4,687
Income After tax	US$			1	200	405	617	836	3,367	3,640	3,921	4,210	4,508	4,814	5,129	8,056	8,435	8,825	9,226	9,639	10,061	10,494	10,936
Cash Flow	US$		-12,224	6	205	410	622	841	3,372	3,645	3,926	4,215	4,513	4,819	5,134	8,061	8,440	8,830	9,231	9,644	10,066	10,499	10,941
FIRR to Equity	**18.60%**																						

Note 2: Assets invested by the government is leased to a concessionaire. This is a sort of lease scheme. In this case, a judicial body -Asset Management Corporation- that owns and manages this asset must be established.

If the value of cash flow of each year becomes minus, it means that the business operation faces cash shortage, and an additional capital injection is needed.

In this calculation, therefore, this situation must be avoided by increasing O&M subsidy or decreasing leasing fee.

5.10.3 EIRR sheet

This sheet is completely automatically calculated if necessary data in the data sheet are input.

EIRR Sheet

Power Wholesale Price	US¢/kWh	2.6
Power Retail Price	US¢/kWh	6.0
Power Loss	%	6.0
O&M Cost	%	2

Value of 2004 US$

Years			0	1	2	3	4	5	6	7	8	9	10
Power Sales (kWh)				404,551	409,023	413,544	418,115	422,737	522,357	527,081	531,838	536,687	541,570
Item	Initial amount	Replacemen t period											
A. Investment Schedule													
Direct Capital Cost	242,472	20	242,472										
I. Total	242,472		242,472	0	0	0	0	0	0	0	0	0	0
B. Working Capital (=Inventory and Startup Cost)													
II. Working capital	12,124			12,124									
C. Annual costs	Annual amount												
Powre Purcased				11,394	11,519	11,647	11,776	11,906	14,711	14,844	14,979	15,115	15,252
O&M				4,849	4,849	4,849	4,849	4,849	4,849	4,849	4,849	4,849	4,849
III. Total			0	16,243	16,369	16,496	16,625	16,755	19,561	19,694	19,828	19,964	20,102
D. Benefits	Annual amount												
IV. Incremental output				24,273	24,541	24,813	25,087	25,364	31,341	31,625	31,911	32,201	32,494
E. Net benefits													
IV-I-II-III			-242,472	-4,094	8,172	8,316	8,462	8,609	11,781	11,931	12,083	12,237	12,392
Discount rate	12%												
Net present value	-169,778		-242,472	-3,655	6,515	5,919	5,378	4,885	5,968	5,397	4,880	4,413	3,990
Internal rate of return	0.5%		-242,472	-4,072	8,088	8,188	8,288	8,388	11,419	11,505	11,591	11,678	11,765

Years	11	12	13	14	15	16	17	18	19	20
Power Sales (kWh)	546,307	551,498	651,492	656,595	661,753	666,969	672,242	677,516	682,789	688,063
Item										
A. Investment Schedule										
Direct Capital Cost										0
I. Total	0	0	0	0	0	0	0	0	0	0
B. Working Capital (=Inventory and Startup Cost)										
II. Working capital										-12,124
C. Annual costs										
Powre Purcased	15,392	15,532	18,348	18,492	18,637	18,784	18,933	19,081	19,230	19,378
O&M	4,849	4,849	4,849	4,849	4,849	4,849	4,849	4,849	4,849	4,849
III. Total	20,241	20,382	23,198	23,341	23,487	23,634	23,782	23,931	24,079	24,228
D. Benefits										
IV. Incremental output	32,790	33,090	39,090	39,396	39,705	40,018	40,335	40,651	40,967	41,284
E. Net benefits										
IV-I-II-III	12,549	12,708	15,892	16,054	16,219	16,385	16,552	16,720	16,888	29,180
Discount rate										
Net present value	3,608	3,262	3,642	3,285	2,963	2,673	2,411	2,174	1,961	3,025
Internal rate of return	11,852	11,940	14,854	14,928	15,002	15,078	15,153	15,227	15,301	26,300

As regards the economic opportunity cost for capital, international institutions generally use 12% as a hurdle rate. But this does not necessary reflect the cost of capital in Malawi

6. Management on progress (Refer to Attachment 3-a)

As mentioned in Section 5.1 (c) Scheduling on field survey, One-week field survey and one-week deskwork for reviewing the progress would be recommended. Progress on a FS should be checked and next survey schedule should be reviewed together with analyses.

7. Reporting (Refer to Attachment 4-a, 4-b)

Report on the result of each and every TC should be made immediately after field surveys together with drawings and results of calculation. It should include some important information listed below and be described as simply as possible.

Check Sheet on Equipment Preparation

Name of the Trading Center: ____________________

Equipment	Check
1/250,000 scale maps, hopefully more detailed maps	
Feasibility Study Manual	
Case study report on MAREP Master Plan	
Copies of the maps around the TC (At least 2/TC) (TC should be at the center of the map)	
Data sheet on public facilities	
More than 30m measuring tape	
Roller measure	
Results on Demand Forecast (as of master plan)	
Plane board for drawings	
White papers (more than 30 for each trip)	
Section papers	
Pencils	
Eraser	
Colored pens	
Rulers	
Calculators (at least 1 per team)	
GPS	
Batteries for GPS	
Magnet compass	
Laser binocular	
Diskette(s) (except one day trip)	
Lap top (except one day trip)	
Watch	
Check sheet on the Field Survey (at least one per TC)	
(Umbrellas)	
(Caps)	

Check Sheet on Field Survey

Name of the Trading Center: ____________________

No	Activities	Check
	Map Study (Using 1/250,000 maps)	
1	Put existing/planned lines on the map	
2	Decide estimated route distance from branch points on existing line to the target TC on the map	
	Field Survey – Outside TC	
3	Confirm GPS position at each and every relevant corner of the road	
4	Confirm relevant TCs, bridges etc on the route to the target TC	
5	Confirm the target TC	
6	Confirm existing line and end pole with GPS	
7	Confirm planned line or relevant TCs with GPS if any	
8	Confirm distance from branch points on existing line to the target TC by odometer	
9	Confirm voltage level of existing line (ESCOM engineer)	
10	Check size "square mm" and condition of conductor on existing line (ESCOM engineer)	
	Field Survey – Inside TC (Sketching)	
11	* The TC's name of, date, start and finish time, drawer's name, direction (North), scale and GPS position should be included on the drawings	
12	Confirm public facilities by interviewing responsible person(s)	
13	Confirm private entities	
14	Confirm daily activities inside/outside of the TC	
15	Measure each person's step length if no digital roller measure	
16	Measure radius (length and width) of the TC	
17	Measure width of the main road through the TC and branches	
18	Measure distance from the main road to existing public facilities	
19	Include major features such as shops in the sketch	
20	Confirm maize mill(s) and measure distance	
21	Confirm obstacles for the proposed line	
22	Decide the transformer position (normally load center) considering the voltage drop	
23	Measure GPS position of the transformer	
24	Put tentative 400/230V lines on the sketch considering the voltage drop	
25	Cross check proposed/planned/existing lines for the TC	

Attachment 1-c

The Basic Time Schedule and each Role in Field Survey

Person	Main Role	Main Equipment	The Basic Time Schedule Start ☆ — 1st Meeting for confirmation ☆ — 2nd Meeting for confirmation ☆ — Finish ☆ Outside TC	Inside TC
DOE Economist	Socio-economic Survey		Assistance of Engineer	12 → 13,14 → 25 →
DOE Engineer	Making Sketch	• GPS • Compass	3,4,5,6,7 →	11 → 15,16,17,18 → 19 → 23,24 → 25 →
ESCOM Engineer	Measuring the Distance Deciding the position of Transformar	• Digital Roller Measure • Laser Meters	8,9,10 →	15,16,17,18 → 20,21,22,24 → 25 →

*After finishing your survey, cooperate with and help other member.

*The numbers in bar show ones in [Check sheet on field survey]

Attachment 1-d

Check Sheet for Demand Forecast (Public Facility and Business Entity)

TC DATA FORM: FEASIBILITY STUDY FOR MAREP PHASE V

DATE: ______________________

DISTRICT: Chitipa	**TA:**	**TC NAME: Kameme**	**DISTANCE FROM DL:**
LOCATION BY GPS:	**Market Fee:**	**IRR:**	

No. OF PUBLIC FACILITIES

	Number				Number				Number				Number		
	M/P	**Survey**	**Planned**		**M/P**	**Survey**	**Planned**		**M/P**	**Survey**	**Planned**		**M/P**	**Survey**	**Planned**
Secondary School:		1		**Health Center :**		1		**Police Unit:**		0		**Court:**		1	
Primary School:		1		**Clinic :**		0		**Admarc:**		0		**Other Public Facilities:**		4	
Teacher's Development Center:		0		**Post Office:**		0		**Government Offices:**		2					
Staff House:		0		**Police Station:**		1		**Church:**		1					
Hospital:		0		**Police Post:**		0		**Mosque:**		0					
TOTAL PUBLIC FACILITIES:	**0**	**12**	**0**												

BUSINESS ENTITIES

	Number				Number				Number				Number		
	M/P	**Survey**	**Planned**		**M/P**	**Survey**	**Planned**		**M/P**	**Survey**	**Planned**		**M/P**	**Survey**	**Planned**
Markets:				**Maize Mills:**	2	2		**Restaurants:**				**Rest Houses:**			
Battery Charge Stations:				**Shops:**		25		**Other BE:**							
TOTAL BUSINESS ENTITIES:	**2**	**27**	**0**	**Total Number for Demand Forcast without Maize Mills:**						25		(A rest house is counted as 5 business entites)			
GRAND TOTAL	**2**	**39**	**0**												

HOUSEHOLD

	Number	
	Census	**Survey**
Number of Household:		342

NAME : ______________________

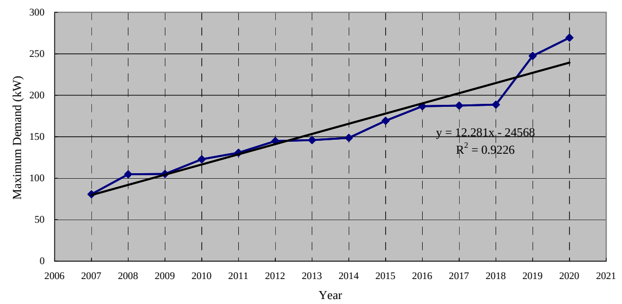
SIGNATURE: ______________________

Demand Forecast in TC

DISTRICT: Chitipa
TC NAME: Kameme

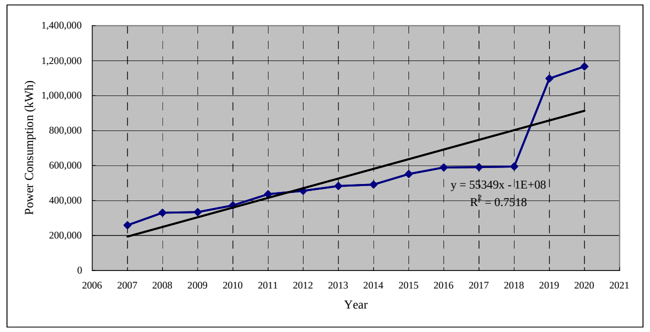
Max Capacity (kW)

Year	Secondary School	Primary School	Teacher's Development Center	Staff House	Hospital	Health Center	Clinic	Post Office	Police Station	Police Post	Police Unit	Admarc	Government Office	Church	Mosque	Court	Other Public Facilities	Public Facilities Total	Maize Mill Number	Maize Mill kW	Business Entities Number	Business Entities kW	Business Entities Total	Ordinary Household Number	Ordinary Household kW	Rich Household Number	Rich Household kW	Household Total	TC Total
2007	0.4000	0.4000	0.0000	0.0000	0.0000	0.3100	0.0000	0.0000	0.3000	0.0000	0.0000	0.0000	0.2000	0.1000	0.0000	0.2000	0.4000	2.3100	2	40.0200	14	1.1200	41.1400	176	35.2000	10	2.0000	37.2000	80.6500
2008	0.4000	0.4000	0.0000	0.0000	0.0000	0.3100	0.0000	0.0000	0.3000	0.0000	0.0000	0.0000	0.2000	0.1000	0.0000	0.2000	0.4000	2.3100	3	60.0300	14	3.9200	63.9500	178	35.6000	10	2.8000	38.4000	104.6600
2009	0.4000	0.4000	0.0000	0.0000	0.0000	0.3100	0.0000	0.0000	0.3000	0.0000	0.0000	0.0000	0.2000	0.1000	0.0000	0.2000	0.4000	2.3100	3	60.1500	14	3.9200	64.0700	180	36.0000	10	2.8000	38.8000	105.1800
2010	0.7200	0.8800	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000	0.2000	0.1400	0.0000	0.2800	0.4000	3.9100	3	60.1500	15	4.2000	64.3500	182	50.9600	10	3.6000	54.5600	122.8200
2011	0.7200	0.8800	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000	0.2000	0.1400	0.0000	0.2800	0.4000	3.9100	3	60.1500	15	8.4000	68.5500	185	51.8000	10	6.4000	58.2000	130.6600
2012	0.7200	0.8800	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000	0.2000	0.1400	0.0000	0.2800	0.4000	3.9100	3	60.1500	15	8.4000	68.5500	187	52.3600	10	20.0000	72.3600	144.8200
2013	0.7500	0.9100	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.5100	0.0000	0.0000	0.0000	0.2000	0.1400	0.0000	0.4800	0.4000	4.1800	3	60.1500	15	8.4000	68.5500	190	53.2000	10	20.0000	73.2000	145.9300
2014	0.7500	0.9100	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.5100	0.0000	0.0000	0.0000	0.2000	0.1400	0.0000	0.4800	0.4000	4.1800	3	60.1500	15	8.4000	68.5500	192	53.7600	11	22.2200	75.9800	148.7100
2015	0.7500	0.9100	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.5100	0.0000	0.0000	0.0000	0.2000	0.1400	0.0000	0.4800	0.4000	4.1800	4	80.2000	15	8.4000	88.6000	194	54.3200	11	22.2200	76.5400	169.3200
2016	0.8500	1.0100	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.5600	0.0000	0.0000	0.0000	0.2800	0.1400	0.0000	0.5300	0.4000	4.5600	4	80.2000	16	8.9600	89.1600	197	70.9200	11	22.2200	93.1400	186.8600
2017	0.8500	1.0100	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.5600	0.0000	0.0000	0.0000	0.2800	0.1400	0.0000	0.5300	0.4000	4.5600	4	80.2000	16	8.9600	89.1600	199	71.6400	11	22.2200	93.8600	187.5800
2018	0.8500	1.0100	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.5600	0.0000	0.0000	0.0000	0.2800	0.1400	0.0000	0.5300	0.4000	4.5600	4	80.2000	16	8.9600	89.1600	202	72.7200	11	22.2200	94.9400	188.6600
2019	1.2500	1.4100	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.7600	0.0000	0.0000	0.0000	0.2800	0.1400	0.0000	0.5300	0.4000	5.5600	4	80.2000	16	8.9600	89.1600	204	130.5600	11	22.2200	152.7800	247.5000
2020	1.2500	1.4100	0.0000	0.0000	0.0000	0.7900	0.0000	0.0000	0.7600	0.0000	0.0000	0.0000	0.2800	0.1400	0.0000	0.5300	0.4000	5.5600	5	100.2500	16	8.9600	109.2100	207	132.4800	11	22.2200	154.7000	269.4700



Power Consumption (kWh)

Year	Secondary School	Primary School	Teacher's Development Center	Staff House	Hospital	Health Center	Clinic	Post Office	Police Station	Police Post	Police Unit	Admarc	Government Office	Church	Mosque	Court	Other Public Facilities	Public Facilities Total	Maize Mill Unit	Maize Mill Year	Business Entities Unit	Business Entities Year	Business Entities Total	Ordinary Household Number	Ordinary Household Year	Rich Household Number	Rich Household Year	Household Total	TC Total
2007	884	884	0	0	0	1,099	0	0	1,820	0	0	0	728	473	0	468	1,560	7,916	2	114,457	14	815	115,273	176	128,128	10	7,280	135,408	258,597
2008	884	884	0	0	0	1,099	0	0	1,820	0	0	0	728	473	0	468	1,560	7,916	3	172,700	14	12,027	184,726	178	129,584	10	8,445	138,029	330,672
2009	884	884	0	0	0	1,099	0	0	1,820	0	0	0	728	473	0	468	1,560	7,916	3	172,762	14	12,689	185,451	180	131,040	10	9,537	140,577	333,945
2010	1,217	1,258	0	0	0	5,293	0	0	3,800	0	0	0	1,144	517	0	666	1,934	15,829	3	172,762	15	19,274	192,036	182	153,695	10	11,029	164,725	372,589
2011	1,217	1,258	0	0	0	5,293	0	0	3,800	0	0	0	1,144	517	0	666	1,934	15,829	3	172,762	15	55,965	228,727	185	156,229	10	35,490	191,719	436,275
2012	1,217	1,258	0	0	0	5,293	0	0	3,800	0	0	0	1,144	517	0	666	1,934	15,829	3	172,762	15	55,965	228,727	187	157,918	10	52,962	210,880	455,436
2013	1,303	1,344	0	0	0	5,584	0	0	3,888	0	0	0	1,196	517	0	1,186	2,028	17,045	3	172,762	15	55,965	228,727	190	181,199	10	56,602	237,801	483,573
2014	1,303	1,344	0	0	0	5,584	0	0	3,888	0	0	0	1,196	517	0	1,186	2,028	17,045	3	172,762	15	55,965	228,727	192	183,107	11	62,502	245,609	491,381
2015	1,303	1,344	0	0	0	5,584	0	0	3,888	0	0	0	1,196	517	0	1,186	2,028	17,045	4	230,350	15	55,965	286,315	194	185,014	11	63,303	248,317	551,676
2016	1,511	1,552	0	0	0	5,584	0	0	4,033	0	0	0	1,378	517	0	1,277	2,392	18,243	4	230,350	16	59,696	290,046	197	217,275	11	63,303	280,578	588,867
2017	1,511	1,552	0	0	0	5,584	0	0	4,033	0	0	0	1,378	517	0	1,277	2,392	18,243	4	230,350	16	59,696	290,046	199	219,481	11	63,303	282,784	591,073
2018	1,511	1,552	0	0	0	5,584	0	0	4,033	0	0	0	1,378	517	0	1,277	2,392	18,243	4	230,350	16	59,696	290,046	202	222,790	11	63,303	286,093	594,382
2019	2,551	2,592	0	0	0	5,584	0	0	4,834	0	0	0	1,378	517	0	1,277	2,392	21,124	4	230,350	16	59,696	290,046	204	723,996	11	63,303	787,299	1,098,469
2020	2,551	2,592	0	0	0	5,584	0	0	4,834	0	0	0	1,378	517	0	1,277	2,392	21,124	5	287,937	16	59,696	347,633	207	734,643	11	63,303	797,946	1,166,703



Attachment 2-b-1

VOLTAGE DROP CALCULATION FOR HV DISTRIBUTION LINES

Equation 1

Input figures in green cell.

HAZEL CONDUCTORS (AAAC 50mm^2)

Sqrt of 3	R/km	X/km	cos φ	sin φ	dist.of line (km)	dem.(kw)	syst.volt.(kV)
1.732	0.616	0.38	0.9	0.48	30.0	3000	33

I(A)	Vs (kV)	VD (kV)	Vr (kV)	% VD
52.486	35	2.009	32.991	0.029

OAK CONDUCTORS (AAAC 100mm^2)

Sqrt of 3	R/km	X/km	Cos φ	sin φ	dist.of line (km)	dem.(kw)	syst.volt.(kV)
1.732	0.311	0.358	0.9	0.48	100.0	2000	33

I(A)	Vs (kV)	VD (kV)	Vr (kV)	% VD
34.991	35	2.738	32.262	2.236

Equation : **Vr = Vs - 1.732I(R cos φ + X sin φ)** **I = (Demand/1.732)/33kV** **% VD = 100 (33kV-Vr)/33kV**

Vs = Supply Voltage
Vr = Received Voltage
VD = Voltage Drop
I = Current

R = Resitance
X = Reactance
cosφ = Power Factor

TAKE NOTE

* In case of 11kV, [syst.volt.(kV)] should be changed from 33kV into 11kV,and [Vs (kV)] also should be changed.

Attachment 2-b-2

VOLTAGE DROP CALCULATION FOR LV DISTRIBUTION LINES

Equation 2

Input figures in green cell.

ANT CONDUCTORS (50mm^2)

R/km	X/km	dist.of line-(km)	demand-(w)	No.of Facility
0.6638	0.275	0.5	4600	1

I(A)	supply voltage	Vr	VD	% VD
20	230	216.724	13.276	5.772

WASP CONDUCTORS (100mm^2)

R/km	X/km	dist.of line-(km)	demand-(w)	No.of Facility
0.3309	0.253	1	4600	1

I(A)	Vs (V)	Vr (V)	VD (V)	% VD
20	230	216.764	13.236	5.755

Equation : **Vr = Vs - 2IR** **I = (Demand*No.of Facility)/voltage** **% VD = (Vs-Vr)/Vs**

Vs = Supply Voltage **R = Resitance**
Vr = Received Voltage **X = Reactance**
VD = Voltage Drop
I = Current

TAKE NOTE

* In case of a maize mill connection, voltage drop calculation should be done using equation3 below.

VOLTAGE DROP CALCULATION FOR LV LINE WITH A MAIZE MILL AS LOAD

Equation 3

Input figures in green cell.

ANT CONDUCTORS (50mm^2)

Sqrt of 3	R/km	X/km	Cos φ	sin φ	dist.of line (km)	dem.(kw)	syst.volt.(V)
1.732	0.6638	0.275	0.8	0.36	0.7	25	400

I (A)	Vs (V)	VD (V)	Vr (V)	% VD
36.084	400	27.564	372.436	6.891

WASP CONDUCTORS (100mm^2)

Sqrt of 3	R/km	X/km	Cos φ	sin φ	dist.of line (km)	dem.(kw)	syst.volt.(V)
1.732	0.3309	0.253	0.8	0.36	1.3	20	400

I (A)	Vs (V)	VD (V)	Vr (V)	% VD
28.868	400	23.127	376.873	5.782

Equation : $V_r = V_s - 1.732I(R \cos \varphi + X \sin \varphi)$ **I = (Demand/1.732)/0.4kV** **% VD = 100(Vs-Vr)/Vs**

Vs = Supply Voltage
Vr = Received Voltage
VD = Voltage Drop
I = Current

R = Resitance
X = Reactance
cosφ =Power Factor

CALCULATION FOR BILL OF QUANTITIES FOR 33kV OVERHEAD LINE

NOTE: Enter length of line in column C3 33.75 km (unit:MK)

QUANTITY/km	MATERIAL DESCRIPTION	TOTAL QUANTITY	UNIT PRICE	TOTAL PRICE
3150	100mm2 AAAC 'OAK'	106312.5	75.39	8,014,899
90	7/8 GMSW	3037.5	97.29	295,518
18	7/8 guy grips	607.5	182.54	110,893
77	Barbed wire	2598.75	24	62,370
1	33kV 200Kg spindles	33.75	166.05	5,604
48	Binding stirrups (33kV)	1620	0.65	1,053
25	Pilot spindles	843.75		0
25	33kV pin insulators	843.75	607	512,156
6	HV stay insulators	202.5	539.75	109,299
27	Disc insulators	911.25	1,117.32	1,018,158
40	Aluminium binding tape	1350	3.31	4,469
16	M12/150 nuts & bolts	540	29.66	16,016
16	M16/150 bolts & nuts	540	58.07	31,358
8	M16/260 bolts & nuts	270	68.81	18,579
10	M16/300 bolts & nuts	337.5	115.13	38,856
66	M16 flat washers	2227.5	0.47	1,047
32	M16 spring washers	1080	0.02	22
4	18mm stay rods	135	868.44	117,239
2	M20/400 bolts & nuts	67.5	134.75	9,096
10	M20 flat wahers	337.5	5.18	1,748
28	M20 spring washers	945	0.04	38
6	M20/400 eye bolts & e/nuts	202.5	145.95	29,555
9	100mm2 Snail clamps	303.75	809.23	245,804
16	Tie straps	540	231.41	124,961
9	Clevis adaptors	303.75	131.38	39,907
9	Insulator hooks	303.75	274.11	83,261
3	Danger plates	101.25	249.76	25,288
1	9.0m wood pole	33.75	853.88	28,818
8	10.8m(s) wood pole	270	5664.32	1,529,366
2	12.3m(H) wood pole	67.5	1975.24	133,329
4	X11 cross arms	135	1610.95	217,478
6	Stay baulk	202.5	717.75	145,344
6	SP 10 spacer block	202.5	111.65	22,609
8	X49 cross arm	270	1988.23	536,822
1	33kV Air Break Switch	33.75	65726	2,218,253
1	33kV Auto-recloser	33.75	79860	2,695,275
SUB-TOTAL				18,444,489
1	Manhrs for gang and Cost	33.75	77,767.00	2,624,636
1	Manhrs for OHL Supervisor &Cost	33.75	14,274.10	481,751
1	km + Hiring for Gang	33.75	66,154.00	2,232,698
1	km + Hiring for Supervisor	33.75	19,795.00	668,081
1	km + Allowed for fuel for gang	33.75	7,817.00	263,824
1	km + Allowed for fuel for Supervisor	33.75	1,868.00	63,045
1	compensation fee	33.75	unknown	
SUB-TOTAL				6,334,035

TOTAL	**24,778,524.04**

Attachment 2-c-2

CALCULATION FOR BILL OF QUANTITIES FOR 400V OVERHEAD LINE

NOTE: Enter length of line in column C48 3.3 km (unit:MK)

QUANTITY/km	MATERIAL DESCRIPTION	TOTAL QUANTITY	UNIT PRICE	TOTAL PRICE
4200	100mm2 AAC 'WASP'	13860	53.53	741,926
154	7/12 GMSW	508.2	36.61	18,605
4	70mm2, 4 core MV Cu Cable	13.2	612.56	8,086
32	MO-O line taps	105.6	128.38	13,557
4	MO-5/5 line taps	13.2	258.4	3,411
4	70mm2 bimetal pin terminals	13.2	11.84	156
88	Bobbin insulators	290.4	44.44	12,905
14	LV stay insulators	46.2	46.07	2,128
14	12mm2 stay rods	46.2	793.85	36,676
32	M16/200 bolts & nuts	105.6	58.28	6,154
40	M16/260 bolts & nuts	132	68.81	9,083
48	D' irons	158.4	88.14	13,961
16	9.0m wood pole	52.8	853.88	45,085
14	Stay baulk	46.2	717.75	33,160
SUB-TOTAL				944,894
1	Manhrs for gang and Cost	3.3	77,767.00	256,631
1	Manhrs for OHL Supervisor &Cost	3.3	14,274.10	47,105
1	km + Hiring for Gang	3.3	66,154.00	218,308
1	km + Hiring for Supervisor	3.3	19,795.00	65,324
1	km + Allowed for fuel for gang	3.3	7,817.00	25,796
1	km + Allowed for fuel for Supervisor	3.3	1,868.00	6,164
1	compensation fee	3.3	unknown	
SUB-TOTAL				619,328
TOTAL				**1,564,222**

COST ESTIMATION CALCULATION SHEET

TC name: Nthalire

Region NORTHERN

District Chitipa

Date: 5/12/03

Exchange rate	110

HV types	HV(km)	HV COST/km*	LV(km)	LV COST/km	HV COST	LV COST	No.of Tx50	50kVA Cost	No.of Tx 100	100kVA Cost	Tx COST	TC COST(Total) MK	TC COST(Total) US$
33kV OAK	33.75	749,687	3.3	286,332	25,301,932	944,894	1	174,400	1	250,700	425,100	26,671,926	242,472
33kV HAZEL		632,662		286,332	0	0		174,400		250,700	0	0	0
11kV OAK		685,957		286,332	0	0		174,400		250,700	0	0	0
11kV HAZEL		572,670		286,332	0	0		174,400		250,700	0	0	0

*(HV COST/km) depend on types of HV

Types of HV	HV COST/km
11kV overhead line constructed with 50mm² AAAC (HAZEL)	572,670
11kV overhead line constructed with 100mm² AAAC (OAK)	685,957
33kV overhead line constructed with 50mm² AAAC (HAZEL)	632,662
33kV overhead line constructed with 100mm² AAAC (OAK)	749,687

Premises

GDP Deflator	%/Yr	1.7	
Effective Income Tax	%	30	
Power Wholesale Price	US¢/kWh	2.6	2.9121
Power Retail Price	US¢/kWh	6.0	6.6
Power Loss	%	6	
Year of Start of Construction Work		2006	
Project Term	Year	20	
O&M Cost	%	2	

Depreciation Base/Schedule

Value in	Year	2006			
Direct Capital Cost	US$	242,472			
Inventory & Startup Cost	US$	12,124	<=	5	% of direct capital cost, and paid by the concessionaire
Total Project Capitalized Cost	US$	254,596			
Depreciable Portion of Capitalized Cost	US$	242,472			
Concession Fee	US$	100	<=	<=paid by the concessionaire	
Equity Portion of the Concessionaire	US$				

Financial Analysis

Attachment 2-d-2

		Values /Costs of 2006	Year 0 2006	1 2006	2 2007	3 2008	4 2009	5 2010	6 2011	7 2012	8 2013	9 2014	10 2015	11 2016	12 2017	13 2018	14 2019	15 2020	16 2021	17 2022	18 2023	19 2024	20 2025
Premises																							
GDP Deflator	%/Yr	1.7																					
Effective Income Tax	%	30																					
Power Wholesale Price	US¢/kWh	2.6																					
Power Retail Price	US¢/kWh	6.0																					
Annual Power Sales	kWh/Yr			94,388	94,388	120,695	121,890	135,995	159,240	166,234	176,504	179,354	201,362	214,937	215,742	216,949	400,941	425,847	450,752	475,658	500,563	525,469	550,374
Power Loss	%	6																					
Year of Start of Construction Work		2006																					
Project Term	Year	15																					
O&M Cost	%	2	<= An expected percentage share of the direct capital cost.																				

Depreciation Base/Schedule

Direct Capital Cost	US$	242,472	242,472	<=paid by the government
Inventory & Startup Cost	US$	12,124	12,124	<= 5 % of direct capital cost, and paid by the concessionaire
Total Project Capitalized Cost	US$	254,596	254,596	
Depreciable Portion of Capitalized Cost	US$	242,472	242,472	
Concession Fee	US$		100	<=paid by the concessionaire
Equity Portion of the Concessionaire	US$		12,224	
Depreciation	%	5.00		<=straight line method

Income Statement under the Current Scheme Applied to ESCOM

		Year 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Power Sales	US$		5,663	5,762	7,495	7,701	8,741	10,413	11,059	11,946	12,349	14,105	15,318	15,642	16,002	30,087	32,510	35,009	37,585	40,239	42,974	45,792
O&M Subsidy	US$		4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
Total Revenue	US$		9,663	9,762	11,495	11,701	12,741	14,413	15,059	15,946	16,349	18,105	19,318	19,642	20,002	34,087	36,510	39,009	41,585	44,239	46,974	49,792
Power Purchased	US$		2,658	2,704	3,518	3,615	4,103	4,888	5,191	5,607	5,797	6,621	7,190	7,342	7,511	14,123	15,260	16,433	17,642	18,888	20,172	21,494
O&M Cost	US$		4,849	4,934	5,019	5,106	5,195	5,285	5,377	5,470	5,565	5,662	5,760	5,860	5,962	6,065	6,170	6,277	6,386	6,497	6,610	6,725
Depreciation of Asset	US$		12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124
Taxable Income	US$		-9,968	-10,000	-9,166	-9,144	-8,680	-7,884	-7,633	-7,255	-7,136	-6,301	-5,756	-5,684	-5,594	1,776	2,956	4,175	5,433	6,730	8,069	9,449
Income Tax	US$		0	0	0	0	0	0	0	0	0	0	0	0	0	533	887	1,253	1,630	2,019	2,421	2,835
Income After tax			-9,968	-10,000	-9,166	-9,144	-8,680	-7,884	-7,633	-7,255	-7,136	-6,301	-5,756	-5,684	-5,594	1,243	2,069	2,923	3,803	4,711	5,648	6,615
Cash Flow	US$	-254,596	2,156	2,124	2,958	2,980	3,443	4,240	4,491	4,868	4,988	5,823	6,368	6,440	6,529	13,367	14,193	15,046	15,927	16,835	17,772	18,738
FIRR to Equity	**-2.77%**																					

Note 1: Initial capital investment paid by the government is a sort of equity financing measure.

Income Statement under a New Scheme Applied to a Concessionaire

		Year 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Power Sales	US$		5,663	5,762	7,495	7,701	8,741	10,413	11,059	11,946	12,349	14,105	15,318	15,642	16,002	30,087	32,510	35,009	37,585	40,239	42,974	45,792
O&M Subsidy	US$		2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Total Revenue	US$		7,663	7,762	9,495	9,701	10,741	12,413	13,059	13,946	14,349	16,105	17,318	17,642	18,002	32,087	34,510	37,009	39,585	42,239	44,974	47,792
Power Purchased	US$		2,658	2,704	3,518	3,615	4,103	4,888	5,191	5,607	5,797	6,621	7,190	7,342	7,511	14,123	15,260	16,433	17,642	18,888	20,172	21,494
O&M Cost	US$		4,849	4,934	5,019	5,106	5,195	5,285	5,377	5,470	5,565	5,662	5,760	5,860	5,962	6,065	6,170	6,277	6,386	6,497	6,610	6,725
Depreciation of Concession Fee	US$		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Leasing Fee Paid Back to the RE Fund (= Depreciation of the Asset)	US$		12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124	12,124
Taxable Income	US$		-11,973	-12,005	-11,171	-11,149	-10,685	-9,889	-9,638	-9,260	-9,141	-8,306	-7,761	-7,689	-7,599	-229	951	2,170	3,428	4,725	6,064	7,444
Income Tax	US$		0	0	0	0	0	0	0	0	0	0	0	0	0	0	285	651	1,028	1,418	1,819	2,233
Income After tax	US$		-11,973	-12,005	-11,171	-11,149	-10,685	-9,889	-9,638	-9,260	-9,141	-8,306	-7,761	-7,689	-7,599	-229	666	1,519	2,399	3,308	4,245	5,211
Cash Flow	US$	-12,224	-11,968	-12,000	-11,166	-11,144	-10,680	-9,884	-9,633	-9,255	-9,136	-8,301	-7,756	-7,684	-7,594	-224	671	1,524	2,404	3,313	4,250	5,216
FIRR to Equity	**#DIV/0!**																					

Economic Analysis

Power Wholesale Price	US¢/kWh	2.6
Power Retail Price	US¢/kWh	6.0
Power Loss	%	6.0
O&M Cost	%	2

Value of 2006 US$

Years			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Power Sales (kWh)				94,388	94,388	120,695	121,890	135,995	159,240	166,234	176,504	179,354	201,362	214,937	215,742	216,949	400,941	425,847	450,752	475,658	500,563	525,469	550,374
Item	Initial amount	Replacement period																					
A. Investment Schedule																							
Direct Capital Cost	242,472	20	242,472																				0
I. Total	242,472		242,472	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. Working Capital (=Inventry and Startup Cost)																							
II. Working capital	12,124			12,124																			-12,124
C. Annual costs	Annual amount																						
Powre Purcased				2,658	2,658	3,399	3,433	3,830	4,485	4,682	4,971	5,051	5,671	6,053	6,076	6,110	11,292	11,993	12,695	13,396	14,098	14,799	15,500
O&M				4,849	4,849	4,849	4,849	4,849	4,849	4,849	4,849	4,849	4,849	4,849	4,849	4,849	4,849	4,849	4,849	4,849	4,849	4,849	4,849
III. Total			0	7,508	7,508	8,249	8,282	8,680	9,334	9,531	9,820	9,901	10,520	10,903	10,925	10,959	16,141	16,843	17,544	18,246	18,947	19,648	20,350
D. Benefits	Annual amount																						
IV. Incremental output				5,663	5,663	7,242	7,313	8,160	9,554	9,974	10,590	10,761	12,082	12,896	12,945	13,017	24,056	25,551	27,045	28,539	30,034	31,528	33,022
E. Net benefits																							
IV-I-II-III			-242,472	-13,968	-1,844	-1,007	-969	-520	220	443	770	861	1,561	1,993	2,019	2,057	7,915	8,708	9,501	10,294	11,087	11,880	24,796
Discount rate	12%																						
Net present value	-243,392		-242,472	-12,471	-1,470	-717	-616	-295	112	200	311	310	503	573	518	472	1,620	1,591	1,550	1,499	1,442	1,379	2,571
Internal rate of return	#NUM!		#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!

Attachment 3-a-1

Progress Management Sheet (Results on MAREP Phase 5 FS)

Region	District	Phase by M/P	Name of TC	Num. of TC along the line	Length of 33kV line (km)	Length of 400/230V line (m)	Num.of Trans. (100kVA)	Num.of Trans. (50kVA)	Estimated cost (1,000MK)	Estimated cost (1,000U$)	IRR	Remarks
Northern	Chitipa	5	Nthalire	3	33.75	3,284	1	1	26,677	242.5		
	Chitipa	**6-1**	**Wenya**	**3**	**72.6**	**2,470**	**0**	**2**	**55,832**	507.6		
	Karonga	**7-2**	**Mulare**	**0**	**7.6**	**1,475**	**1**	**0**	**6,371**	57.9		
	Karonga	**9-1**	**Hara**	**0**	**5.8**	**1,320**	**0**	**1**	**4,901**	44.6		
	Rumphi	5	Katowo	2	41	1,300	1	0	30,906	281.0		
	Rumphi	5	Chitimba	1	11	1,680	1	1	9,151	83.2		
	Nkhata Bay	5	Mpamba							0.0		
	Nkhata Bay	5	Kavuzi							0.0		
	Mzimba	5	Edingeni	0	11	2,400	1	1	9,358	85.1		
	Mzimba	**7-1**	**Mnyamula**	2	28	1,500	1	0	21,671	197.0		
Central	Kasungu	5	Chamama							0.0		
	Kasungu	5	Mpepa							0.0		
	Nkhotakota	5	Mkaika							0.0		
	Nkhotakota	5	Dwambadzi							0.0		
	Ntchisi	5	Nthesa							0.0		
	Ntchisi	5	Khuwi							0.0		
	Dowa	5	Thambwe							0.0		
	Dowa	5	Bowe							0.0		
	Salima	5	Kandulu	0	1.8	240	0	1	1,292	11.7		
	Salima	5	Chilambula	0	1.6	1,780	0	2	2,059	18.7		
	Lilongwe	5	Chilobwe							0.0		
	Lilongwe	5	Nyanja							0.0		
	Mchinji	5	Mkanda							0.0		
	Mchinji	5	Chiosya							0.0		
	Dedza	5	Kabwazi							0.0		
	Dedza	5	Golomoti	0	17.8	3,770	3	0	13,782	125.3		
	Ntcheu	5	Ntonda							0.0		
	Ntcheu	5	Kasinje	0	14	2,460	1	0	23,969	217.9		
Southern	Mangochi	5	Makanjira	4	80	1,830	2	1	61,175	556.1		
	Mangochi	5	Chilipa	0	11	750	1	0	8,712	79.2		
	Machinga	5	Chikwewu							0.0		
	Machinga	5	Nampeya							0.0		
	Balaka	5	Chendausiku							0.0		
	Balaka	5	Kwitanda							0.0		
	Zomba	5	Jenale							0.0		
	Zomba	5	Sunuzi							0.0		
	Chiradzulu	5	Kanje							0.0		
	Chiradzulu	**6-1**	**Chimwawa**							0.0		
	Blantyre	5	Chikuli							0.0		
	Blantyre	5	Mombo							0.0		
	Mwanza	**6-1**	**Ligowe**							0.0		
	Mwanza	5	Thambani							0.0		
	Neno	**Mwanza**	**Chikonde**							0.0		
	Neno									0.0		
	Thyolo	5	Nansadi							0.0		
	Thyolo	**6-1**	**Lalakani**	**0**	**4.2**	**283**	**0**	1	3,400	30.9		
	Mulanje	5	Chinyama	2	20.2	568	0	2	15,700	142.7		
	Mulanje	**6-1**	**Nanthombozi**	**0**	**5.2**	**526**	**1**	0	4,300	39.1		
	Phalombe	**6-1**	**Phaloni**	**0**	**12.6**	**880**	**0**	**2**	**10,000**	90.9		
	Phalombe	5	Mlomba	1	14.4	1,355	1	1	11,600	105.5		
	Chikwawa	5	Mitondo	2	10.2	919	1	1	8,335	75.8		
	Chikwawa	5	Linvunzu	2	7.9	2,141	1	1	7,000	63.6		
	Nsanje	5	Tengani	0	0.8	1,300	1	1	1,400	12.7		
	Nsanje	5	Mankhokwe	0	0.021	500	0	1	333	3.0		
	Total			**22**	**412.47**	**34,731**	**18**	**20**	**337,924**	**3,072**		
	Quantity of Foreign materials applied											

Attachment 3-a-2

Progress Management Sheet (on MAREP Phase 5 FS)

D: Done, S: Sent to the Study Team

Region	Name	Phase by M/P	TC Name	complete	Date of Survey	Report	Rroute Map 1/250,000	Route Map Around TC	Map Inside TC (White)	Map Inside TC (Trans. Line)	Table on Socio-Economic	Calculation Voltage Drop	Calculation Cost	Demand Forecast	Calculation IRR	BOQ	Num. of TC along the line	Remarks and public facilities within about 1km from the TC
Northern	Chitipa	5	Nthalire	1	5/12/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				3	1 Primary School
	Chitipa	6-1	Wenya	1	4/12/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				3	No comment
	Karonga	7-2	Mulare	1	3/12/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				0	2 Secnodary schools (2 groups)
	Karonga	9-1	Hara	1	2/12/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				0	No comment
	Rumphi	5	Katowo	1	10/12/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				2	1 Agriculture offices
	Rumphi	5	Chitimba	1	11/12/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				1	No comment
	Nkhata Bay	5	Mpamba															
	Nkhata Bay	5	Kavuzi															
	Mzimba	5	Edingeni	1	12/12/03												0	
	Mzimba	7-1	Mnyamula	1	13/12/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				0	
Central	Kasungu	5	Chamama															
	Kasungu	5	Mpepa															
	Nkhotakota	5	Mkaika															
	Nkhotakota	5	Dwambadzi															
	Ntchisi	5	Nthesa															
	Ntchisi	5	Khuwi															
	Dowa	5	Thambwe															
	Dowa	5	Bowe															
	Salima	5	Kandulu	1	4/12/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				0	No comment
	Salima	5	Chilambula	1	1/12/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				0	No comment
	Lilongwe	5	Chilobwe															
	Lilongwe	5	Nyanja															
	Mchinji	5	Mkanda															
	Mchinji	5	Chiosya															
	Dedza	5	Kabwazi															
	Dedza	5	Golomoti	1	3/12/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				0	No comment
	Ntcheu	5	Ntonda															
	Ntcheu	5	Kasinje	1	2/12/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				0	1 Secondary school
Southern	Mangochi	5	Makanjira	1	12/11/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				4	1 Police unit must be electrified
	Mangochi	5	Chilipa	1	11/11/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				0	1 Primary Axhool, 1 Secondary school (1 group), 1 ADMARK and 1 Office (1group)
	Machinga	5	Chikwewu															
	Machinga	5	Nampeya															
	Balaka	5	Chendausiku															
	Balaka	5	Kwitanda															
	Zomba	5	Jenale															
	Zomba	5	Sunuzi															
	Chiradzulu	5	Kanje															
	Chiradzulu	6-1	Chimwawa															
	Blantyre	5	Chikuli															
	Blantyre	5	Mombo															
	Mwanza	6-1	Ligowe															
	Mwanza	5	Thambani															
	Neno	Mwanza 5	Chikonde															
	Neno																	
	Thyolo	5	Nansadi															
	Thyolo	6-1	Lalakani	1	6/11/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				0	1 primary school
	Mulanje	5	Chinyama	1	7/11/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				2	No comment
	Mulanje	6-1	Namthombozi	1	8/11/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				0	No comment
	Phalombe	6-1	Phaloni	1	20/11/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				0	No comment
	Phalombe	5	Mlomba	1	19/11/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				1	1 Agriculture offices
	Chikwawa	5	Mitondo	1	18/11/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				2	No comment
	Chikwawa	5	Linvunzu	1	17/11/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				2	1 Primary school
	Nsanje	5	Tengani	1	4/11/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				0	Part of the TC is electrified, 1 Police unit
	Nsanje	5	Mankhokwe	1	5/11/03	D,S	D,S	D,S	D	D,S	D,S	D,S	D,S				0	No comment
			total	23														

Attachment 4-a

Format of Report

1. Name of the TC :
2. Date and time of the field survey:
3. Participants:
4. Outline of the TC

Region	
District	
Traditional Authority	
Scale/Size of the TC	
Public facilities ( ):Number of buildings	
Number of maize mill(s)	
Demand in 2001,2020(kW)	
Activities inside TC	
Activities outside TC	
Public facilities outside TC	
GPS position	
Location of the TC	
Location of existing line	

5. Recommended route

33kV line	Total : 7.6km from Recommended 33kV route is
Step down transformer(s)	Number and capacity of transformer(s): Place of transformer
400/230V line	Total length of 400V (3phases) : m Total length of 230V (single phase): m

6. Voltage drop calculation (Refer to Result)

33kV	
400/230V	

7. Cost estimation (Refer to BOQ)

Total cost (MK)	
Total cost (U$)	(Exchange rate: 1U$= MK)

8. Economical Analysis(Refer to the results)

Internal Rate of Return	%

Attachment 4-b

Sample of Report
(Report on the MAREP Phase V Feasibility Study)

1. Name of the TC: Mulare
2. Date and time of the field survey: From 13.58 hrs to 15.53 hrs, 2 Dec 2003
3. Participants: Mr. K. Lungu, Mr. D. Kalimba, Mr. Y. Kawakami, Mr. G. Moya
4. Outline of the TC

Region	North
District	Karonga
Traditional Authority	Kyungu
Scale/Size of the TC	Medium
Public facilities (): Number of buildings	1 Primary School (16), 1 SEDOM Office (1), 1 Health Centre (3), 1 P0st Office (1).
Number of maize mill(s)	3
Demand in 2020(kW)	38
Activities inside TC	Vending of groceries, foodstuffs and alcoholic beverages
Activities outside TC	Farming
Public facilities outside TC	1 Secondary School about 1km to the East of TC 1 Secondary School about 0.75 km to the west of TC.
GPS position	S10°13'01.6" E034°05'41.5"
Location of the TC	Along the M1 Road, 7.6 km North of Ngara TC (or 15.5 km North of Nyungwe TC) in Karonga.
Location of existing line	An 11KV line following the road from Wovwe to Uliwa and ending at Ngara TC along the M1 Road. GPS Position of end pole is S10°13'01.6" E034°05'41.5"
Trading Centres between end pole and TC	None

5. Recommended route

33kV line	Total: 7.6 km from Ngara TC Recommended 33KV route is from Ngara TC to Mlare TC along the M1 Road
Step down transformer(s)	Number and capacity of transformer(s): 1 X (100KVA) GPS Position of transformer: S10°10'26.1"

	E034°02'30.6"
400/230V line	Total length of 400V (3phases): 1475m Total length of 230V (single phase): Not applicable

6. Voltage drop calculation (Refer to Result)

33kV	0.011295447
400V/230V	Not necessary

7. Cost estimation (Refer to BOQ)

Total cost (MK)	6,552,217
Total cost (U$)	(Exchange rate: 1U$= 110 MK) 59,566

8. Economical Analysis (Refer to the results))

Internal Rate of Return	18.32%