Government of the Republic of Zambia

RURAL ELECTRIFICATION MASTER PLAN FOR ZAMBIA 2008 - 2030

A Blue Print for Providing Electricity To All Rural Areas

February, 2009

PREPARED WITH TECHNICAL ASSISTANCE FUNDED BY THE GOVERNMENT OF JAPAN THROUGH THE JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

Foreword

The Government of the Republic of Zambia has identified rural electrification as a vehicle to eradicate poverty by stimulating the rural economy in the country. Although the Rural Electrification Fund (REF) was created in 1994 through an administrative *fiat* to facilitate rural electrification, the rate of electrification has remained low. Recent statistics indicate that the electrification rate (as at 2006) countrywide was at approximately 22% and only 3% in the rural areas. This low rate of electrification could, among other things, be attributed to the low levels of funding and lack of a coherent plan.

It is with a great sense of relief and satisfaction that I take this great honour to offer a foreword to the first ever national Rural Electrification Master Plan (REMP) that has been prepared more than forty-years after independence. The development of this Plan must be seen in the context of the overall strengthening of policies and regulations related to rural electrification that the new deal government has been implementing since the enactment of the Rural Electrification Act in December 2003. The Act formally established the Rural Electrification Authority (REA) and the rural electrification fund.

The Master plan has set ambitious targets for increasing access to electricity by the year 2030. The plan has identified 1,217 rural growth centres throughout the country as targets for electrification during the period 2008 to 2030. These rural growth centres will be electrified using three principle methods: (i) extension of the nation grid; (ii) construction of mini-hydro power stations where the potential exists; and (ii) installation of solar home systems at a total cost of US$1.1 billion equivalent to about K4.4 trillion during the period 2008-2030. This translates into an annual expenditure of US$50 million equivalent to about K200 billion over the same period. Once this investment is made, the rate of electrification will increase from the current 3% to 51% by the year 2030.

The preparation of this Master Plan was highly consultative process. Workshops involving key stakeholders were held at each Provincial headquarters between August and December 2006. Between March and April 2007, all Hon. Members of Parliament were consulted to give input to the Plan.

I would like to pay tribute to the Government of Japan for providing the financing that made it possible to develop this Master plan. In addition the Government of Japan has provided a soft loan through the Japanese International Cooperation Agency (JICA) to kick-start the implementation of the Master plan. I also want to extend a special word of thanks to Tokyo Electric Power Company, the consultants who prepared the Plan; the Provincial and District planners, traditional rulers, non-governmental organisations and private sector representatives, and all stakeholders who attended the nine provincial workshops, the Members of Parliament who provided inputs to the Master plan and; last but the least officials from my Ministry and the Rural Electrification Authority who worked closely with the consultants over a period of eighteen months to come up with what I consider to be splendid master plan.

Government has now spelled out its targets for rural electrification, set priorities for electrification and worked out the costing and methods of electrification. It is now incumbent upon us to work with all stakeholders to ensure that the pace of electrification is accelerated through adherence to the financing and implementation plans outlined in this Master plan.

KENNETH KONGA, MP

MINISTER FOR ENERGY AND WATER DEVELOPMENT

LUSAKA

February 2009

PREFACE

In response to a request from the Government of the Republic of Zambia, the Government of Japan decided to conduct a study for development of Rural Electrification Master Plan in Zambia and entrusted to the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Hitoshi Koyabu of Tokyo Electric Power Co., Inc. and consists of Tokyo Electric Power Co., Inc. between May 2006 and January 2008.

The team held discussions with the officials concerned of the Government of Zambia and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Zambia for their close cooperation extended to the study.

January 2008

Seiichi NAGATSUKA,

Vice President

Japan International Cooperation Agency

The Rural Electrification Master Plan for Zambia 2008 - 2030

FINAL REPORT

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Acronyms

ACSR	Aluminium Conductor Steel Reinforced
AfDB	African Development Bank
CA	Catchment Area
CBR	Crude Birth Rate
CEC	Copperbelt Energy Corporation
CHESCO	Chipata Energy Service Company
CSAA	Client Service Accounts Assistants
CSO	Central Statistics Office
DDACC	Direct Debit and Credit Clearing
DoE	Department of Energy
DWA	Department of Water Affairs
ECZ	Environmental Council of Zambia
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Margin
EIS	Environmental Impact Statement
EPPCA	Environmental Protection and Pollution Control Act
ERB	Energy Regulation Board
ESCO	Energy Service Company
ESU	Environment and Social Affairs Unit of ZESCO
FIRR	Financial Internal Rate of Return
FNDP	The Fifth National Development Plan
FY	Fiscal Year
GEF	Global Environmental Facility
GIS	Geographical Information System
GNI	Gross National Income
GRZ	Government of the Republic of Zambia
IEE	Initial Environmental Examination
IMR	Infant Mortality Rate
IPP	Independent Power Producer
JBIC	Japan Bank for International Corporation
JICA	Japan International Corporation Agency
K	(Zambia) Kwacha
KG-PS	Kafue Gorge Power Station
KNB-PS	Kariba North Bank Power Station
KPLC	Kenya Power & Lighting Company
KSh	Kenya Shilling
kW, MW	kilowatt, megawatt
kWh, MWh, GWh	kilowatthour, megawatthour, gigawatthour
LDC	Least Developed Countries
LEB	Life Expectancy at Birth
LESCO	Lundazi Energy Service Company

Mc-HP	Micro-hydropower plant
MEWD	Ministry of Energy and Water Development
MFNP	Ministry of Finance and National Planning
MTENR	Ministry of Tourism, Environment and Natural Resources
NEP	National Energy Policy
NESCO	Nyimba Energy Service Company
NRSE	New and Renewable Source of Energy
PB	Project Brief
PRP	Power Rehabilitation Project
REA	Rural Electrification Authority
REF	Rural Electrification Fund
REMP	Rural Electrification Master Plan
REP	Rural Electrification Programme
RGC	Rural Growth Centre
ROA	Return on Assets
SAPP	Southern African Power Pool
SEA	Strategic Environmental Assessment
TEPCO	Tokyo Electric Power Company, Inc.
TFR	Total Fertility Rate
Tr	Transformer
UNIDO	United Nations Industrial Development Organization
UTM	Universal Transverse Mercator
VF-PS	Victoria Falls Power Station
WB	World Bank
ZAMSIF	Zambia Social Investment Fund
ZCCM	Zambia Consolidated Copper Mines
ZESCO	Zambia Electricity Supply Corporation (Currently “ZESCO Ltd.” is the company’s official name)
ZMD	Zambia Meteorological Department

Chapter 1

Introduction

Chapter 1. Introduction

1.1. Background

Rural electrification has long been identified as a vehicle to eradicate poverty by stimulating the rural economy in the Republic of Zambia. In 1994, the Government of the Republic of Zambia (GRZ) established the Rural Electrification Fund (REF) by committing the sales tax on electricity, and has been trying to increase the electrification rate in rural area by executing projects funded by REF. The household electrification rate, however, still remains at approximately 20% countrywide, and only 2 –3% in rural area. As a mid-term target, achieving 35% of household electrification rate (50% in urban area and 15% in rural area) by 2010 was set in the Poverty Reduction Strategy Paper published in 2002. For aiming to achieve this goal, GRZ has been strengthening policies and institutions related to rural electrification. In December 2003, the Rural Electrification Act was enacted to establish Rural Electrification Authority (REA) and to improve the management of REF.

In order to enhance rural electrification efficiently, preparation of the Rural Electrification Master Plan in Zambia (REMP) was considered as an urgent issue, and GRZ requested the Government of Japan to assist the development of Master Plan in 2004. Accordingly, Japan International Cooperation Agency (JICA), an official agency responsible for the implementation of the technical cooperation program on behalf of the Government of Japan, sent a study team to Zambia for project formulation in September 2005, followed by the preliminary study team in January 2006. The study team held discussion with GRZ on the Scope of Work of the Master Plan Study, and execution of the study was approved.

JICA selected the Tokyo Electric Power Company, Inc. (TEPCO) as consultant to execute this Master Plan Study. The Study Team of TEPCO commenced the study in May 2006.

1.2. Purpose of the Study

The objective of the Master Plan Study is to formulate the Master Plan for rural electrification in Zambia up to the year 2030 and to bring about technology transfer to counterparts so that they can continue updating and implementing the Master plan by themselves.

The Study consists of the following items:

(1) Rural Electrification Plan up to 2030

(a) Development of selection criteria for rural electrification projects

(b) Selection of candidate site for rural electrification considering socio-economic and technical aspects

(c) Selection of electrification methods

- Extension of existing grid
- Isolated mini-grid with renewable energy, such as mini- and micro-hydro power generation
- Solar home system (SHS)
- Mini-grid with diesel power generation, if none of the above is feasible

(d) Case study executions

(2) Financial Plan for Rural Electrification

(a) Study on financing strategy

(b) Cost estimation of implementing the Master Plan at each phase

(c) Evaluation of the validity of rural electrification projects (EIRR / FIRR)

(3) Policy Recommendations for Acceleration and Dissemination of Rural Electrification

(a) Organization structure for promoting rural electrification
(b) Operational management of Rural Electrification Fund
(c) Framework of promoting the participation of private sector (IPP and ESCO)
(d) Affordable initial connection fee and sustainable electricity tariff
(e) Policy on curbing the negative impact of electrification on society and environment

(4) Development of Comprehensive Rural Electrification Program

(a) Implementation procedure of long-term rural electrification plan
(b) Prioritisation of execution plans
(c) Consensus-oriented rural electrification plan with donors; ex. Japanese Bank for International Cooperation (JBIC), African Development Bank (AfDB) and World Bank (WB)

1.3. Scope of Works

This study started at the beginning of May 2006, and is scheduled to continue until the beginning of December 2007. The terms of reference of work as provided to TEPCO was shown in Appendix-A. The scope of works is summarized in Figure 1-1.

1.4. Study Flow and Schedule

This study will be carried out in five stages and completed by December 2007. The flow and the schedule of the study are shown in

Figure 1-2 and Table 1-1 respectively.

1.5. Study Team

Member of the Study Team and their respective Zambian counterparts, are shown in Table 1-2.

Table 1-2 Members of JICA Study Team

No.	Position	Name	Zambian Counterpart
1	Team Leader Rural Electrification Planning Expert	Hitoshi Koyabu	Charles Mulenga
2	Deputy Team Leader Electrification Policy & Organization Expert	Tomoyuki Yamashita	Arnold Simwaba
3	Hydro Power Planning Expert	Takayuki Abe	Nkusuwila Silomba
4	Renewable-Energy-Based Rural Electrification Planning Expert	Genshiro Kano	Malama Chileshe
5	Transmission and Distribution Planning Expert	Kenichi Kitamura	Mushimbwa Fred
6	Socio Economic Expert	Yasushi Iida	Wankunda Siwakiwi Langiwe Chandi
7	Environmental and Social Impact Analysis Expert	Yasuharu Sato	Michael Mulasikwanda Mundu Mwila
8	GIS Database Development Expert	Atsushi Yuihara	Aggrey Siuluta C.Kasango / B.Mukala
9	Power System Analysis Expert	Takashi Chujo	William Sinkala
10	Project Coordinator	Osamu Matsuzaki	Patrick Mubanga

Note: List of Zambian counterpart is the one originally approved and does not reflect the personnel reshuffle during the Study period.

1.6. Outline of Report

This report consists of 15 chapters. Back ground, purpose, scope, schedule of the study, and so on are introduced in Chapter 1. General profile and current status of the power sector in Zambia are summarized in Chapter 2 and Chapter 3. The selection methods of electrification targets (Rural Growth Centers) in this master plan are explained in Chapter 4. The social aspect analysis results, such as ability and willingness to pay and prioritized property for electrification, are also shown in this chapter. The potential power demand for selected electrification targets is forecasted and an initial ranking for electrification for these targets is given in Chapter 5. Transmission system analysis, such as the capacity analysis of the system based on a simulation, is executed in Chapter 6. Plans for distribution system, micro-hydropower generation, solar power, and other renewable energies to realize rural electrification are provided in Chapter 7, Chapter 8, Chapter 9, and Chapter 10 respectively. Environmental and social considerations are explained in Chapter 11. Results of case studies (or pre feasibility studies), 3 sites for distribution lines, 2 sites for mini-hydropower, and 2 sites for environmental impact assessment, are introduced in Chapter 12. In Chapter 13, development process of GIS database is explained. The optimal electrification method for each target, final electrification priority based on financial indicators, and project execution phase from 2008 to 2030 are specified as a comprehensive rural electrification master plan in Chapter 14. Finally, conclusion and recommendation are provided in Chapter 15.

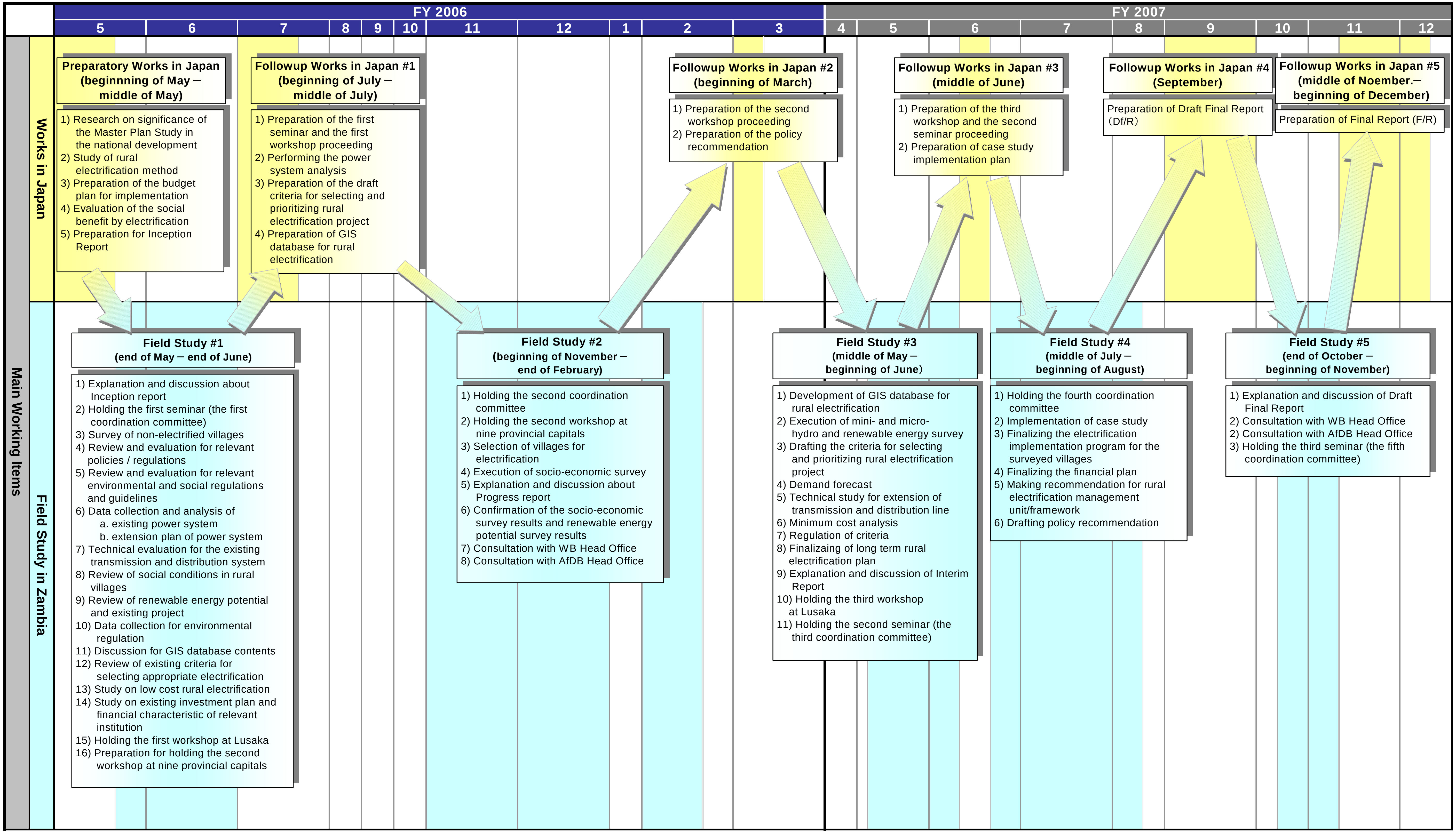


Figure 1-1 Scope of Works

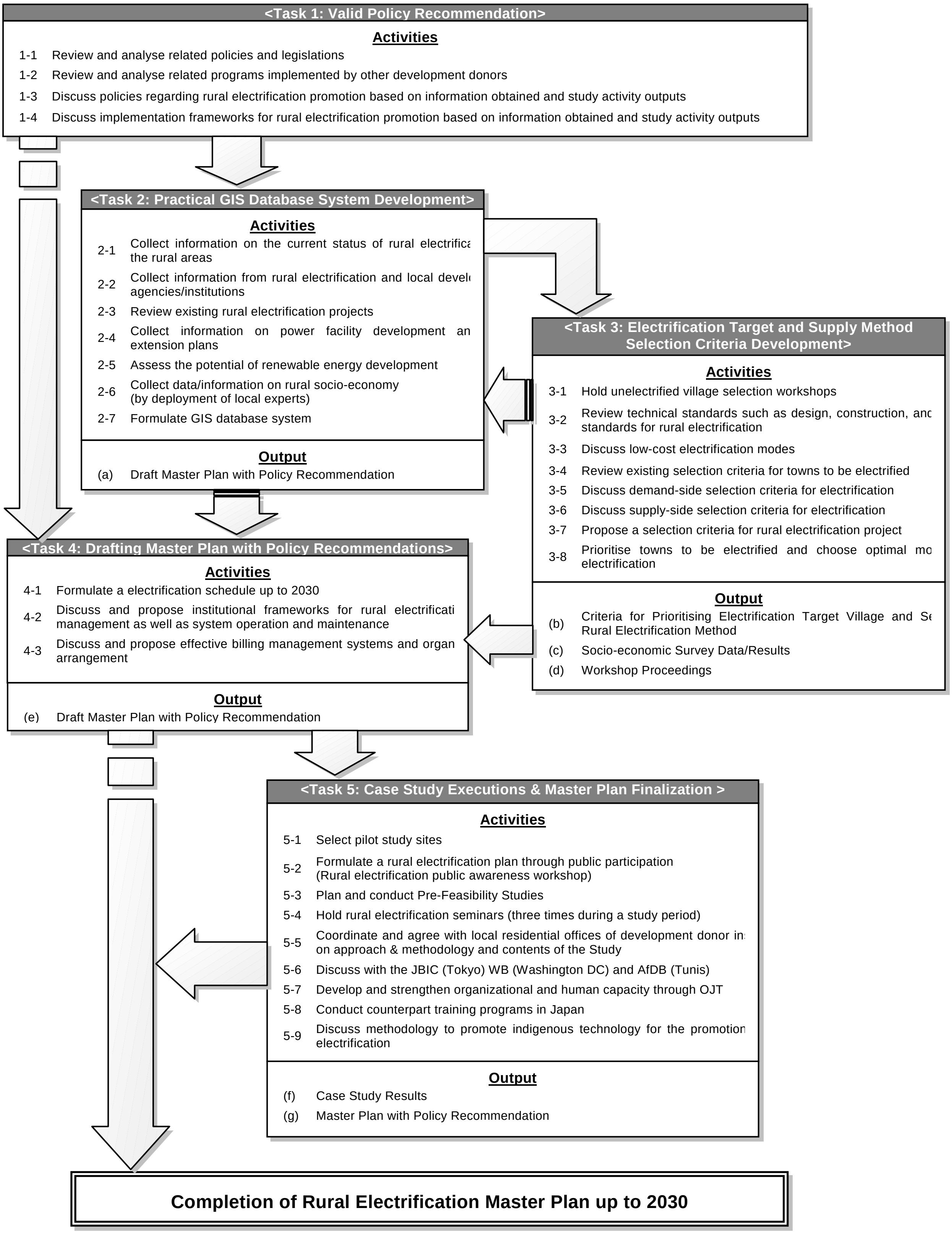


Figure 1-2 Flow of the Study

Table 1-1 Schedule of the Study

Stage	Activity	2006								2007												Output
		5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	
<Stage 1> Valid Policy Recommendation	1-1 Review and analyze related policies and legislations																					<Stage 1>
	1-2 Review and analyze related programmes implemented by other development donors																					
	1-3 Discuss policies regarding rural electrification promotion based on information obtained and study activity outputs																					
	1-4 Discuss implementation frameworks for rural electrification promotion based on information obtained and study activity outputs																					
<Stage 2> Practical GIS Database System Development	2-1 Collect information on the current status of rural electrification in the rural areas																					<Stage 2> a. GIS Database
	2-2 Collect information from rural electrification and local development agencies/institutions																					
	2-3 Review existing rural electrification projects																					
	2-4 Collect information on power facility development and grid extension plans																					
	2-5 Assess the potential of renewable energy development																					
	2-6 Collect data/information on rural socio-economy (by deployment of local experts)																					
	2-7 Formulate GIS database system																					
<Stage 3> Electrification Target and Supply Method Selection Criteria Development	3-1 Hold unelectrified village selection workshops - 1st WS : Preliminary workshop in Lusaka - 2nd WS : Province workshops in nine provincial capitals - 3rd WS: Dissemination workshop in Lusaka																					<Stage 3> b. Criteria for Prioritizing Electrification Target Village and Selecting Rural Electrification Method c. Socio-economic Survey Data/Results d. Workshop Proceedings
	3-2 Review technical standards such as design, construction, and safety standards for rural electrification																					
	3-3 Discuss low-cost electrification modes																					
	3-4 Review existing selection criteria for towns to be electrified																					
	3-5 Discuss demand-side selection criteria for electrification																					
	3-6 Discuss supply-side selection criteria for electrification																					
	3-7 Propose a selection criteria for rural electrification project																					
	3-8 Prioritize towns to be electrified and choose optimal modes of electrification																					
<Satge 4> Drafting Master Plan with Policy Recommendations	4-1 Formulate a electrification schedule up to 2030																					<Stage 4> e. Draft Master Plan with Policy Recommendation
	4-2 Discuss and propose institutional frameworks for rural electrification fund management as well as system operation and maintenance																					
	4-3 Discuss and propose effective billing management systems and organizational arrangement																					
<Stage 5> Case Study Executions and Final Master Plan Development	5-1 Select pilot study sites																					<Stage 5> f. Case Study Results g. Master Plan with Policy Recommendation
	5-2 Formulate a rural electrification plan through public participation (Rural electrification public awareness workshop)																					
	5-3 Plan and conduct Pre-Feasibility Studies																					
	5-4 Hold rural electrification seminars (three times during a study period)																					
	5-5 Coordinate and agree with local residential offices of development donor institutions on approach & methodology and contents of the Study																					
	5-6 Discuss with the JBIC (Tokyo) WB (Washington DC) and AfDB (Tunis)																					
	5-7 Develop and strengthen organizational and human capacity through OJT																					
	5-8 Conduct counterpart training programs in Japan																					
	5-9 Discuss methodology to promote indigenous technology for the promotion of rural electrification																					
Reporting Schedule			▲ Ic/R								▲ Pr/R				▲ It/R				Df/R ▲		F/R ▲	

Chapter 2

General Profile of Zambia

Chapter 2. General Profile of Zambia

2.1. Land

Zambia used to be the colony of United Kingdom and gained its independence on 24th October 1964. The country is located in southern Africa, with the area of 752,614 square kilometres. Zambia is a land-locked country sharing borders with the Democratic Republic of the Congo (DR Congo) and Tanzania to the north; Malawi and Mozambique to the east; Zimbabwe and Botswana to the south; Namibia to the south-west and Angola to the west.

2.2. Administrative Organization and Local Social Structure

Lusaka is the capital city of Zambia and the seat of Government. The Government comprises the Central and Local Authorities. The province is the highest level of local administration of Zambia, and there are nine provinces, namely Central, Copperbelt, Eastern, Luapula, Lusaka, Northern, North-Western, Southern and Western provinces. The provinces are broken down into 72 districts, as seen in Figure 2-1. Districts are further broken down into wards, which are the smallest unit of local administration. There are 1,286 wards in total as of the Census of 2000.

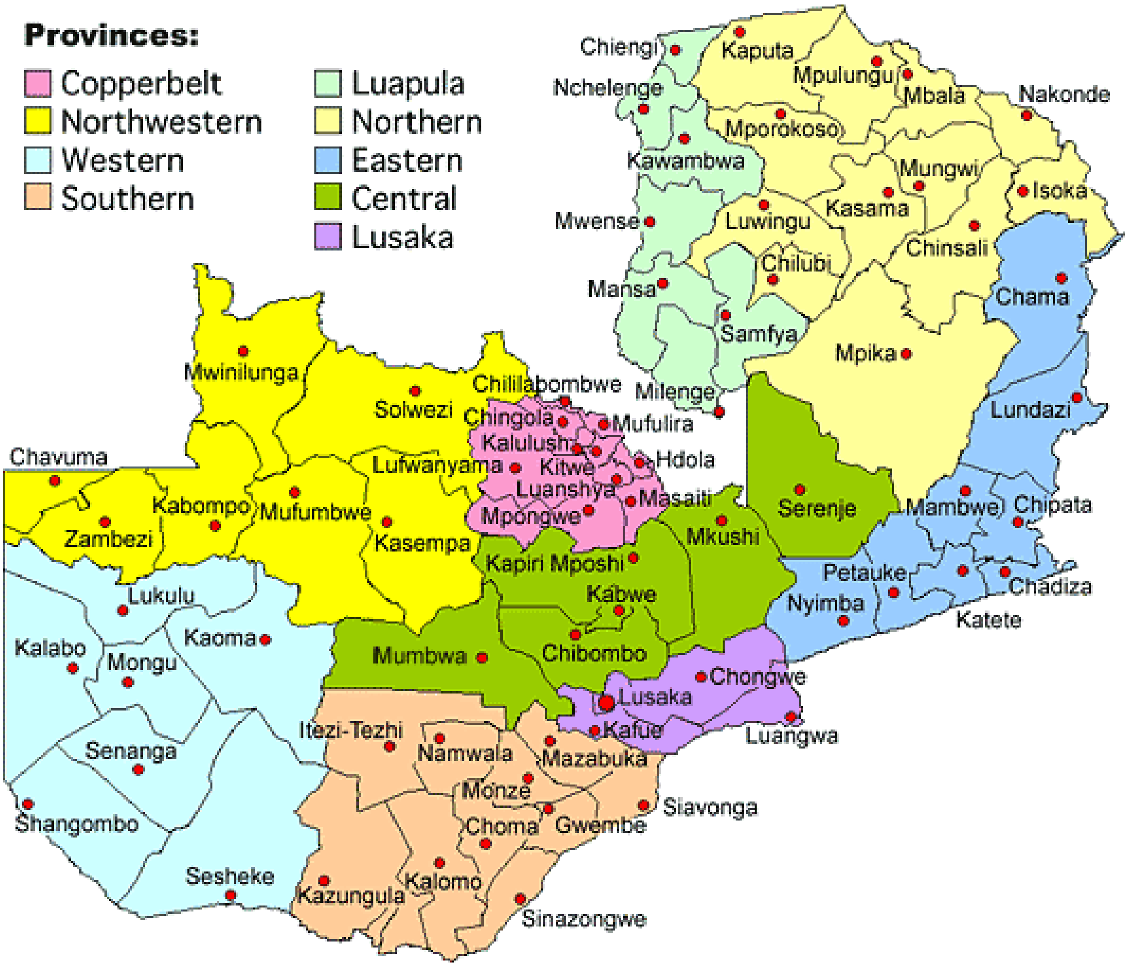
2.3. Population

The census of Population and Housing has been executed by GRZ once in a decade. The total population of Zambia has been increasing from 5.7 million of the 1980 Census to 7.8 million of the 1990 Census, then 9.8 million of the 2000 Census. Population growth is getting moderate gradually, from 3.1% p.a. in 1970s (1970-1980) to 2.7% p.a. in 1980s (1980-1990), then 2.4% p.a. in 1990s (1990-2000).

Breaking down the population by Provinces, Copperbelt Province with 1,581,221 people is the largest Province in population (or 16.1% of the country’s total population) according to the Census in 2000. The smallest Province in population is North-Western Province, with 583,350 people or 5.9 % of total population. Provinces with high population growth in 1990s are Lusaka (3.4% p.a.), Luapula (3.2% p.a.), and Northern (3.1% p.a.). Copperbelt Province recorded the population growth rate of 0.8% p.a., the lowest among 9 Provinces during the decade (refer to Table 2-1).

According to the population projections published by the Central Statistics Office, 34.6% of the population (or 3.9 million out of 11.4 million total population) is estimated to live in urban area while the remaining 65.4% (or 7.5 million) is estimated to reside in rural area. Lusaka and Copperbelt Provinces have high percentage of urban population at 82% and 81 % respectively, while that in Eastern Province is only 9%. Urban population is expected to increase from 3.9 million in 2005 to 5.6 million in 2025 at the average annual growth rate of 1.75%. Rural population is estimated to grow more rapidly at the average annual growth rate of 3.34%: from 7.5 million in 2005 to 14.4 million in 2025. In total, Zambia’s population is expected to grow at 2.84% per annum up to 2025, and to reach approximately 20 million by 2025 from 11.4 million in 2005, as shown in Figure 2-2.

Population density has been increasing from an average of 5.4 people/km^2 in 1970 to 7.5 people/km^2 in 1980, 9.8 people/km^2 in 1990, and 13.0 people/km^2 in 2000. Population density of each Province reveals the significant gap between Provinces with high density (e.g. Lusaka: 63.5 people/km^2 in 2000) and those with low density (e.g. North-Western: 4.6 people/km^2), as shown in Table 2-1 and Figure 2-3).



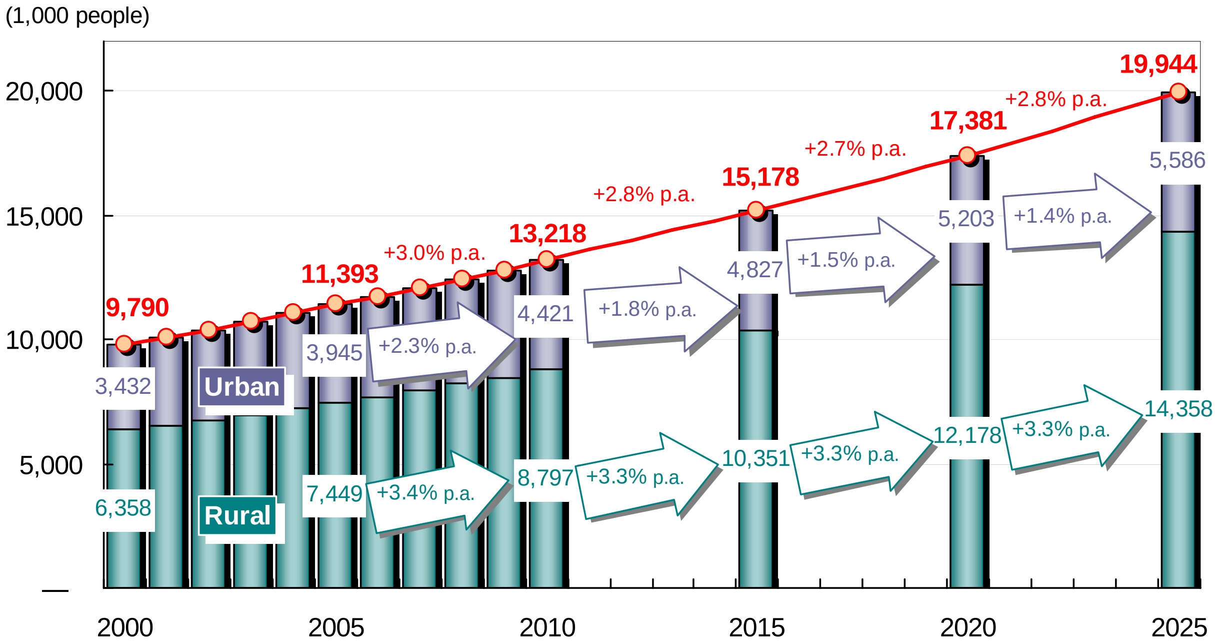
Source: JICA Zambia Office Web Site
(http://www.jica.go.jp/zambia/activities/haichi.html)

Figure 2-1 Provinces and Districts in Zambia

Table 2-1 Populations, Area, Density and Growth Rate (2000 Census)

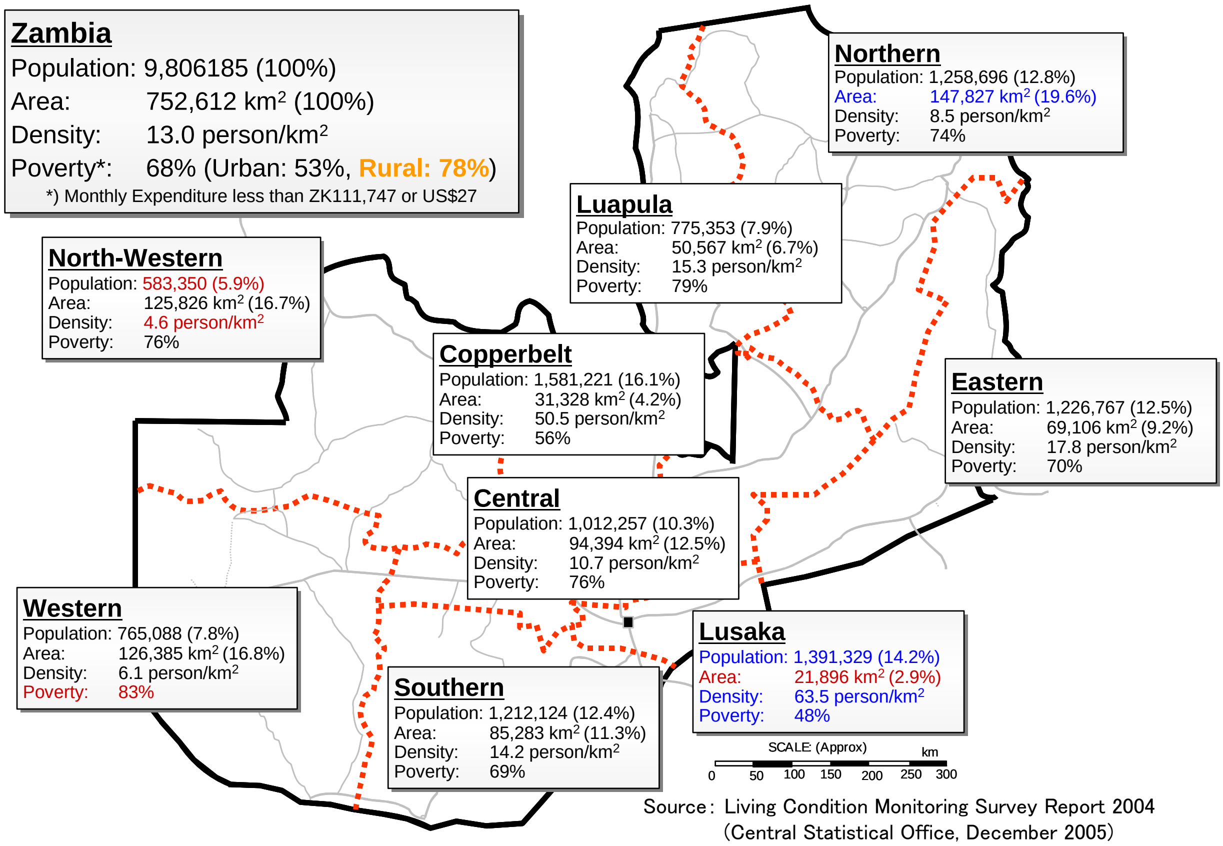
	Population (% of total population) 2000	Population Density [person/km^2] 2000	Annual Growth Rate [%] 1990 – 2000	Area [km^2]
Zambia	**9,806,185 (100.0%)**	**13.0**	**2.4%**	**752,612**
Central	1,012,257 (10.3%)	10.7	2.7%	94,394
Copperbelt	1,581,221 (16.1%)	50.5	0.8%	31,328
Eastern	1,226,767 (12.5%)	17.8	2.0%	69,106
Luapula	775,353 (7.9%)	15.3	3.2%	50,567
Lusaka	1,391,329 (14.2%)	63.5	3.4%	21,896
Northern	1,258,696 (12.8%)	8.5	3.1%	147,827
North-Western	583,350 (5.9%)	4.6	2.9%	125,826
Southern	1,212,124 (12.4%)	14.2	2.3%	85,283
Western	765,088 (7.8%)	6.1	1.8%	126,385

Source: Summary Report 2000 Census of Population and Housing
(Central Statistical Office, November 2003)



Source: Central Statistics Office "Population Projections Report", November 2003

Figure 2-2 Population Projections



Source: Living Condition Monitoring Survey Report 2004
(Central Statistical Office, December 2005)

Figure 2-3 Populations, Area and Density by Province

2.4. Ethnic Composition, Language and Religion

The overwhelming majority of Zambian people are ethnically African, with the variety of 73 tribes, while there also exist some minorities, such as Europeans, who mostly derive from immigrants since the modern times. Although each of these African tribes has its own vernacular language, English is used as the official language of Zambia and most of urban residents speak it fluently. In rural areas, communication in daily life is usually done in vernacular languages, which can be roughly divided into seven major groups: Bemba, Kaonde, Lozi, Lunda, Luvale, Nyanja and Tonga. Bemba is spoken in Northern, Luapula, Copperbelt, and Central Provinces. Kaonde, Lunda and Luvale languages are commonly used in North-Western Province. Lozi is commonly used in Western Province. Nyanja is spoken in Eastern and Lusaka provinces. Tonga is spoken in Southern Province.

The predominant religion in Zambia is Christianity, among which Roman Catholic is said to be the majority, while various traditional religions also exist, which is especially believed in rural area.

2.5. Fertility, Mortality and Life Expectancy

Total Fertility Rate (TFR), which is defined as the number of births a woman will have assuming that she survives to the end of her childbearing age, namely 50 years old, is estimated at 5.8 in 2004. TFR is higher in rural area (6.6) than that in urban area (4.5), which is considered to be the main drive of higher population growth in rural area than that in urban area, as discussed in Section 2.3. despite the general trend of migration from rural area to urban area. TFR in Luapula Province is 7.0, the highest among 9 Provinces, while that in Lusaka Province is the lowest at 4.3.

Crude Birth Rate (CBR), which is defined as the number of births that occurred in the 12-month period prior to the census against 1,000 people, is about 47.1 in urban area and 39.3 in rural area respectively. The average CBR of the whole nation is 44.2 in 2004. Among Provinces, Lusaka Province has the lowest CBR (37.6), followed by Copperbelt Province (39.3) while the highest CBR was recorded in Northern Province (48.4).

Infant Mortality Rate (IMR), which is defined as the number of deaths in a year that occurred to infants under one year of age against 1,000 live births, is higher in rural area (117 in 2000 and 91 in 2004) than urban area (91 in 2000 and 75 in 2004). Luapula Province saw the highest IMR among 9 Provinces both in 2000 (132) and 2004 (108), while the lowest IMR among Provinces is that in North-Western Province in 2000 (83) and that in Lusaka Province in 2004 (67). In comparison between 2000 and 2004 data, IMR improved in all Provinces.

Life Expectancy at Birth (LEB), which is defined as the average number of year that a newly born babies would live if subjected to the prevailing mortality conditions, is 52.4 in 2004, prolonged by 2.4 years from 50.0 in 2000. No significant difference in LEB was found between rural and urban areas as of 2004 though, according to the statistics of 2000, LEB in urban area was rather higher than that in rural area. The same trend is observed in the statistics broken down by sex, in that a significant difference is of LEB found between both sexes in 2004 though in 2004 female LEB was considerably higher than male’s. Copperbelt Province (57.6 years) indicates the highest LEB among Provinces in 2004 while Northern Province (45.5 years) saw the lowest.

Table 2-2 Fertility, Crude Birth, Infant Mortality Rates and Life Expectancy at Birth

Area / Sex / Province	TFR		CBR		IMR		LEB	
	2000	2004	2000	2004	2000	2004	2000	2004
Zambia Total	**6.0**	**5.8**	–	**44.2**	**110**	**83**	**50.0**	**52.4**
Rural	6.7	6.6	–	47.1	117	91	48.0	50.5
Urban	4.9	4.5	–	39.3	91	75	54.0	50.0
Male	–	–	–	–	–	–	48.0	52.3
Female	–	–	–	–	–	–	52.0	52.6
Central	6.1	6.0	–	44.6	100	70	52.0	55.0
Copperbelt	5.2	4.8	–	39.3	91	63	54.0	57.6
Eastern	6.7	6.6	–	46.7	129	100	46.0	47.0
Luapula	7.1	7.0	–	46.9	132	108	45.0	47.5
Lusaka	4.6	4.3	–	37.6	88	67	54.0	54.1
Northern	7.0	6.7	–	48.4	130	100	46.0	45.5
North-Western	6.6	6.4	–	46.1	83	74	56.0	55.6
Southern	6.3	6.1	–	45.2	93	79	53.0	51.6
Western	5.9	5.9	–	44.3	140	104	44.0	48.2

Source: Selected Socio-Economic Indicators 2003-2004
(Central Statistical Office, November 2003)

2.6. Education and Literacy

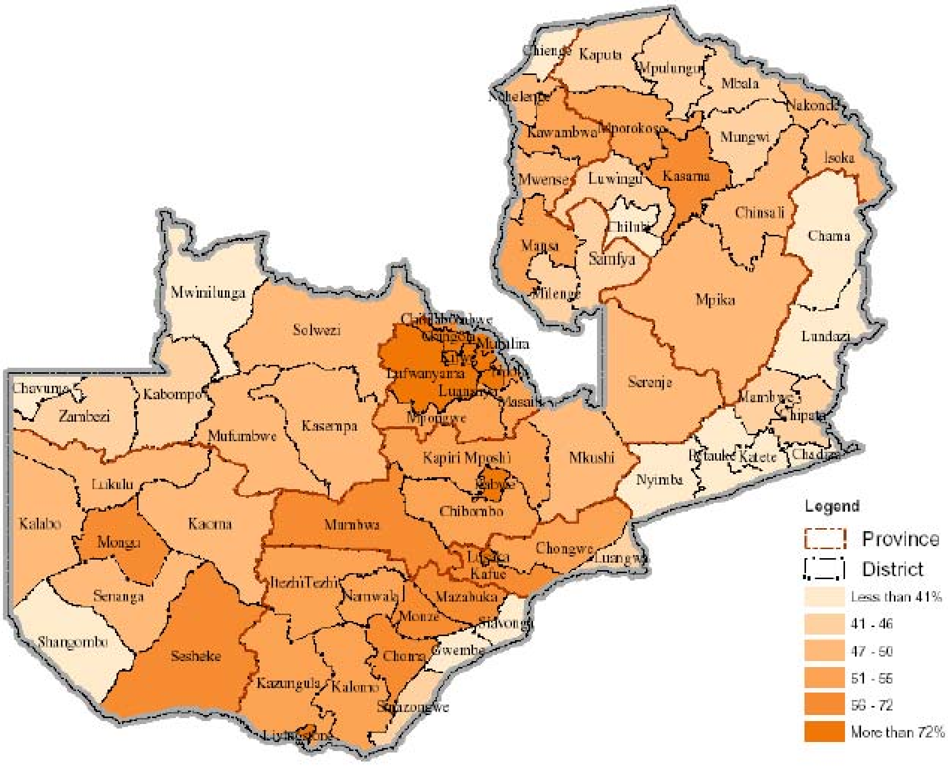
A large segment of the Zambian Population remains uneducated and illiterate. As shown in Table 2-3, literacy rate of the population aged 5years old and above is 55.3% as of 2000. And no improvement has been seen compared to that as of 1990. There's a significant gap in literacy rate between rural area (45.0% in 2000) and urban area (73.5% in 2000), which is also observed in Figure 2-4 that illustrates the literacy rate of each District: Districts in Copperbelt Province, Lusaka, Livingstone, and Kabwe Districts, which are mostly categorized as urban area, are showing a relatively high literacy rate while Eastern Province recorded the lowest literacy rate among 9 Provinces. On top of that, the comparison between 1990 and 2000 data indicates a growing gap of literacy rate between urban and rural areas: literacy rate in urban area saw improvement more or less in all Provinces while in rural area not remarkable improvement is observed (except Lusaka Province). The problem of illiteracy lies more common in rural area than urban area.

There is also a significant gap in literacy rate regarding sex, that is, the literacy rate of female population (49.8% in 2000) is much lower than that of male population (61.1%), and no remarkable mitigation of this gap can be seen during the decade with some exceptions (Western Province).

Table 2-3 Literacy Rate (5 years old and above)

	1990					2000				
	Total	Rural	Urban	Male	Female	**Total**	Rural	Urban	Male	Female
Zambia Total	**55.3%**	44.7%	71.5%	61.6%	49.2%	**55.3%**	45.0%	73.5%	61.1%	49.8%
Central	**56.2%**	50.3%	70.0%	61.8%	50.6%	**55.8%**	50.4%	71.8%	60.8%	50.9%
Copperbelt	**69.9%**	53.4%	72.7%	74.2%	65.4%	**70.5%**	52.6%	75.3%	74.3%	66.8%
Eastern	**37.7%**	34.9%	65.8%	45.8%	30.8%	**37.9%**	35.0%	67.1%	45.5%	30.8%
Luapula	**49.4%**	46.5%	64.9%	56.9%	42.4%	**48.4%**	45.3%	68.2%	56.0%	41.2%
Lusaka	**68.6%**	50.3%	72.0%	73.5%	63.6%	**70.1%**	55.0%	73.3%	74.7%	65.5%
Northern	**47.5%**	44.2%	67.3%	55.5%	40.1%	**47.0%**	43.3%	68.7%	55.3%	39.3%
North-Western	**42.4%**	38.3%	66.4%	50.4%	35.1%	**43.4%**	40.1%	67.0%	50.5%	36.6%
Southern	**56.5%**	51.4%	72.5%	61.1%	52.1%	**56.2%**	50.5%	76.0%	60.2%	52.3%
Western	**48.1%**	44.9%	69.3%	54.2%	42.9%	**50.6%**	46.7%	77.9%	55.3%	46.4%

Source: 2000 Census Analytical Report
(Central Statistical Office, October 2004)



Source: Census Atlas 2000
(Central Statistical Office, November 2003)

Figure 2-4 Literacy Rates by District

The level of education is summarized in Table 2-4. In Zambia, 27.2% of the population aged 5 years and above have had no formal education, 25.9% completed lower primary (4 years or less), 24.5% completed upper primary (5-7 years), 10.7% accomplished junior secondary (8-9 years), and 9.0% accomplished senior secondary (10-12 years). Only 1.2% of the population has completed Grade 12 Graduate Certification with A level, and 1.5% completed Bachelor's degree or above. 24.6% of males and 29.7% of females have never had any formal education, and more males have attained secondary school or higher levels than females. There is also a gap in education level between urban population and rural population: about 40% of urban people completed secondary school or higher while less than 13% of rural population had same opportunity.

Table 2-4 Percentage Distribution of Population by Highest Level of Education Attended

	Highest Level of Education							Total
	None	Lower Primary (1 - 4)	Upper Primary (5 - 7)	Junior Secondary (8 - 9)	Senior Secondary (10 - 12)	Grade 12 GCE (A) / Collage / Undergraduate	Bachelors Degree and Above	
Zambia Total	**27.2%**	**25.9%**	**24.5%**	**10.7%**	**9.0%**	**1.2%**	**1.5%**	**100.0%**
Male	24.6%	25.1%	24.3%	11.3%	11.5%	1.3%	1.9%	100.0%
Female	29.7%	26.7%	24.8%	10.1%	6.5%	1.0%	1.2%	100.0%
Rural	**33.0%**	**29.6%**	**25.0%**	**7.6%**	**3.8%**	**0.5%**	**0.5%**	**100.0%**
Male	29.4%	29.0%	26.1%	8.8%	5.4%	0.6%	0.7%	100.0%
Female	36.4%	30.1%	24.0%	6.3%	2.5%	0.4%	0.3%	100.0%
Urban	**16.9%**	**19.5%**	**23.7%**	**16.2%**	**18.0%**	**2.4%**	**3.3%**	**100.0%**
Male	16.1%	18.1%	21.0%	15.6%	22.4%	2.6%	4.2%	100.0%
Female	17.7%	20.8%	26.3%	16.7%	13.7%	2.2%	2.6%	100.0%

Source: Selected Socio-Economic Indicators 2003-2004
(Central Statistical Office, January 2006)

2.7. Poverty and Living Standards

In Zambia, poverty line is set based on the Food-Energy Intake (FEI) approach. The methodology of this approach is to establish a monetary value, at which the predetermined average food energy requirements for normal bodily functions are met, i.e. the minimum intake of 2,094 calories per day per person. People in the Extremely Poor status cannot afford to meet the basic minimum food requirements, even if they allocate all the expenditure on food. Households whose total monthly expenditure is less than K78,223 per adult equivalent at 2004 price level are categorized as “extremely poor”. People who can afford the basic minimum food requirements but cannot afford minimum basic non-food items, such as health, shelter, and education, are categorized as “moderately poor", i.e. K111,747 per adult equivalent. Poverty lines at “extremely poor” and “moderately poor” levels from 1991 to 2004 are summarized in Table 2-5. People whose expenditure exceeds the upper poverty line (or the expenditures on basic minimum food requirements as well as minimum basic non-food items) are categorized as “non poor.

Table 2-5 Poverty Levels

(K/adult/month)

Year	1991	1993	1996	1998	2002	2004
Extremely Poor	961	5,910	20,181	32,861	64,530	78,223
Moderately Poor	1,380	8,480	28,979	47,187	92,185	111,747

Source: Living Conditions Monitoring Survey Report 2004
(Central Statistical Office, December 2006)

Trends of population living in poverty from 1991 to 2004 are summarized in Table 2-6. Poverty ratio saw an improvement recently, dropping from 73% in 1998 to 68% in 2004, after the period of stagnation during 1990s, when the country experienced economic recession triggered by drought and falling copper prices, the country’s main export. In rural area, the poverty ratio dropped remarkably from 88% in 1991 to 78% in 2004, though there was a reverse trend in early 1990s. In urban area, the poverty ratio worsened in 1990s increasing from 49% in 1991 to 56% in 1998, though it improved slightly afterwards, dropping to 53% in 2004, which is considered due to the overall economic recovery in 2000s. The improving trend in rural area and the worsening trend in urban area might be a trade-off caused by the population migration, by which those people in villages who are too poor to earn minimum requirement to sustain their lives settled in so-called peri-urban area.

Broken down by province, the poverty ratio saw an improvement in all Provinces from 1998 to 2004, but the trend between 1993 and 1998 shows a clear contrast among Provinces: considerable worsening is observed in Copperbelt (from 49% to 65%) and Lusaka (from 39% to 53%) Provinces while in other Provinces the poverty ratio improved more or less during the same period, especially in Eastern (from91% to 79%), North-Western (from 88% to 77%), and Southern (from 87% to 75%) Provinces.

Table 2-6 Poverty Trends from 1991 to 2004

			1991	1993	1996	1998	2004
Zambia Total		**Poverty Ratio**	**70%**	**74%**	**69%**	**73%**	**68%**
		Extremely Poor	58%	61%	53%	58%	53%
		Moderately Poor	12%	13%	16%	15%	15%
Rural / Urban	**Rural**	**Poverty Ratio**	**88%**	**92%**	**82%**	**83%**	**78%**
		Extremely Poor	81%	84%	68%	71%	65%
		Moderately Poor	7%	8%	14%	12%	13%
	Urban	**Poverty Ratio**	**49%**	**45%**	**46%**	**56%**	**53%**
		Extremely Poor	32%	24%	27%	36%	34%
		Moderately Poor	17%	21%	19%	20%	19%
Provinces	**Central**	**Poverty Ratio**	**70%**	**81%**	**74%**	**77%**	**76%**
		Extremely Poor	56%	71%	59%	63%	63%
		Moderately Poor	14%	10%	15%	14%	13%
	Copperbelt	**Poverty Ratio**	**61%**	**49%**	**56%**	**65%**	**56%**
		Extremely Poor	44%	28%	33%	47%	38%
		Moderately Poor	17%	21%	23%	18%	18%
	Eastern	**Poverty Ratio**	**85%**	**91%**	**82%**	**79%**	**70%**
		Extremely Poor	76%	81%	70%	66%	57%
		Moderately Poor	9%	10%	12%	13%	13%
	Luapula	**Poverty Ratio**	**84%**	**88%**	**78%**	**82%**	**79%**
		Extremely Poor	73%	79%	64%	69%	64%
		Moderately Poor	11%	9%	14%	13%	15%
	Lusaka	**Poverty Ratio**	**31%**	**39%**	**38%**	**53%**	**48%**
		Extremely Poor	19%	24%	22%	35%	29%
		Moderately Poor	12%	15%	16%	18%	19%
	Northern	**Poverty Ratio**	**84%**	**86%**	**84%**	**81%**	**74%**
		Extremely Poor	76%	72%	69%	66%	60%
		Moderately Poor	8%	14%	15%	15%	14%
	North-Western	**Poverty Ratio**	**75%**	**88%**	**80%**	**77%**	**76%**
		Extremely Poor	65%	76%	65%	64%	61%
		Moderately Poor	10%	12%	15%	13%	15%
	Southern	**Poverty Ratio**	**79%**	**87%**	**76%**	**75%**	**69%**
		Extremely Poor	69%	76%	59%	59%	54%
		Moderately Poor	10%	11%	17%	16%	15%
	Western	**Poverty Ratio**	**84%**	**91%**	**84%**	**89%**	**83%**
		Extremely Poor	76%	84%	74%	78%	73%
		Moderately Poor	8%	7%	10%	11%	10%

Source: Living Conditions Monitoring Survey Report 2004
(Central Statistical Office, December 2006)

Relations between poverty and household characteristics in 2004 are summarized in Table 2-7. Regarding household head, there are more female-headed households below the Poverty Lines (71%) than male-headed ones (66%), and especially household in “extreme poverty” is more prevalent for female-headed ones (57%) than male-headed ones (51%), though the difference might not be too serious. Households headed by an old person are more likely to be below the Poverty Line, especially in “extremely poor” category.

Education level of household head shows strong correlation to the poverty status. Poverty ratio of households headed by a person with no educational background is 81%; among which 70% is categorized in “extremely poor”. On the other hand, poverty ratio of households headed by a person with tertiary education stays as low as 30%, among which 16% is categorized in "extremely poor". The incident of poverty also worsens with the increase of household size. Only 32% of single-person households are living below the poverty line, while the 73% of households with family of six or more members are categorized as living below poverty line. This correlation becomes clearer when the poverty status is limited to "extremely poor".

Table 2-7 Poverty and Household Characteristics in 2004

	Poverty Status				Total Population
	Poor			Non Poor	
	Extremely	Moderately	Total		
Zambia Total	53%	15%	68%	32%	10,898,614
Rural/Urban					
Rural	65%	13%	78%	22%	6,632,709
Urban	34%	18%	53%	47%	4,265,905
Sex of Household Head					
Male	51%	15%	66%	34%	8,815,110
Female	57%	14%	71%	29%	2,106,981
Age of Household Head					
12 – 19	23%	42%	65%	35%	27,716
20 – 29	43%	16%	59%	41%	1,604,459
30 – 59	52%	15%	67%	33%	7,860,620
60 +	66%	12%	78%	22%	1,429,296
Education of Household Head					
None	70%	11%	81%	19%	1,185,678
Primary School	63%	14%	77%	23%	4,781,457
Secondary	43%	17%	60%	40%	4,108,386
Tertiary	16%	14%	30%	70%	846,570
Household Size					
1	22%	10%	32%	68%	112,910
2 – 3	34%	17%	51%	49%	1,280,614
4 – 5	48%	16%	64%	36%	2,914,579
6 +	59%	14%	73%	27%	6,613,988
Province					
Central	63%	12%	76%	24%	1,130,372
Copperbelt	38%	18%	56%	44%	1,650,981
Eastern	57%	13%	70%	30%	1,507,974
Luapula	64%	15%	79%	21%	859,170
Lusaka	29%	19%	48%	52%	1,526,381
Northern	60%	14%	74%	26%	1,400,650
North-Western	61%	15%	76%	24%	649,414
Southern	54%	14%	69%	31%	1,352,699
Western	73%	10%	83%	17%	820,973

Source: Living Conditions Monitoring Survey Report 2004
(Central Statistical Office, December 2006)

Chapter 3

Current Status
of
the Power Sector

Chapter 3. Current Status of the Power Sector

3.1. Policy and Organizations

3.1.1. History of Electrification and Policy

Rural Electrification in Zambia dates back to the colonial period when electricity lines were extended to European settler farmers in rural areas. Since Zambia's independence in 1964, the electrification of district administrative centres has received high priority. As a result, nearly all the district centres have been electrified either through national grid or by isolated grid systems supplied from micro-hydro power stations or diesel generators.

On the other hand, household electrification, especially in rural areas, has not made significant progress due to the high capital costs involved. The wide scatter of the Zambian rural population raises the cost of building distribution lines, especially as most villages are distant from the national electricity grid.

The Government has funded electrification projects from annual national budgets since the early 1980s. However, the funds proved inadequate for the large number of projects embarked upon, which prolonged completion times.

In January 1994, the Government established the Rural Electrification Fund (REF) under the Ministry of Energy and Water Development (MEWD) in order to increase the funding and improve the management of the rural electrification programme. A levy of 3.45% on electricity consumption was introduced and the Ministry of Energy and Water Development was charged with ensuring that the funds allocated to the REF were disbursed in accordance with the best principles of transparency and accountability.

Accordingly in January 1995, MEWD issued the "Guidelines on Selection of Rural Electrification Projects for Funding by Government", which outlined the procedure of selecting projects proposed by Provincial Planning Units for support from the REF. The criteria were in two categories: primary and secondary considerations. The primary considerations consisted of (1) economic aspects, (2) regional distribution, and (3) social aspects. "Economic aspects" were to be evaluated from the aspects of agricultural development potential and the evidence of industrial/commercial growth. "Regional distribution" was also a key factor to ensure that the projects were equitably distributed in the country. "Social aspects" gave due consideration to the electrification of public facilities, such as hospitals, clinics, health centres, schools and community centres.

The secondary considerations comprised (1) technical aspects and (2) willingness of recipients to contribute to the capital cost and the cost of internal wiring. "Technical aspects" were the selection criteria of the most suitable electrification method among all possible options, such as grid extension, micro-hydro, SHS, and diesel. The last criterion, "willingness of recipients" was in intended to avoid supplying electricity to areas where the target communities were unprepared for it. For that reason, preference was given to communities that demonstrated capacity to meet part of the project capital cost and/or a practical willingness to meet the cost of internal wiring of their houses/buildings. Based on these five criteria, MEWD developed a scoring system for ranking projects for funding.

Despite the development of the REF and the adoption of project selection criteria in the mid-1990s, rural electrification did not take off as expected. Although the REF was established as Government Excise Duty collected exclusively for financing rural electrification projects, a portion of the levy was actually diverted to the Government's general-account. In addition, it is often pointed out that the selection criteria were not strictly adhered to. To improve matters, the Rural Electrification Authority (REA) was established in 2004 under MEWD as an independent administrator to manage REF. The main responsibilities of REA are to elaborate annual electrification programs, to implement approved rural electrification projects using the REF, and to monitor the status of projects contracted to institutions/organizations/companies in order to ensure that they fulfil their obligations and perform in accordance with set standards. MEWD / REA with the assistance from JICA undertook the development of Rural Electrification Master Plan (REMP) inline with Zambia's Vision 2030.

3.1.2. Key Players of the Power Sector

The overall responsibility for energy administration and policy formulation lies with the **Ministry of Energy and Water Development** (**MEWD**). The organizational chart of MEWD, focusing on the Department of Energy (DoE) is summarized in Figure 3-1.

The **Rural Electrification Authority** (**REA**) is a statutory body created under the MEWD through the enactment of the Rural Electrification Act No. 20 of 2003. Functions of REA are as follows:

- Administer and manage REF
- Develop, implement and update REMP for systematic electrification of rural area
- Promote utilization of available rural electrification technological options to enhance the contribution of energy to develop agriculture, manufacturing, mining and other economic activities in rural area
- Mobilize funds from within and outside of Zambia to support rural electrification
- Offer, on a competitive basis, the opportunity of rural electrification projects for contractors and developers, and periodically publish information on programs being carried out
- Design and offer, on a competitive basis, smart subsidies for the capital cost of projects to enhance energy supply for development in rural areas
- In conjunction with stakeholders, develop mechanisms of the operation of grid network for rural electrification and other rural energy supply networks
- Finance project preparation studies for rural electrification projects in accordance with guidelines that are developed and approved by the Authority
- Provide recommendations to the Government for the enhancement of access to electricity by the rural population
- Undertake such other activities as are conducive or incidental to the performance of its functions under the Act.

The current organization chart of REA is shown in Figure 3-2. .

The **Energy Regulation Board** (**ERB**), formed through an Act of Parliament of 1995, is responsible for licensing generating plants, regulating transmission and distribution operations, regulating power tariffs, especially retails, and mediating conflicts regarding these issues.

ZESCO Limited,is a vertically integrated public power utility, with the functions of generation, transmission, and distribution. The organizational chart of ZESCO is shown in Figure 3-3. ZESCO owns most of the power stations, transmission lines, and distribution facilities in Zambia, including small hydro and diesel power plants. ZESCO is undergoing commercialisation to improve its performance though the Government still retains 100% stake in the company. ZESCO sells approximately half of its electricity to the Copperbelt Energy Corporation and the remaining half to its own retail customers through its own transmission and distribution networks.

The **Copperbelt Energy Corporation** (**CEC**) is a private power utility that owns and controls small gas power plants, 220kV and 66kV transmission lines, and distribution facilities in Copperbelt Province. CEC used to be a division of Zambia Consolidated Copper Mines (ZCCM) but was separated as a private entity in November 1997. CEC has most of the mining and large industrial customers that are supplied at 66kV or higher voltage in Copperbelt Province as its customers, while small customers within CEC's service area are supplied by ZESCO.

The **Lunsemfwa Hydropower Company Plc** is a private Independent Power Producer (IPP) that owns Mulungushi and Lunsemfwa Hydropower Stations with the total capacity of 38MW. The largest shareholder is ESKOM, the power utility of South Africa, who has 51% of the stake.

In some rural areas where ZESCO's national grids do not cover, small IPP and Non-Governmental Organizations (NGOs) are supplying electricity with either small hydro or diesel power plant through the isolated distribution network. In Eastern Province, there are three **Energy Service Companies** (**ESCOs**) established with the support from international donor agencies. ESCOs are leasing Solar Home Systems to several hundred of households and collecting a fixed monthly fee.

The overall structure of electricity sector in Zambia is summarized in Figure 3-4.

3.1.3. Acts Related to Rural Electrification

There are three main statutes related to rural electrification: Electricity Act (enacted in April 1995 and amended in December 2003), Energy Regulation Act (enacted in April 1995), and Rural Electrification Act (enacted in December 2003).

The **Electricity Act** was enacted to regulate the generation, transmission, distribution, and supply of electricity. This Act was amended in 2003.

The **Energy Regulation Act** was enacted to establish the Energy Regulation Board and to define its functions and responsibilities, and to manage the licensing of undertaking for the production of energy or production or handling of certain fuels.

The **Rural Electrification Act** was enacted to establish Rural Electrification Authority and to define its functions and to provide for matters connected with or incidents to the foregoing.

3.1.4. Policy Related to the Renewable Energy

Currently, firewood and charcoal account for 80% of Zambia's total energy consumption. From the viewpoint of environmental conservation, GRZ has been promoting the efficient use of wood fuels and the reduction of charcoal consumption by 400,000 tonnes by 2010. As a country that imports 100% of the petroleum consumed domestically, the Government recognizes the importance of New and Renewable Sources of Energy (NRSE). The Policies regarding NRSE as stated in the revised National Energy Policy of 2007 are as follows:

- Promotion of the NRSE technology
- Promotion of the wider application of NRSE technology
- Promotion of information dissemination on the use of NRSE
- Promotion of education, research and training in NRSE at various levels

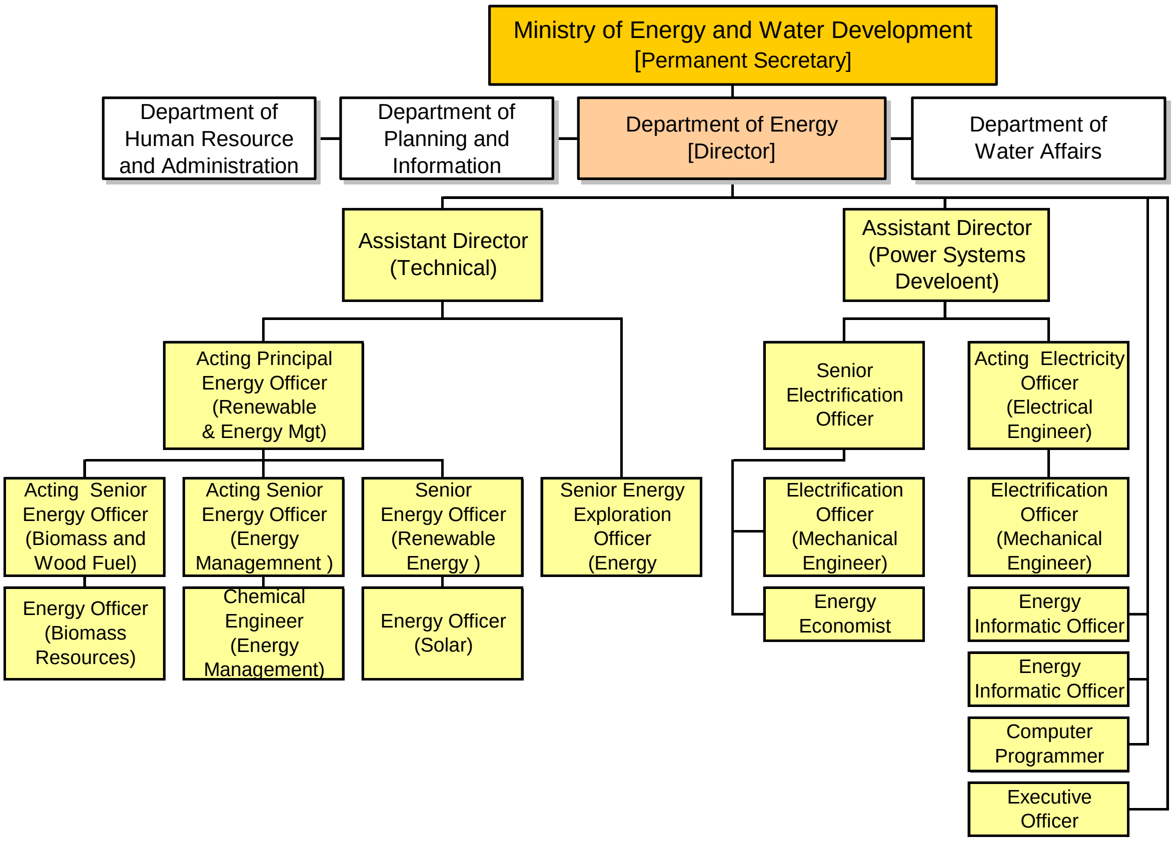


Figure 3-1　Organization Chart of MEWD and DoE

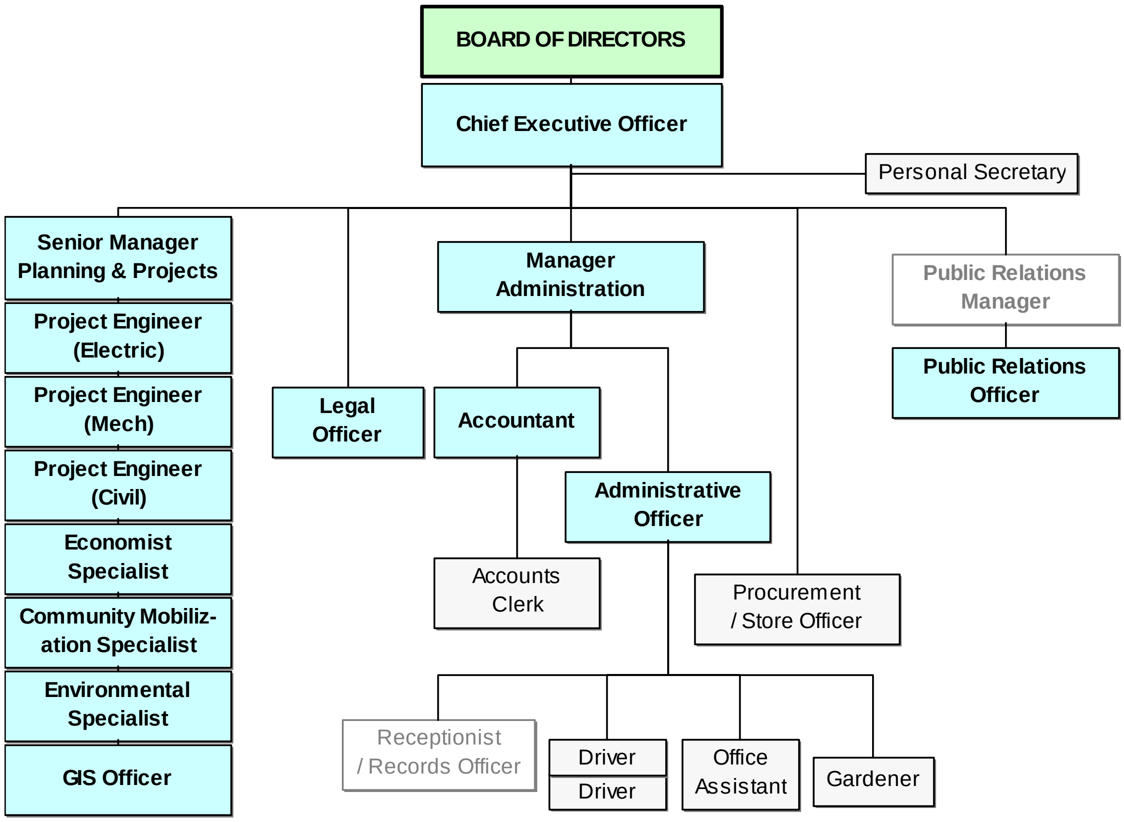


Figure 3-2　Organization Chart of REA

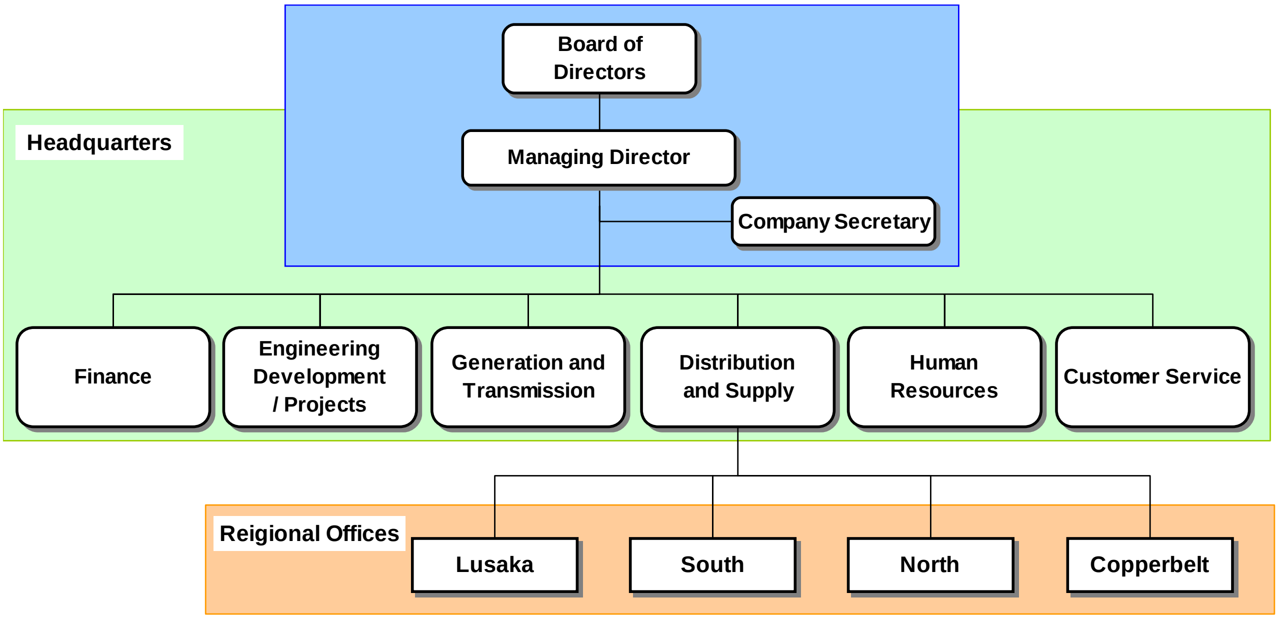
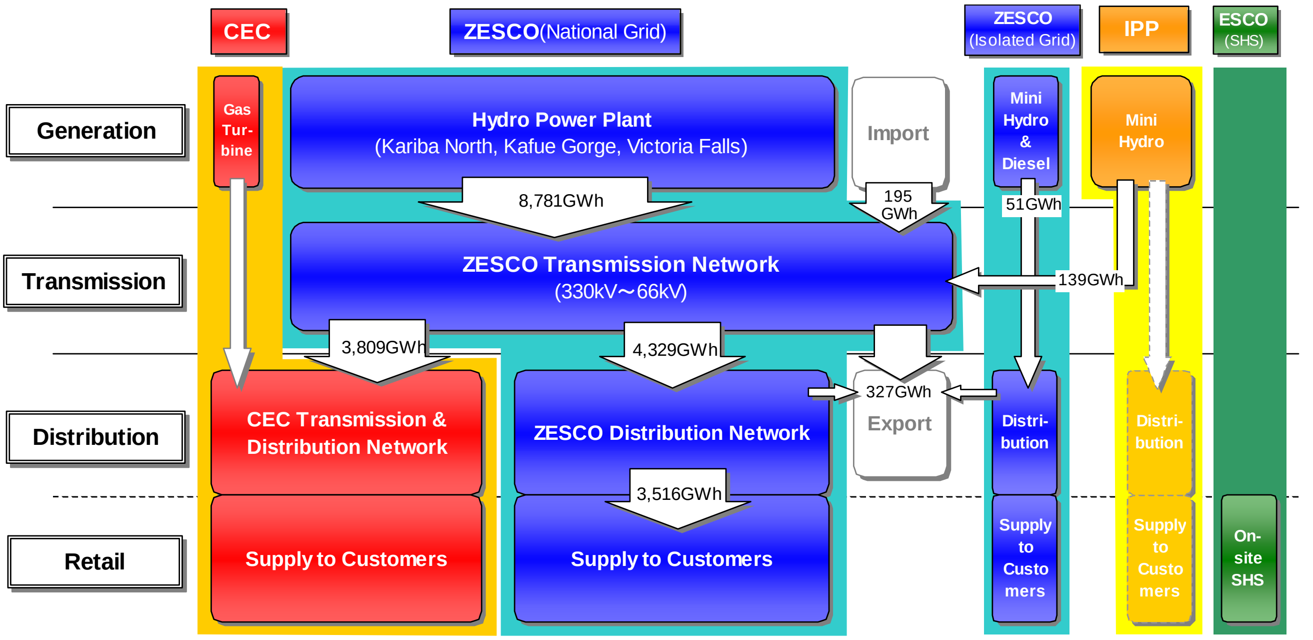


Figure 3-3　Organization Chart of ZESCO



Source：ZESCO Statistical Yearbook of Electricity Energy 2005/2006 [1]

Figure 3-4　Electricity Sector Structure

[1] CEC's "Distribution Network" in Figure 3-4 means electricity supply to customers with high-voltage lines (66kV or higher), not in a narrower sense of distribution lines (33kV or lower).

3.2. Rural Electrification Fund and Its Management

3.2.1. Rural Electrification Fund Scheme in Zambia

ZESCO's customers are obliged to pay Government Excise Duty on their monthly electricity bills. This Excise Duty amounts to 5% of total electricity bill which is broken down as follows: 3% is appropriated for Rural Electrification Fund (REF), which is used to finance rural electrification projects and 2% is for the other Government programs. ZESCO's bulk supply to CEC and exports are exempt from this Government Excise Duty.

The 3% levy was originally established in 1995, but this scheme did not work well for the following reasons:

- Revenues and expenses of REF were not separated from those of the Government's general account budget, thus the disbursements to the REF were delayed.
- MEWD was responsible for selecting rural electrification projects to be financed using REF, but did not have enough capacity to assign its staff to investigate and evaluate the cost and benefit of proposed rural electrification projects and to manage ongoing projects.
- ZESCO was a contractor but at the same time it was responsible for planning and managing of rural electrification projects.

Figure 3-5 is a flow chart illustrating the raising and release of REF. The 5% Excise Duty, is collected by ZESCO on behalf of Government. Ministry of Finance and National Planning (MFNP) appropriates 3% for REF, however the amount allocated to REA as REF does not exactly match this 3%, because REA receives its income based on a budget approved by the Government, and not the exact amount that MFNP receives from ZESCO.

It is expected that once the REMP is finalized REA will be able to attract loans, grants and donations from international cooperating partners to augment the REF.

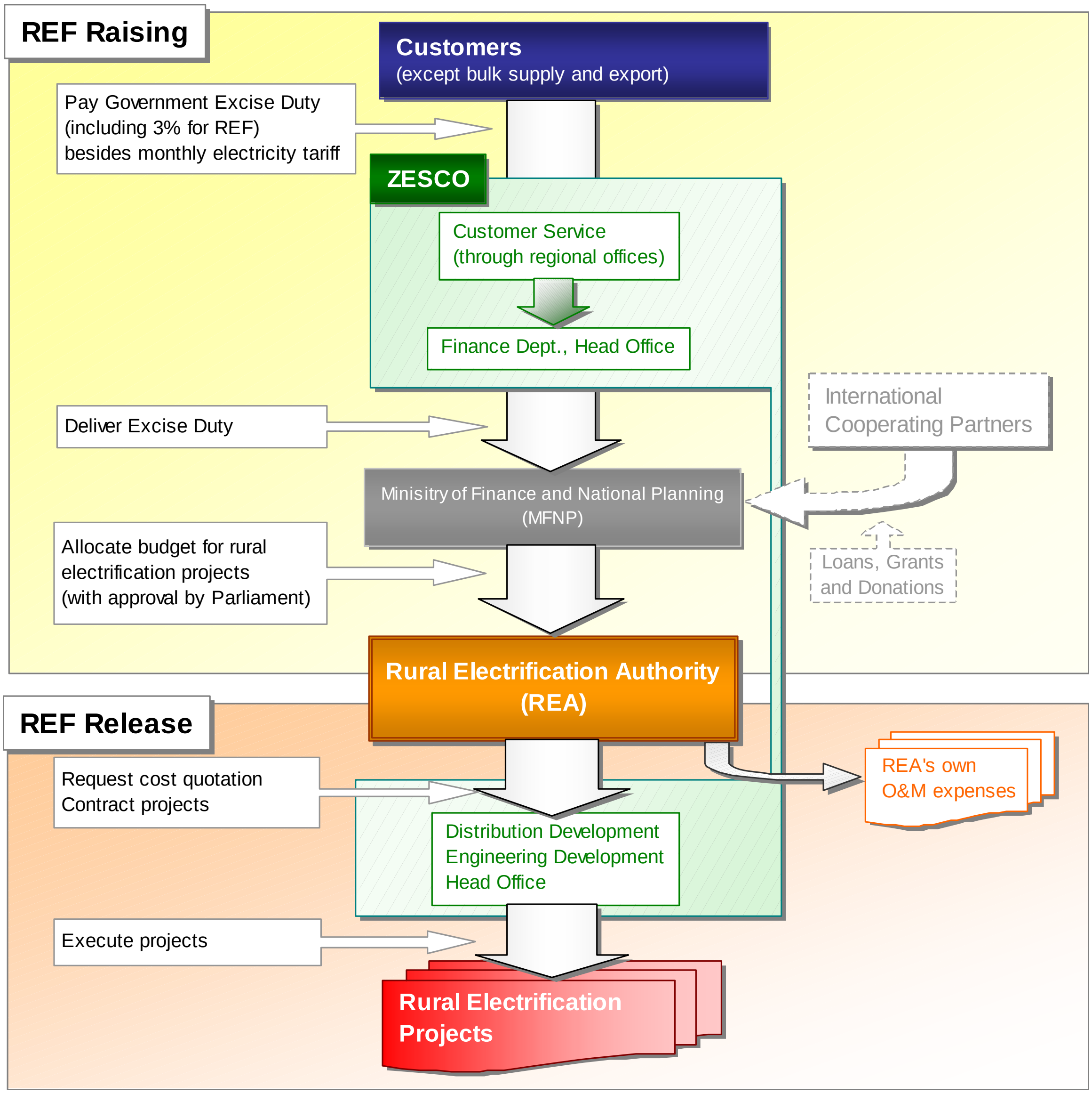


Figure 3-5 Current Flow of Rural Electrification Fund (REF)

3.2.2. REA's Budget

The initial budgetary allocation to REA for the year 2005 was K11.3 billion, which roughly matches the expected REF levy for the year, that is, 3% of ZESCO's revenue from retail sales (K353 billion in FY 2004/05). And according to this budget, REA's expenditure would consist of K1.3 billion for administration and K10 billion for projects. As opposed to this original plan, however, REF release for projects in 2005 was done by MEWD while REA only handled funds for own operation and management.

The first audited accounts of income and expenditure for the year 2005 (from 1st January to 31st December) for REA, together with the pre-audit statement of FY 2004, are summarized in Table 3-1. REA's income for FY2005 was around K5.7 billion, about half of that was originally budgeted, and REF release is not accounted for in this statement[2]. REA's expenditure was about K1.3 billion for its operations and related costs, and the remainder, about K4.4 billion, was carried forward to the next year.

[2] REA had planned its first release of REF in the name of REA by the end of 2005, however, due to the delay in Government approval, it was postponed to 2006.

Table 3-1 REA's Audited Income and Expenditure Account (Jan-Dec 2005)

	(K1,000)		(1,000US$)	
	FY2004	*FY2005*	*FY2004*	*FY2005*
Income	***348,750***	**5,674,053**	***(91.8)***	**(1,493.2)**
Expenditure				
Administration	*156,530*	545,835	*(41.2)*	(143.6)
Personnel	*2,355*	546,398	*(0.6)*	(128.3)
Board Expenses	*50,218*	111,320	*(13.2)*	(29.3)
Movable Assets	*13,597*	75,449	*(3.6)*	(19.9)
Bank Charge	*589*	2,251	*(0.2)*	(0.6)
Miscellaneous	*1,348*	15,145	*(0.4)*	(4.0)
	224,638	**1,296,398**	***(59.1)***	**(341.2)**
Surplus	***124,112***	**4,377,656**	***(32.7)***	**(1,152.0)**

Note: Exchange rate of 1US$ = K3,800 was applied for currency conversion

The gap between REA's initial budget (K11.3 billion) and its actual income (K5.7 billion) is partly, covered by the REF release from the MEWD, which, according to ZESCO's internal report, was about K3.8 billion in 2005 Clearly the gap between the two figures needed to be closed

In 2006, REA took over the full responsibility of managing REF. After the signing the Project Implementation Agreement with ZESCO in May 2006, REA published the list of rural electrification projects to be executed in 2006 (see Table 3-2). In its 2006 budget, K11.66 billion was allocated to REA, of which 90% (K10.44 billion) was released for rural electrification projects. REA's financial statements of FY2006, which covers not only its own administration costs but also the REF release for projects, are still in progress and are expected to be completed by the end of 2007.

Figure 3-6 summarizes the difference between REF levy and REA's budget.

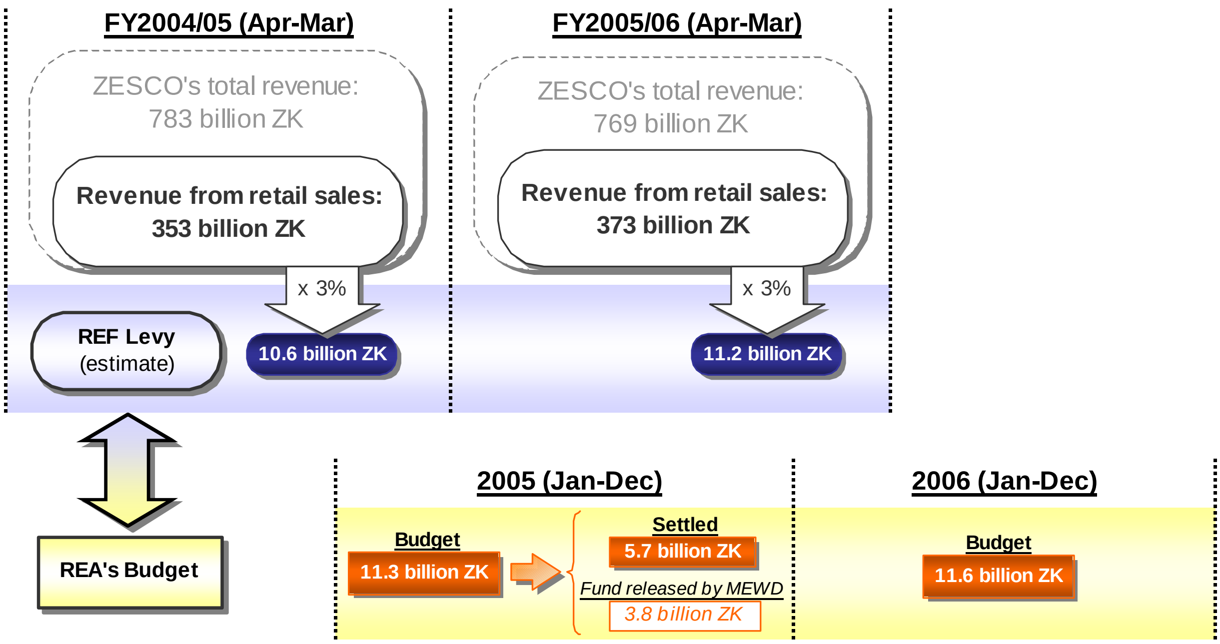


Figure 3-6 Difference between REF Levy and REA's Budget

Table 3-2 Rural Electrification Projects Approved by REA for Implementation in 2006

(K million)

Province	Project Name	Estimate Cost	2006 Allocation
Central	Mungule's Area – Phase 1 Clinic Court & Mutakwa School	920	500
	Mutombe Basic School	250	250
	Nambala High School	443	443
	Serenje's Area Muzamene Basic School	215	215
Copperbelt	Lubendo Basic School	181	181
	Mushili School	175	175
	Kabushi – Phase 1	6,000	500
	Kankoyo	1,231	231
Eastern	Mphamba School	112	112
	Mtenguleni's Area Katinta Basic School, Chipungu RHC & Chankanga Basic School	630	630
	Ndake Area – Ndake Basic School, Court House, Ndake RHC	500	500
	Lumezi	3,424	500
Luapula	Lukwesa High School	87	87
	Bakashiwa Home Care	85	85
	Nsengaila Basic Schools	45	45
	Nshungu Basic Schools	75	75
	Mashitolo Basic Schools	55	55
	Mambilima Mwenge Basic School	62	62
	Lubansa & Kalasa Basic Schools	64	64
	Chabilikila School	80	80
Lusaka	Palabana	200	–
	Mupelekese Area (Schools & Health Centres)	1,200	–
	Luangwa	1,200	–
North-Western	Kamiteto Primary Schools	168	168
	R.Mwepu Primary Schools	67	–
	Kisalala Primary Schools	126	–
	Tumvwananai Primary Schools	9	9
	Kapijimpanga Primary Schools	134	134
	Kaimbwe School	527	–
	Chitokoloki Mission *	N.A.	100
	Zengamene *	N.A.	100
Northern	Chikwanda Basic School, Court House, Market & RHC	100	100
	Luwingu High School	93	93
	Saili Basic School	77	77
	Kaputa to the Grid – Phase 1	12,000	1,000
	Chozi- Waitwika Area	535	535
	Mpumba Basic School & Court House	221	221
	Mulilansolo – Phase 1	2,500	243
	Kafwimbi's Area	784	–
	Chitimukulu RHC & Police Kapolyo Basic And Kanyanta Basic School	543	543
Southern	Sianjalika's Area – School And RHC	73	73
	Sikalongo Mission – Choma	567	–
	Mwanachingala's Area - School And RHC	42	42
	Gwembe Tonga	200	200
	Nansenga Basic Mulawo APU, Kaunga Basic, Kaunga Basic and Malala Basic Schools	250	250
	Choongo's Area – Ntema Basic School	200	200
Western	Shang'ombo – Phase 1	3,500	1,000
	Luampa Mission	760	360
	Sikongo-Phase 1 (Kalabo Basic & Kalabo Farm Training Centre)	7,600	–
	Mwandi B School Royal Court & Market	200	200
	Kaoma to the Grid	N.A.	N.A.
	Lukulu	N.A.	N.A.
Total		**48,512**	**10,439**

Note: "Chitokoloki Mission" and "Zengamene" projects in North-Western Province are micro-hydro projects contracted to private investors, not ZESCO

In FY 2007 REA's total budget was K23.21 billion, whose source consisted of the REF levy (about K13 billion) and additional Government funding amounting to about K10 billion. According to REA, 78% (about K18 billion) of the budget would be allocated to rural electrification projects (16 grid extension projects, 1 pre-feasibility study for a mini hydro, and 2 solar panel installation projects, refer to Table 3-3), and the remaining 22% (about K5 billion) for REA's administrative costs. ZESCO was expected to undertake 7 projects out of the 16 grid extension projects (including the continuation of 4 ongoing projects), while the remaining 9 projects were expected to be carried out by private entities on a turnkey basis. The selection of private entities to undertake the projects (9 projects are grouped into 5 lots) would through a tender process,.

Table 3-3 Rural Electrification Projects Approved by REA for Implementation in 2007

Province	District	Project Name	Note
Central	Chibombo	Mungule's Area – Phase II (Mungule Clinic & Court and Mutakwa School)	Grid extension by ZESCO
Central	Chibombo	Moombo Clinic & School	Grid extension by private sector (Lot-1)
Central	Chibombo	Kayosha Basic School & Rural Health (RH) Centre	Grid extension by private sector (Lot-1)
Copperbelt	Mpongwe	Machiya Basic School, RH Centre & GRZ Offices	Grid extension by private sector (Lot-2)
Eastern	Chipata	Undi RH Centre, Undi School & Local Court	Grid extension by private sector (Lot-3)
Eastern	Lundazi	Mwase	Grid extension by private sector (Lot-3)
Eastern	Chama	Chama	Grid extension by ZESCO
Luapula	Mansa	Mutiti, Chimfula, Kalaba, Lupende & Chibinda	Grid extension by private sector (Lot-4)
Luapula	Milenge	Pre-feasibility Study for a Mini-hydro at Mumbotuta Falls	Pre-FS for mini-hydro
Lusaka	Kafue	Chipapa School & Clinic	Grid extension by private sector (Lot-1)
North-Western	Kasempa	Kaimbwe School	Grid extension by ZESCO
North-Western	Kasempa	Selauke School & RH Centre	Grid extension by private sector (Lot-2)
Northern	Kaputa	Kaputa to the Grid – Phase II	Grid extension by ZESCO
Northern	Chinsali	Muliansolo – PhaseII	Grid extension by ZESCO
Southern	Sinazongwe	Gwembe Tonga: Ngoma Basic School & RH Centre	Grid extension by private sector (Lot-5)
Western	Kaoma	Luampa Mission	Grid extension by ZESCO
Western	Kalabo	Sikongo – Phase II	Grid extension by ZESCO
Luapula	Samfya	Rural Solar Energy Systems	Solar panel installation in partnership with UNIDO
Various Areas		Solar Energy Systems	Continuition of ongoing projects

3.2.3. The Way Forward

An important observation regarding REA's accounting system was that it consisted only of cash accounting. Thus no distinction was made between capital expenditure and operating expenses, a system typical of Government financial reporting. There were no "balance sheets" or "profit and loss accounts" which could be used to assess the effectiveness of the capital expenditures .

According to the policy of REF, funds released for rural electrification projects to ZESCO (or other contractors if any) were treated as grants. REA did not account for these releases as "assets", which should be recorded by ZESCO as "Capital Grants and Contributions" (= liabilities) in its balance sheet. Similarly ZESCO, did not keep maintain separate accounts of the fixed (tangible) assets that acquired through the REF. Thus no information at all was available on the performance of the rural electrification schemes. In cases where revenues from such REF schemes fell short of the operating cost, the losses were generally covered by ZESCO's total revenue without clear distinction. The Study Team recommends that REA, which is responsible not only for each year's fund allocation but also for monitoring the performance of released REF, should consider developing "balance sheet" and "profit and loss account" of REF schemes in close coordination with ZESCO, in order to improve the monitoring of the effectiveness of the Fund.

3.2.4. Rural Electrification Programme in Kenya

Kenya's Rural Electrification Programme (REP) is an example of more advanced and established scheme of rural electrification than Zambia's in that Kenyan scheme can provide statistical data regularly that are useful for monitoring its performance.

REP in Kenya was established in 1973 under the agreement between the Government of Kenya and East African Power & Lightning Company, predecessor of the existing Kenya Power & Lighting Company Limited (KPLC). The REP is funded through the Government, whose fund source is not only REP levy collected by KPLC (5% on "all electricity consumed in the country") but also donor-funding that is usually financed as project-based. Its conspicuous difference from Zambian scheme is the ownership of facilities. Under the Kenyan scheme, any property acquired by REP remains the property of the Government even after the completion of construction works, and KPLC, which is virtually the monopoly in transmission and distribution, only acts as a management agent to contract distribution lines extension and electricity supply on behalf of the Government. KPLC provides the customers of REP with same services as KPLC's own customers, that is, the same electricity tariff is applied universally whether it's for REP customers or KPLC's own customers.

Financial statements ("balance sheet" and "profit and loss accounts") of REP are compiled by KPLC staff, but separately from those of KPLC. These financial statements are reported to the Government (Ministry of Energy), who audits them with the support of hired external auditors.

REP's operational and financial performances are summarized in KPLC's annual report.

Table 3-4 shows the number of customers under REP scheme and the electricity sold to them. The number of customers as of June 2006 is about 110,000, or about 16% of KPLC's own customers, and the electricity sales is 186 GWh, about 4% of KPLC's own electricity sales that include large industrial customers. Both the number of customers and the electricity sales have grown by 54% for the past 5 years, which is a little higher than those of KPLC's own customers respectively.

Table 3-4 Number of Customers and Electricity Sales (Kenya's REP Scheme)

		2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	FY05/06 against FY00/01
Customers	**REP**	**71,718**	**78,941**	**87,175**	**93,442**	**101,789**	**110,724**	**154%**
	KPLC	465,361	514,680	556,099	592,752	633,355	691,525	149%
Electricity Sales (GWh)	**REP**	**121**	**130**	**147**	**150**	**164**	**186**	**154%**
	KPLC	3,091	3,498	3,654	3,940	4,200	4,420	143%

Source: KPLC Annual Report Note: Statistics of KPLC exclude REP scheme

Table 3-5 shows the profit and loss account of REP. The REP scheme has been in the red, but the loss margin has shown improvement recently, from –115% in FY2001/02 to –53% in FY2005/06. The book value of REP's assets as of June 2006 is 8,277 million KSh, about 20% of KPLC's own assets (38,729 million KSh). The ratio of annual net loss against assets generates an indicator similar to return on assets (ROA), which was around –10% for the past 3 years . This operating loss belongs to the Government thus the levy is also used for compensating for the operating loss of REP.

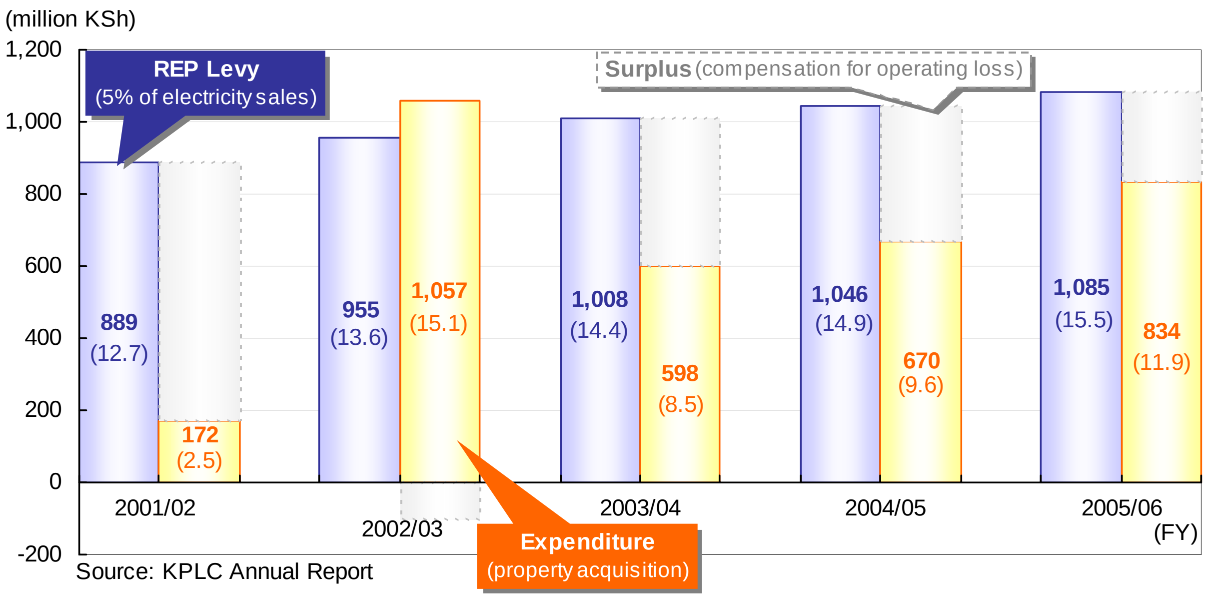
Table 3-5 "Profit and Loss Account" and "Assets" of Kenya REP

(million KSh) *(million US$)*

	2001/02	2002/03	2003/04	2004/05	2005/06	*2005/06*
Revenue from Electricity Sales (A)	**979**	**1,006**	**978**	**1,208**	**1,539**	***22.0***
Operating Cost (B)	2,103	1,932	1,681	1,912	2,347	*33.5*
Net Operating Loss (C) = (A)-(B)	**-1,124**	**-927**	**-703**	**-704**	**-808**	***-11.5***
(C) / (A)	-115%	-92%	-72%	-58%	-53%	*-53%*
Assets (D)	**5,777**	**6,694**	**7,066**	**7,634**	**8,277**	***118.2***
(C) / (D)	-19%	-14%	-10%	-9%	-10%	*-10%*

Source: KPLC Annual Report
Note: Exchange rate of 1US$ = 70KSh is applied for currency conversion

Figure 3-7 shows the balance between REP levy, i.e.5% of electricity sales collected by KPLC, and expenditure for property acquisition (capital expenditure for REP projects) under this scheme.



Note: Numbers in parentheses are the values in million US$ (1US$ = 70KSh)

Figure 3-7 Levy and Expenditure of Kenya REP Scheme

These numbers conceptually corresponds to Figure 3-6 in Zambia's case. As seen in the chart, annual expenditure for projects is less than the collected levy except in FY2002/03, and the surplus is reserved for compensating for REP's operating loss.

According to MoE and KPLC, REP's assets will be transferred to KPLC in the future when the assets become as profitable as KPLC's own, but so far no asset transfer has been made or even discussed.

This Kenyan scheme also has drawbacks, especially in that REP's operation is excluded from KPLC's financial performance, thus little incentive may be imposed to KPLC to improve the profitability than in Zambia's case, where the ownership of assets is transferred to ZESCO once the construction works are completed and ZESCO has to take the responsibility to improve profitability[3]. However, Zambia's rural electrification scheme, which is still at the very early stage to grasp its financial status, has a lot to learn from the scheme of other countries like Kenya, where at least the tools for monitoring the performance of rural electrification projects are considerably developed.

3.3. Power Supply and Demand

3.3.1. On-grid Power Plants

(1) ZESCO's Major Hydropower Plants

ZESCO owns three large hydropower plants, and on all of them major works were under way under a Power Rehabilitation Project (PRP). Table 3-6 shows the details of the major hydropower plants. In FY 2004/05, they generated in total 8,816GWh, which almost matches the electricity consumption in Zambia.

Table 3-6 Three Major Hydropower Plants in Zambia

Name of Power Station		Kariba North Bank	Kafue Gorge	Victoria Falls
Number of Units		4	6	14
Original Installed Capacity		600MW	930MW	108MW
Available Capacity (Mar.2007)		510MW	750MW	108MW
Expected Capacity after Rehabilitation		720MW	990MW	108MW (Completed)
Electricity Generation	FY2001/02	2,886GWh	5,570GWh	602GWh
	FY2002/03	2,790GWh	4,806GWh	448GWh
	FY2003/03	3,158GWh	4,668GWh	354GWh
	FY2004/05	3,644GWh	4,073GWh	269GWh
	FY2005/06	3,661GWh	4,619GWh	537GWh
	FY2006/07	3,949GWh	5,034GWh	674GWh

Source: ZESCO Annual Report

(a) Kariba North Bank Power Station

Kariba North Bank Power Station (KNB-PS), which is located in Southern Province, was commissioned in 1976. KNB is connected with Leopards Substation via 330kV transmission lines. This power station used to belong to the Kariba North Bank Company Limited (KNBC), a company in which the Government had 100% stake and sold all of its electricity generation to ZESCO. In June 2004 the KNBC was formally integrated with ZESCO .

KNB-PS consists of four 150MW units each. The rehabilitation works for Units 1 and 2 were finished in 2005, and the unit outputs of these 2 units were upgraded to 180MW each. The rehabilitation works for unit 3 and 4 were also scheduled for completion from 2007 and 2008, increasing their outputs to 180MW as well. Thus the total capacity of KNB-PS will be increased to 720MW after the completion of rehabilitation works.

[3] In fact, KPLC is obliged to improve the profitability of REP to a certain extent by promising to achieve numerical targets regarding rural electrification, as a part of the Performance Contract agreed between the Government and power utilities (in this case, KPLC), that are also state-owned companies, at the beginning of every fiscal year. Achievement of the numerical targets is monitored by the Government for evaluating the performance of power utilities, which, according to the Government, may also affect the managers' remuneration.

(b) Kafue Gorge Power Station

Kafue Gorge Power Plant (KG-PS), located in Southern Province bordering on Lusaka Province with Kafue River, is the biggest power plant in Zambia. KG-PS is connected to Leopards Hill Substation via 330 kV transmission lines. The six-150MW-units power station have been the central pillar of Zambia's power supply since its inauguration in 1971. The rehabilitation works at Units 3 and 4 were completed at the end of FY2005/06. It was planned to rehabilitate, the rest of the units by 2008. After the rehabilitation, the unit output will be increased to 165 MW, raising the total plant capacity to 990MW.

(c) Victoria Falls Power Station

Victoria Falls Power Station (VF-PS), which is located in Southern Province, was commissioned in 1938. This hydropower station consists of 3 groups of turbines that are called "Station A", "Station B" and "Station C" respectively. Station A has two 1MW units and two 3MW units (8MW in total), Station B has six 10MW units (60MW), and Station C has four 10MW units (40MW). The total output of these fourteen units of VF-PS is 108 MW. With the completion of rehabilitation works in FY2005/06, VF-PS recovered its original available capacity. VF-PS is connected to Muzuma Substation via 220 kV transmission lines.

(2) ZESCO's Small Hydropower Plants

Table 3-7 shows ZESCO's four small hydropower plants.

Table 3-7 ZESCO's Small Hydropower Plants

Name		Lusiwasi	Musonda	Chishimba	Lunzua
Province		Central	Luapula	Northern	Northern
Installed Capacity		12MW	5MW	6MW	0.75MW
Available Capacity (Mar.2007)		9MW	5MW	5MW	0.75MW
Number of Units		3MW x 4	1MW x 5	1.2MW x 4 0.3MW X4	0.25MW x 3
Electricity Generation	FY2001/02	9.8GWh	17.7GWh	5.5GWh	2.0GWh
	FY2002/03	15.7GWh	15.8GWh	7.0GWh	2.7GWh
	FY2003/03	17.7GWh	15.4GWh	16.6GWh	1.1GWh
	FY2004/05	13.7GWh	17.2GWh	16.9GWh	1.7GWh
	FY2005/06	3.7GWh	17.0GWh	16.3GWh	1.7GWh
	FY2006/07	33.8GWh	16.0GWh	11.9GWh	1.4GWh

Source: ZESCO Annual Report

Lusiwasi HP is synchronized to the grid. The other three HPs are also connected to the grid via transmission line, but since they do not have synchronizer they must be isolated from the grid by circuit breakers. ZESCO planned not only to synchronize these three HPs to the grid by but also to renovate and increase their capacities. Details of these expansion plans are given in Chapter 8.

(3) Generating Facilities of Other Private Companies

(a) Lunsemfwa Hydropower Company

Lunsemfwa Hydropower Company (LHPC) is an independent power producer (IPP),. The largest shareholder of LHPC is ESKOM, the power utility of South Africa with a 51% stake. LHPC owns two Hydropower Stations, namely, Lunsemfwa Hydropower Plant (18MW) located in Mkushi District and Mulungushi Hydropower Plant (20MW) in Kabwe District. LHPC sells all its electricity to ZESCO under a long term Power Purchase Agreement (PPA). LHPC's electricity supply to ZESCO was 225GWh in FY2004/05 and 139GWh in FY2005/06, representing 2.7% and 1.6% of the total supply in Zambia.

The Zambian Government plans to of liberalize the electricity market so that IPPs such as LHPC can supply electricity directly to large customers through ZESCO's transmission lines.

(b) Copperbelt Energy Corporation

Copperbelt Energy Corporation (CEC) buys electricity from ZESCO on a long-term PPA to supply its customers, mostly the mining companies on the Copperbelt, . CEC's power demand constitutes about half of Zambia's total electricity demand, and its power system, wheels power export from DR Congo to Zimbabwe and South Africa. The CEC system handles about 70% of the electricity running through Zambia's national grid.

CEC operates an 80 MW emergency gas turbine station and the transmission and distribution networks consists of 808 kilometres of overhead lines and 36 high voltage substations. Table 3-8 gives the details of CEC's four emergency gas turbines.

Table 3-8 CEC's Gas Turbines

Name	Bancroft	Luano	Maclaren	Kankoyo
Installed Capacity	20MW	40MW	10MW	10MW
Available Capacity	20MW	40MW	10MW	10MW
Number of Unit	2	2	1	1
Unit Capacity	10MW	20MW	10MW	10MW
Generation (FY2005)	310kWh	677kWh	422kWh	303kWh

Source: CEC

(c) Konkola Copper Mines

Konkola Copper Mines (KCM) owns a 20MW Nkana Gas Thermal Power Plant located in Kitwe District, Copperbelt Province. KCM is the leading copper mining company in Zambia and purchases electricity from CEC while its own Nkana Gas thermal Power Plant is maintained as an emergency standby facility.

3.3.2. Off-grid Power Plants

(1) Off-grid Power Generation in Zambia

Off-grid power generation plays an important role of supplying electricity to areas that are remote from the national grid. A possible mode of electrifying these areas is power supply through isolated small distribution networks, called "micro-grids". These may be powered by diesel or hydropower plant. However, in some areas where even an isolated grid is not economically viable, a solar home system (SHS) is another alternative electricity supply, Details of this are discussed in Chapter 9.

The Zambian Government has shown strong interest in the research and development of renewable energy sources, such as biomass and geo-thermal, as sustainable means of electricity supply in remote areas.

(2) Diesel Generation

ZESCO has diesel power plants in some remote areas, and about half of them are located in North-Western Province. Table 3-9 shows the list of these diesel power plants. Taking into account the high cost of fossil fuels and their negative impact on the environment, these diesel power plants are unsustainable. ZESCO had plans to replace them by connecting to the national grid or with renewable energy sources such as micro-hydro. Along these lines, Kaoma diesel power plant in Western Province and Kasempa diesel power plant in North-Western Province ceased operations following the connection of their supply areas to the national grid. In FY2004/05, the sales revenue by diesel generation was only K1,319 million, which was only 6% of their fuel cost of K20,844 million.

Contrary to this general trend, however, some new diesel power plants have been installed and inaugurated recently, which is in line with the Government's policy to electrify all the 72 District Administrative Centres (DAC). This is the only feasible means of supplying DACs that are too remotely located from existing distribution lines. Examples are the Chavuma diesel power plant that started commercial operations in FY2004/05, followed by Shang'ombo diesel power plant in Western Province, which was under construction at the time of reporting and was expected to start operations in January 2007.

Table 3-9 ZESCO's Diesel Power Plants

Name	Province	Capacity	Generation (FY2006/07)
Chama	Eastern	263kW	828MWh
Luangwa	Lusaka	732kW	756MWh
Kaputa	Northern	486kW	1,196MWh
Mwinilunga	North-Western	1,430kW	2,729MWh
Kabompo	North-Western	1,560kW	2,599MWh
Zambezi	North-Western	800kW	2,075MWh
Chavuma	North-Western	690kW	688MWh
Mufumbwe	North-Western	320kW	933MWh
Kasempa (operation suspended)	North-Western	530kW	N.A.
Kaoma (operation suspended)	Western	2,620kW	N.A.
Lukulu	Western	512kW	1,140MWh

Source: ZESCO Annual Report

(3) Micro-Hydro Power Generation

There are many micro hydropower plants owned and managed by local community or local residents especially in remote areas of Zambia. These HPs supply electricity to some specific place or areas via isolated micro-grids. Details of these micro HPs are described below. The information on micro HPs is scanty and unreliable. It is possible that there are more micro HPs than indicated by the data from either DoE or REA.

(a) Zengamina Hydropower Plant

Zengamina HP is located 95km north of Mwinilunga District centre, North-Western Province. It uses the water of Zambezi River for power generation, and a 700 kW cross-flow turbine manufactured by Ossberger was installed. The plant started commercial operation in July 2007, supplying electricity to a hospital, clinics, schools, small business and households in Ikelenge RGC and Nyakaseya RGC.

Zengamina Power Company owns and operates this Power Plant. The company offers two types of electricity tariffs to its customers. One is a prepaid-fixed charge of 10US$ per month for which the maximum current is limited at one ampere. The other is commodity charge, which consists of 12.5US$ per month for basic charge and 11US Cents per kWh for electricity usage. Zengamina also plans to adopt another option of cheaper 8US Cents tariff for electricity usage from midnight to 6:00 AM, and for community services like the hospital. The connection fee is fixed at 65US$ for low-end customers, rising to 200US$ for a three phase metered connection. These tariffs are quite different from those of ZESCO. Zengamina HP reasons that its low connection fee enables many customers to afford a connection, while the high electricity charge encourages them to use electricity carefully.. In the micro-grid system such as Zengamina HP, limited electricity must be supplied to as many people as possible. Therefore, this type of tariff is suitable for a rural electrification program.

Nevertheless, these two RGCs have quite large potential demand, and Zengamina Power Company expects that the demand will exceed the maximum capacity of Zengamina HP in eight years. In anticipation of this, there are plans to construct a new 1,000kW hydropower plant upstream of the existing scheme, including a storage dam (this site was visited by the Study Team and is described in Chapter 8 of this report). Furthermore, the storage dam to be installed at the upper site could enhance the efficiency of water usage, allowing the existing Zengamina HP to use more water for power generation. There are also plans to install the second turbine-generator unit with another 700 kW capacity at the existing Zengamina HP, where the first and end section of second penstock and a bed for second turbine have already been installed. Figure 3-8 shows pictures of Zengamina HP.

a) Weir

b) Silt basin and water channel

c) Penstock and powerhouse

d) Turbine

e) Switchyard

f) Office

Figure 3-8 Pictures of Zengamina Hydropower Plant

(b) Nyangombe Hydropower Plant

Nyangombe HP is located about 15 km southeast of Mwinilunga District centre, North-Western

Province. In use is a Cross-flow turbine manufactured by Ossberger with a maximum capacity of 73kW . The plant is owned by the corporative of local residents at Nyangombe and is operated by the resident engineer. The electricity is supplied only to the institution, hammer mill and residences at Nyangombe, and it is not used for commercial purpose. Figure 3-9 shows pictures of Nyangombe HP.

a) Place of the resident

b) Water channel

c) Powerhouse

d) Turbine

Figure 3-9 Pictures of Nyangombe Hydropower Plant

(c) Sachibondu Hydropower Plant

Sachibondu HP is located about 25km north of Mwinilunga District centre, North-Western Province. This operation is a 15 kW Cross-flow turbine, owned and operated by a mechanic at the corporative of local residents, and there are no commercial sales, as it is solely for own use.

(d) Lwawu Hydropower Plant

Lwawu HP is located very close to the border with Republic of Angola, about 45 km west of Mwinilunga District centre, North-Western Province. Its generation capacity is 50 kW. Lwawu Mission owns and manages this plant to supply electricity to the institution, a hammer mill and to the residents.

(e) Mutanda Hydropower Plant

The Technology Development and Advisory Unit (TDAU) of the University of Zambia installed 2.5 kW micro-hydro turbine in early 1990s at Mutanda Centre, situated 35 km west of Solwezi, North-Western Province. This power plant was on the Mapunga River and used to supply electricity to a hammer mill, a compressor and a generator. However the supply was inadequate for the ever-increasing local demand. Hence TDAU and Mutanda Evangelical Centre conducted the Pre-investment study on the expansion of the capacity up to 200 kW in 2001. However, this plan was superseded by a 33 kV connection to the national grid.

(f) Mporokoso Hydropower Plant

Mporokoso HP is located in the Mporokoso District centre, Northern Province. This plant is designed and manufactured by a local citizen. The water from a nearby swamp has been dammed by rocks, and then transferred to a turbine via water channel made from cut drums. The turbine is also made from scrapped wheels and drum cut in the shape of runner blade. The flush of water passes through the lower side of horizontal-shaft-type turbine, so this turbine can be categorized as a kind of undershot water wheel. The maximum output is about 5 kW, and the electricity is consumed mainly by the owner, but he also sells electricity to neighbours through a battery charging service. Figure 3-10 shows pictures of Mporokoso HP.

a) Weir

b) Head pond

c) Penstock and turbine

d) Wiring

Figure 3-10 Pictures of Mporokoso Hydropower Plant

(g) Luena River Hydropower Plant

Luena River Hydropower Plant is located about 70 km northwest of Kaoma District centre, Western Province, in Mayukwayukwa Refugee Settlement. This HP is owned and managed by UNHCR (Office of the United Nations High Commissioner for Refugees), and supplies electricity free of charge to 64 households in the settlement. The capacity of Italian Propeller turbine was 24 kW, but its capacity has reduced with age. The plant is operated and maintained by two engineers (mechanical and electrical) trained by the turbine manufacturer. The UNHCR meets all the Operation and Maintenance costs. Figure 3-11 shows pictures of Luena River HP.

a) Households in the refugee settlement

b) Weir

c) Water channel and powerhouse

d) Turbine

Figure 3-11 Pictures of Luena River Hydropower Plant

(h) Mangongo Hydropower Plant

Mangongo Hydropower Plant is located in Mangongo Mission, about 35 km northeast of Kaoma District centre, Western Province. Mangongo Mission owns this 17 kW hydropower plant and supplies electricity to the church, clinic, and 54 households. Public facilities are exempted from electricity charges, but the households pay a flat-rate electricity charge of K10,000 per month. Figure 3-12 shows pictures of Mangongo HP.

a) Head pond

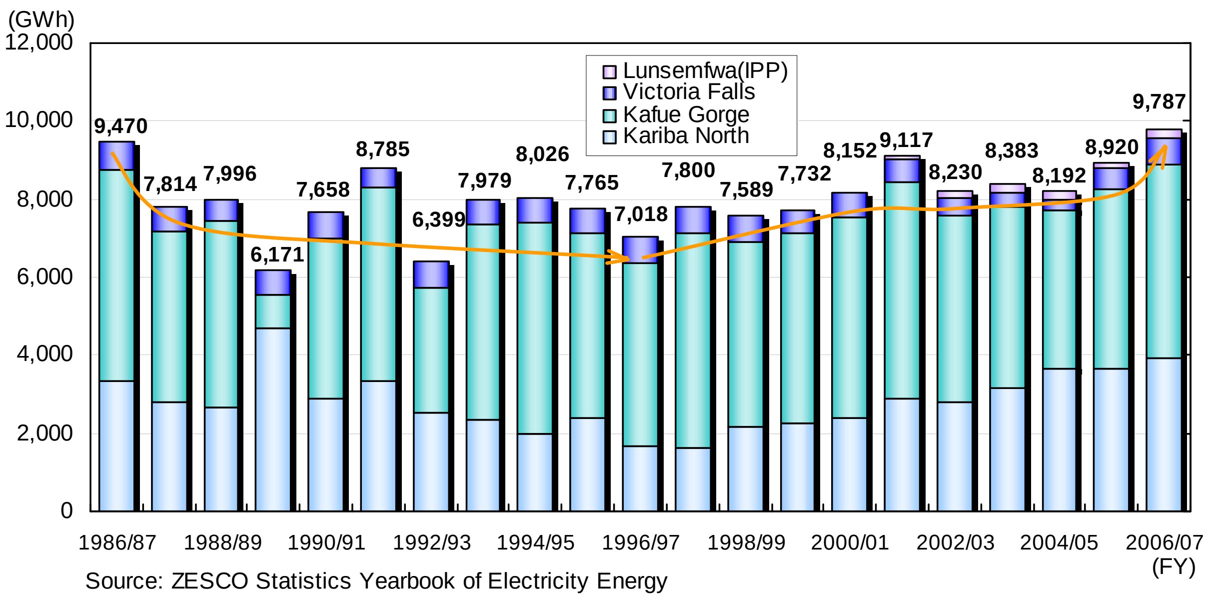
b) Spill stream and powerhouse (left side)

Figure 3-12 Pictures of Mangongo Hydropower Plant

3.3.3. Supply and Demand Balance (National Grid)

After about a decade's slump from mid 1980s, total electricity generation has been gradually recovering since 1997, when ZESCO started the implementation of the Power Rehabilitation Project (PRP) at Kariba North Power Station (installed capacity: 660MW, upgraded from original 600MW), which is in a few years followed by PRPs at Kafue Gorge (installed capacity: 900MW) and Victoria Falls (installed capacity: 108MW) Power Stations. Since FY 2000/01 these power stations have steadily sent out more than 8,000GWh per year. The increase of power generation from FY2004/05 (8,192GWh) to FY2006/07 (9,787GWh) is mainly due to the completion of some rehabilitation works of hydropower stations.

Lunsemfwa Hydropower Company, which owns Mulungushi (20 MW) and Lunsemfwa (18 MW) hydropower stations and is currently the sole IPP to sell electricity to ZESCO's national grid, accounts for less than 3% of the electricity supply countrywide.



Source: ZESCO Statistics Yearbook of Electricity Energy

Figure 3-13 Electricity Generation (sent out to national grid)

Total domestic electricity consumption on ZESCO's national grid (bulk deliveries, including distribution loss) changed little through the 1990s, when the small increase of electricity consumption in ZESCO's distribution system was offset by a decline of power demand of the copper mining industry currently supplied by CEC. In 2000 consumption started growing rapidly due to the recovery of mining industry. In the six years from FY2000/01 to FY2006/07 national electricity consumption increased by about 34% from 6,724 GWh to 8,421 GWh

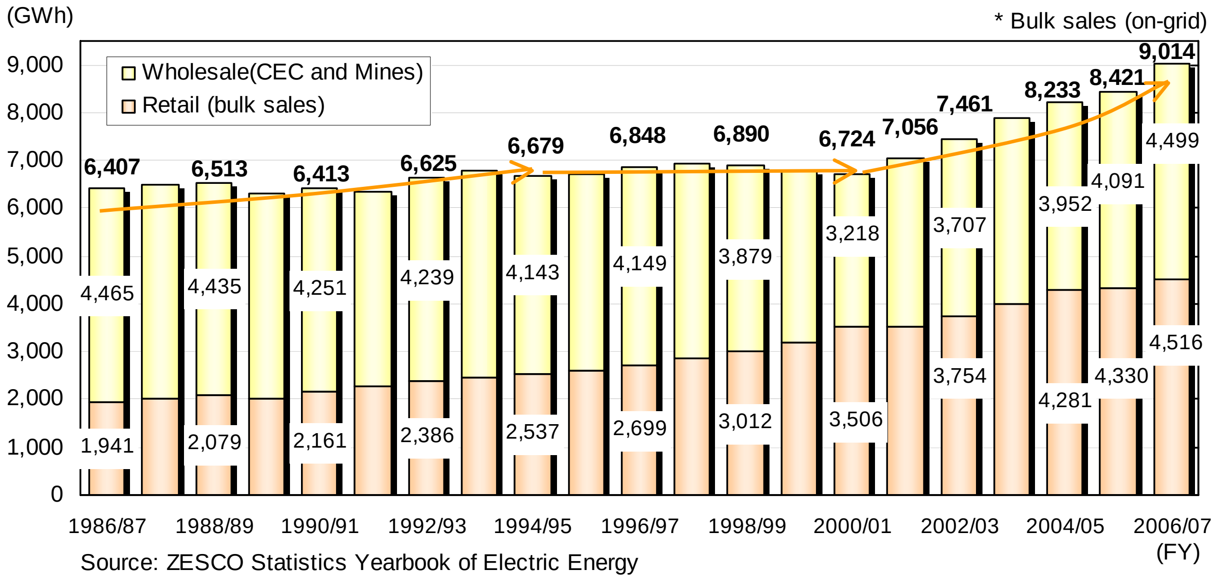


Figure 3-14 Domestic Electricity Consumption

Figure 3-15 illustrates the balance between electricity supply and demand. Until early 1990s annual power generation in general overwhelmed domestic consumption, and this allowed Zambia to be a regional power exporter . This excess became smaller and imports began to increase in the 1990s, though the balance varied year-by-year depending mainly on the availability of generation plant. In the 2000s, as the domestic electricity consumption started increasing rapidly, the supply-demand balance has become tighter still. The Power Rehabilitation Projects and new generation projects, namely Kafue Gorge Lower Hydroelectric Power Project (750MW), Kariba North Power Station Extension Project (300MW), and Itezhi-tezhi Hydropower Project (120MW), when completed, were expected to mitigate this situation, However, if demand continues go grow at the current pace, the the supply-demand balance could be even tighter..

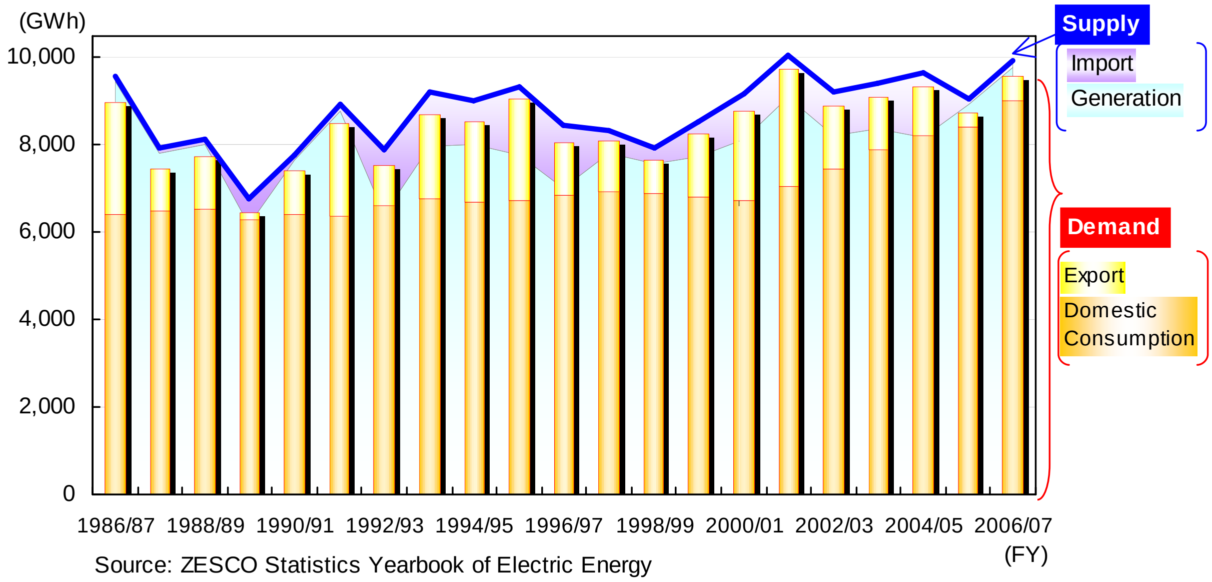


Figure 3-15 Electricity Supply and Demand

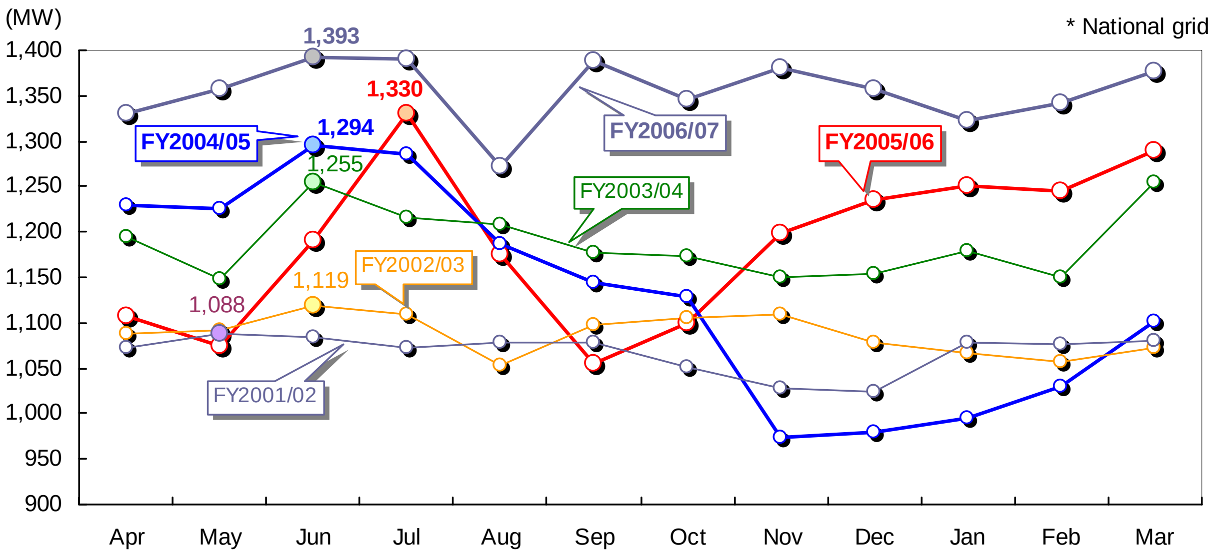
3.3.4. Seasonal and Daily Characteristics of Power Demand

Figure 3-16 shows the monthly peak demand of ZESCO's national grid for the past 6 years (from FY2001/02 to FY2006/07), and the numbered points in the chart indicate each year's peak demand. For the six-year period up to 2006/07 the annual peak load grew from 1,088 MW to 1,393 MW, an increase of about 22% increase. For the past 6 years, the annual peak load occurred in the winter, months between May and July.

As seen in the chart, there are significant variations of the peak load demand curve from year to year . Until FY2002/03 little fluctuation has been observed in every month's peak load, for example, the peak load of August 2002, the lowest in 12 months, was 1,053MW, which is 94.1% of the year's peak load (1,119MW in June 2002). This ratio still remained at 91.5% in FY2003/04 and each month's peak load was higher than that of previous year. In FY2004/05 the monthly peak load started fluctuating significantly: November 2004's peak load dropped to 974MW, which is the lowest in the past 5 years and its ratio against that of June 2004, the year's highest, also went down to 75.2%. This significant fluctuation in monthly peak load is also observed in the next FY2005/06: September 2005's peak load, the lowest among 12months, was 1,056MW and remained at 79.4% of that of annual peak load (1,330MW in July 2005). In November 2005 the monthly peak load rose considerably from the previous month, and this shows a sharp contrast against the previous year, when the peak demand sharply dropped in November. The fluctuation of monthly peak load was mitigated in FY2006/07 and the lowest monthly peak load among 12 months (1,273MW in August 2006) was as high as 91.4% of annual peak load (1,393MW in June 2006).

ZESCO has not given details to explain this trend, but the following hypotheses to clarify this might be possible as far as we assume that these numbers are statistically consistent.

- The increase of electricity consumption for residential use, which is especially remarkable between FY2003/04 (2,052GWh) and FY2004/05 (2,542GWh), has made power consumption more sensitive to weather changes.
- ZESCO's reduction of losses, makes the total system load more responsive to the end-users' actual power consumption. This is also evidenced by the improvement of distribution losses from 20.9% in FY2003/04 to 18.1% in FY2004/05 (discussed in Section 3.3.5). In the same vein, the relatively stable trend of monthly peak load in FY2006/07 may be more or less related to the worsened distribution losses (25.2%).



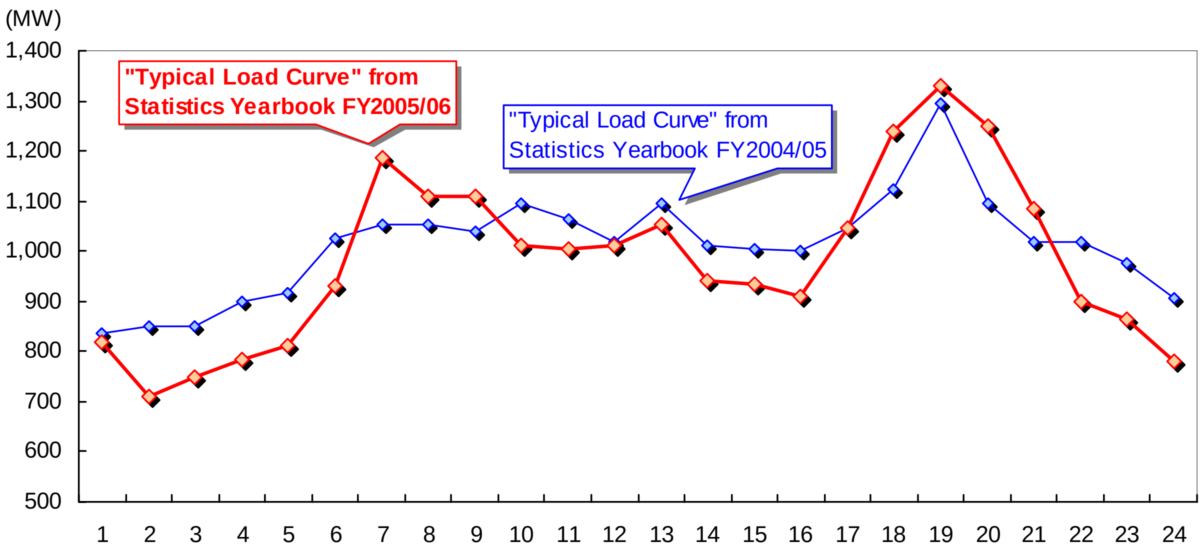
Source: ZESCO Statistics Yearbook of Electric Energy

Figure 3-16 Monthly Peak Load

Figure 3-17 shows the daily load of ZESCO's national grid system. In its annual "Statistics Yearbook of Electric Energy", ZESCO provides "typical" daily load curves, but does not indicate the date when the data were recorded. However, since the “typical” load curve in for 2005/06” is different from that for 2004/05, it is assumed that the former reflects the newer load data than the latter.

Here we can observe similar changes in the monthly peak load. The red line in the figure, that is, the later daily load curve, shows a larger gap between the peak and bottom loads than the older daily load curve, or the blue line in the figure. This change is considered consistent with the two hypotheses discussed about the monthly peak load.

Another significant difference between the new and the old load curves is that the new load curve shows a second peak in the morning (7:00) besides the highest peak in the evening (19:00) while the old daily load curve only shows a maximum demand in the evening and a relatively flat load throughout the daytime. This change is also considered consistent with the increase of electricity consumption for residential use, which by nature has two peaks, breakfast time and dinner time while during the daytime between them, when family members are out for work or study, the power demand is relatively low.



Source: ZESCO Statistics Yearbook of Electric Energy

Figure 3-17 Daily Load Curve

Reflecting the changes of load curve, whose shape is getting steeper both annually and daily, the load factor, which is the ratio of system consumption (MWh) against peak demand (MW), dropped, though not drastically, from 76.1% in FY2002/03 to 71.4% in FY2003/04, but it has seen a slight improvement since then.

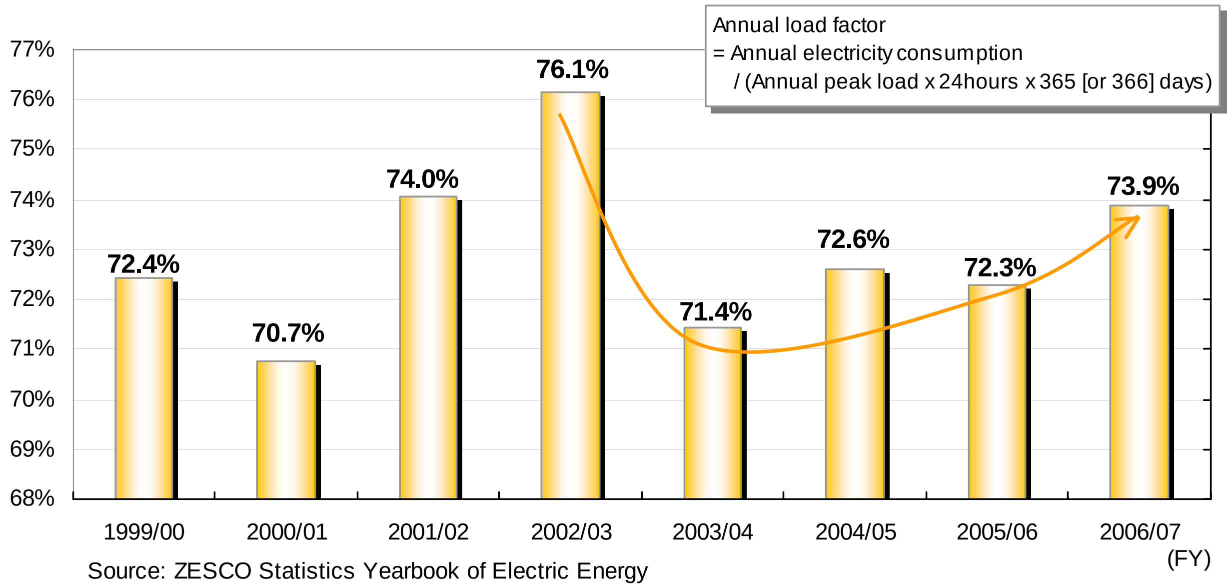


Figure 3-18 Annual Load Factor

3.3.5. Power System Losses

ZESCO's transmission loss is or the difference between the total energy sent out to the network (including power purchase and import) and the bulk delivery (including power wholesale and export), against the total energy sent out. The transmission loss has been kept stable and low at 3% since late 1980s.

Distribution loss, is the difference between the bulk delivery (only to ZESCO's distribution network) and end-user consumption metered by ZESCO The distribution losses has seen a reduction since FY2000/01, but increased again in FY2006/07.

The otal system energy losses, which comprise both transmission losses and distribution losses, is between transmission loss rate and distribution loss rate[4]. This is because that about half of the energy is delivered for wholesale (to CEC, Kansanshi Mining Plc., and First Quantum Minerals Ltd.) and export, both of which are not affected by distribution loss[5]. The gradual increase of total system losses is mainly attributed to the fact that the consumption of ZESCO's retail customers has grown as a proportion of total energy supply.

[4] When the energy is mostly, if not all, supplied through distribution lines, total system energy loss rate becomes higher than both transmission and distribution loss rates.

[5] Except the energy export through ZESCO's distribution lines to border areas in neighbouring countries, which is minor in total energy supply

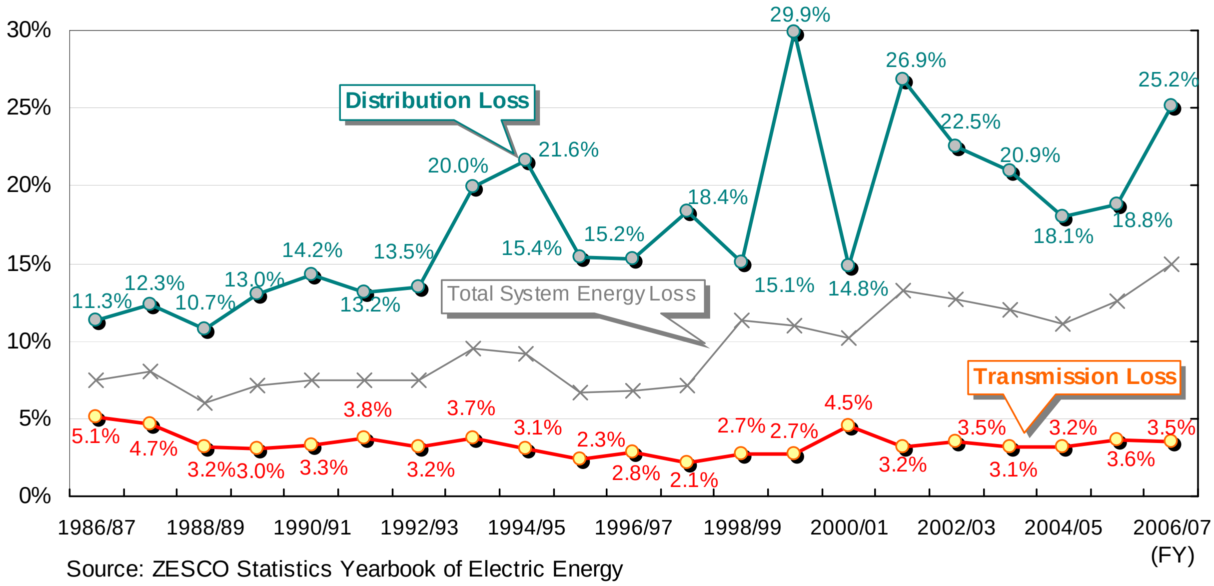


Figure 3-19 Transmission/Distribution Loss

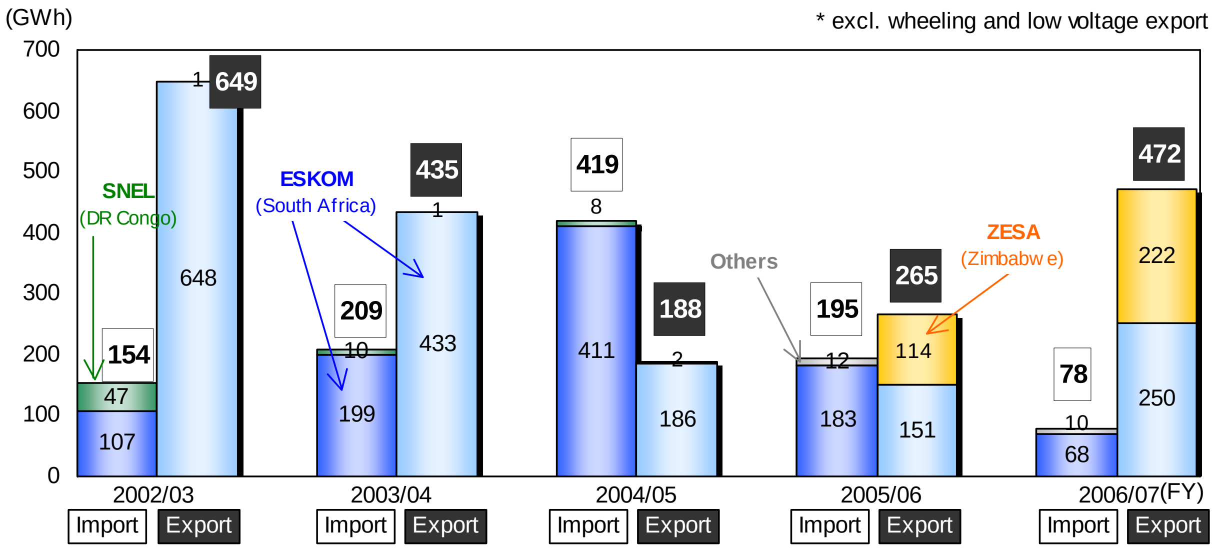
3.3.6. Electricity import/Export

As already discussed in Section 3.3.3, balance between electricity supply and demand has been tighter and more dependent on imports than ever.

Figure 3-20 shows ZESCO's electricity import and export for the previous 4 years, broken down by trading partners[6]. In FY2004/05 ZESCO's annual electricity import exceeded electricity export, which meant that Zambia that had long been a power exporter in the region turned into a net importer. With the completion of some Power Rehabilitation Projects (PRPs), ZESCO gained additional electricity supply and returned to the status of net exporter in FY2005/06.

ESKOM of South Africa was ZESCO's largest trading partner in both import and export. ZESCO's exports to ESKOM increased in FY2006/07 after the decreasing trend for the past years. Export to ZESA of Zimbabwe was a rapidly increasing trend, and was related to the serious shortfall of supply in Zimbabwe.

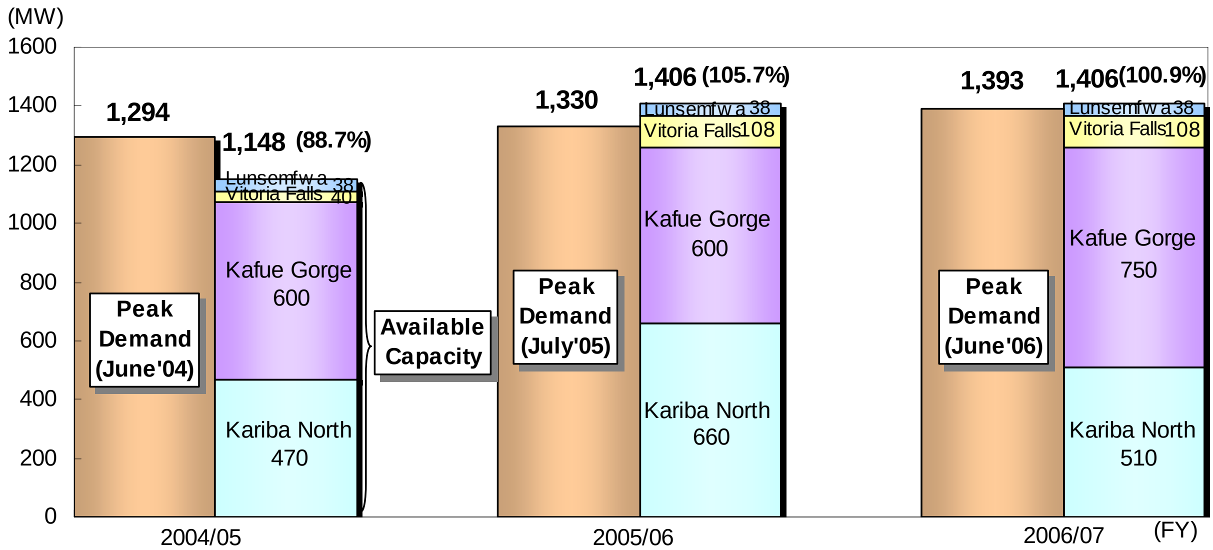
[6] The import and export data in this chart are different from those in Figure 3-15, which includes ZESCO's energy loss caused by wheeling (from SNEL to ZESA and ESKOM) and so on.



Source: ZESCO Statistics Yearbook of Electric Energy

Figure 3-20 Electricity Import / Export

The main reason why Zambia needed to import electricity despite its inherent capacity to export was the hourly mismatch between domestic power demand and generation capacity in Zambia. Figure 3-21 shows the comparison between the annual peak demand and the year's available capacity of power plants on the national grid[7]. In FY2004/05, the national grid recorded the peak demand of 1,294MW; but the generation capacity (1,148MW) covered only 88.7%., ZESCO had to import the deficit during peak hours. In FY2005/06 and FY2006/07, with the completion of rehabilitation projects, the generation capacity became higher than the peak demand, but the margin was insufficient when transmission losses (3-4%) and an operation reserve were taken into account. Therefore imports during peak hours were still needed. At the same time, there was sufficient capacity during off-peak hours for Zambia to export..



Source: ZESCO Statistics Yearbook of Electric Energy

Figure 3-21 Annual Peak Demand and Available Capacity (national grid)

[7] ZESCO's small hydropower stations and CEC's gas turbine stations are not considered because they are not expected to work with full capacity to cover the peak demand of the whole grid.

The unit cost of the base-load exports was much less than the unit cost of the peak-load imports. As shown in Figure 3-23, ZESCO's average export price is lower than 30 K/kWh until FY2004/05, much lower than its average unit cost, though it increased to about 70 K/kWh in FY2005/06, while the average import price is estimated at much higher than that[8] though the specific information was not availed to the Study Team. In other words, the value of exports was much less than the cost of imports.

Despite ZESCO's diminishing excess for export, Zambia's role as a hub of electricity supply in the region, namely Southern African Power Pool (SAPP), the regional power trading framework, is expected to gain importance in the future. ZESCO's transmission lines that run across the country from Copperbelt to Livingstone, is not only a backbone of the country's power system but also a part of international connection that wheels electricity generated in DR Congo to Zimbabwe and South Africa, the power importers. ZESCO is planning to extend 330kV transmission lines to North-Western Province to build another inter-connector with DR Congo and to enhance international power trade. In addition, studies on the extension of 220kV lines from Livingstone to Namibia, the Zambia-Tanzania-Kenya (ZTK) Interconnection Project, and interconnection with Malawi were underway (refer to Figure 3-22). These grid extension projects were also expected to enhance the capacity and stability of electricity supply to remote area in North-Western, Western, Northern, and Eastern Provinces.

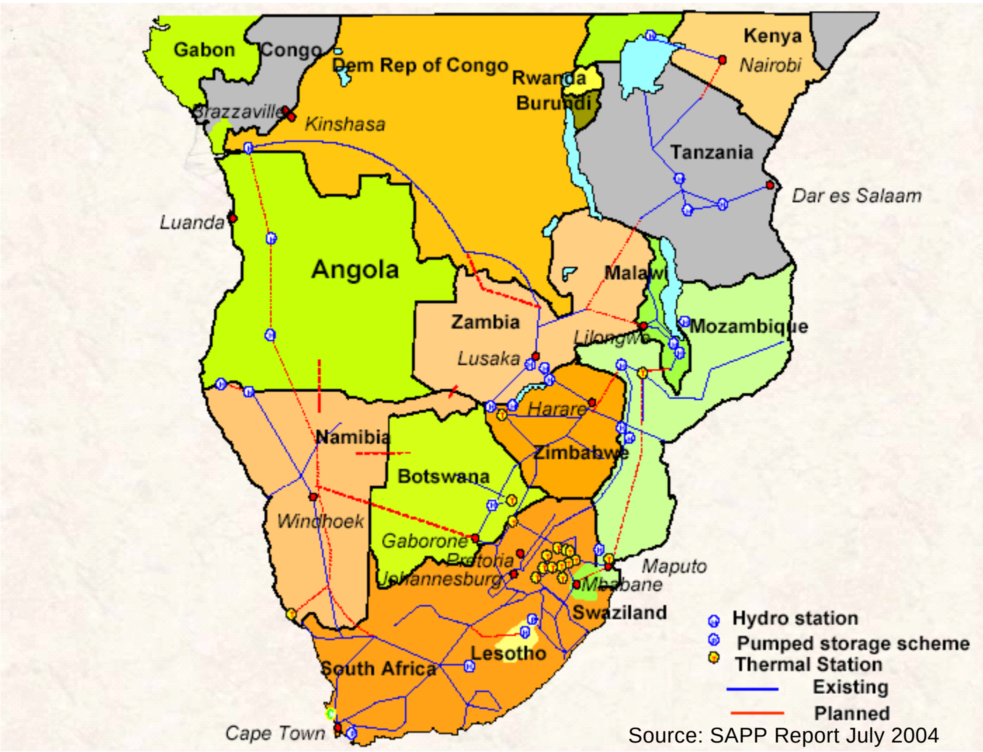


Figure 3-22 Southern African Power Pool Interconnection

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[8] According to ZESCO's financial statements of FY2005/06, the year's cost of sales is K149,487 million, which is supposed to mainly consist of electricity import and purchase because ZESCO expenses very small amount on fossil fuel. Meanwhile, ZESCO imported 195GWh and purchased 139GWh for the year, thus the unit imported and purchased price is estimated at 448 K/kWh. In the same way, the unit imported and purchased prices for FY2004/05, FY2003/04 and FY2002/03 are estimated at 262 K/kWh, 417 K/kWh and 388 K/kWh respectively.

3.4. Electricity Tariff

3.4.1. Electricity Tariff Structure

Section 7 of the Electricity Act, CAP433 of the laws of Zambia, states that charges made by "an undertaking", i.e. ZESCO or any other electricity service companies if they exist, "shall be determined in accordance with the licence governing the undertaking". Therefore, ZESCO's tariff to its customers, except those to whom ZESCO provides bulk supply, is regulated and needs the approval of the Energy Regulation Board (ERB). Section 8 of the Electricity Act states that "an undertaking" needs to give notice of any proposal to vary or alter the charges, which comes into effect 30 days after the notice unless the consumer applies to ERB to review the proposal."

Table 3-10 was ZESCO's revised tariff, proposed and implemented in October 2007. Unlike the previous tariff revision in May 2005, where 11% increase was applied to all customer categories, this time different increase rate was applied to each customer category; 45% for residential, 49-50% for commercial and social services, and 70-75% for large customers, thus the impact of tariff increase is slightly mitigated for households compared to other categories.

Table 3-10 ZESCO's Revised Tariff (implemented in October 2007)

			Current Tariff	Old Tariff
1. UNMETERED RESIDENTIAL TARIFFS			**Current Tariff**	Old Tariff
Consumption up to 2 Amps		(K/month)	**7,121**	4,911
Consumption between 2-15 Amps		(K/month)	**25,767**	17,770
2. METERED RESIDENTIAL TARIFFS (Capacity up to 15kVA)			**Current Tariff**	Old Tariff
Energy charge	up to 300kWh	(K/kWh)	**102**	70
	301 to 700kWh	(K/kWh)	**145**	100
	above 700kWh	(K/kWh)	**236**	163
Fixed monthly charge		(K/month)	**8,475**	5,845
Pre-paid (Energy charge)		(K/kWh)	**161**	111
3. COMMERCIAL TARIFFS[9] (Capacity up to 15kVA)			**Current Tariff**	Old Tariff
Energy charge		(K/kWh)	**245**	163
Fixed monthly charge		(K/month)	**43,841**	29,227
4. SOCIAL SERVICES TARIFFS[10]			**Current Tariff**	Old Tariff
Energy charge		(K/kWh)	**201**	135
Fixed monthly charge		(K/month)	**34,839**	23,382
5. MAXIMUM DEMAND TARIFFS			**Current Tariff**	Old Tariff
MD1: Capacity between 16 - 300kVA				
MD charge		(K/kVA/month)	11,803	6,943
Energy charge		(K/kWh)	170	100
Fixed monthly charge		(K/month)	115,603	68,200
MD2: Capacity between 300-2,000kVA				
MD charge		(K/kVA/month)	22,083	12,990
Energy charge		(K/kWh)	145	85
Fixed monthly charge		(K/month)	231,205	136,003
MD3: Capacity between 2,00-7,500kVA				
MD charge		(K/kVA/month)	34,277	19,587
Energy charge		(K/kWh)	110	63
Fixed monthly charge		(K/month)	476,011	272,006
MD4: Capacity above 7,500kVA				
MD charge		(K/kVA/month)	34,468	19,696
Energy charge		(K/kWh)	91	52
Fixed monthly charge		(K/month)	952,021	544,012

[9] "Commercial" here includes industrial and agricultural energy usage.

[10] Schools, hospitals, orphanages, churches, water pumping, street lighting etc.

Customers who were not metered were charged monthly fixed tariff. According to ZESCO, Northern Regional Office, about 30% of customers of its service area in Northern Province[11] were not metered.

For metered customers whose capacity did not exceed 15kVA, ZESCO offered three different tariffs depending on customer class, that is, residential, commercial, and social services. The tariff for each of these consists of monthly fixed charge (K/month) and energy charge (K/kWh). The same fixed charge applies to all three classes. The unit energy price for residential customers increases progressively with three steps, that is, 70 K/kWh for the first 300kWh consumption, 100 K/kWh for the next 400kWh consumption (301-700kWh), and 163 K/kWh for the consumption above 700kWh. This progressive unit price system for residential customers is commonly adopted in many countries, for the following reasons:

- To mitigate the burden of poor households
- To encourage energy conservation and to restrain waste (in some countries where energy conservation is a policy priority issue)

Thus the first threshold (between the first and the second lowest steps) is usually set at a level that is considered to be the minimum monthly electricity consumption for a household's subsistence. Typically this is between 20 kWh and 50 kWh per month in developing countries. In Japan where the assumed "lowest level of lifestyle for subsistence" is higher than in developing countries, this first threshold is 120 kWh/month. In the ZESCO's tariff system, the first threshold was set at 300 kWh/month, which is higher than generally adopted in other countries. This is equivalent to the second threshold in Japan[12], where "300kWh/month" approximately corresponds to an average electricity consumption of a household. ZESCO referred to the low unit price for the first 300 kWh "Life-line Tariff", justified on the basis that, "the 300 units are enough to use in a 2 to 3 roomed house. The units can be used for cooking on a 2 plate cooker, radio and lighting"[13]. For "Commercial" and "Social Services" customer types, only a single unit energy price is applied respectively regardless of monthly consumption.

ZESCO's tariff for large customers, whose capacity is more than 15kVA, is called "Maximum Demand Tariff (MD)", and consists of three parts, that is, fixed monthly charge (K/month, for each customer), MD charge (K/kVA/month), and energy charge (K/kWh). MD Tariff has four sub-categories depending on the capacity, namely MD1 (capacity 16-300kVA), MD2 (301-2,000kVA), MD3 (2,001-7,500kVA) and MD4 (above 7,500kVA), and different tariff is applied to each category.

Since in Zambia the source of energy supply is almost entirely from hydropower, there is no automatic adjustment of the unit energy price with fluctuations of fuel costs.

In addition to the price in the electricity tariff, customers were also charged a Government Excise Duty, which was 5% of every electricity bill, and 17.5% VAT. Of the Government Excise Duty, 3% was appropriated for the Rural Electrification Fund (REF, also refer to Section 3.2.

The graphs in Figure 3-23 show ZESCO's average selling price to different customer categories[14], such as "Residential", "Non-residential (ZESCO retail)", "Bulk Sales to Mining Industry (CEC etc.)", and "Export", together with the average cost of electricity supply[15] as bar chart in background. As

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[11] The service area of ZESCO's Northern Regional Office is not exactly the same as the area of Northern Province. A part of the province is covered by Luapula Regional Office.

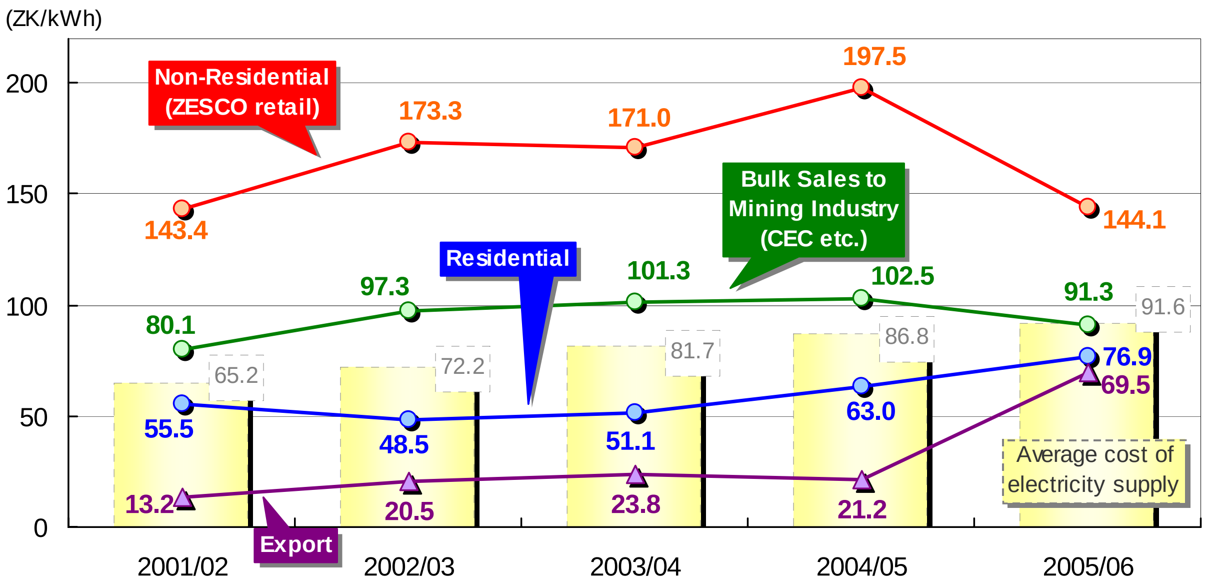
[12] 9 out of Japan's 10 power utilities set this second threshold at "300kWh/month", while the Hokkaido Electric Power Company, the only exception, set this threshold at "280kWh/month" that also used to be the standard for other 9 utilities until 1990s. "120kWh/month" has been uniformly adopted by all Japanese utilities since the three-steps progressive unit price was applied in Japan in mid-1970s.

[13] Source: ZESCO Website http://www.zesco.co.zm/why-pay-for-elec.html

[14] ZESCO's "Statistics Yearbook of Electric Energy" changed the classification of power consumption from its "2005/06" edition. For this reason, data of average selling price for FY2005/06 may not be consistent with those in the past.

[15] Definition of "Cost of Electricity Supply" is same as that of Figure 3-27 to be discussed in Section 3.5.1.

observed in the Figure, average selling price for residential customers is relatively low, even lower than the average cost of electricity supply. On the other hand, average selling price to customers other than residential, such as commercial, industrial and agricultural customers, is far higher than that of residential customers and the average cost of electricity supply. A significant gap between residential and non-residential selling prices is also confirmed in the tariff table (Table 3-10), according to which "Commercial Tariffs" must always be higher than "Metered Residential Tariffs" with same electricity consumption. Taking into consideration that the average unit selling price of residential customers would be by nature a little higher than that of non-residential customers if the tariffs were set strictly reflecting the marginal unit cost of supply[16], we can observe the existence of cross-subsidization from non-residential tariff to residential tariff to benefit residential customers while total revenue balances with total cost of supply. This cross-subsidization, however, should be evaluated taking into account the residential customers' affordability to pay for electricity.



Source: ZESCO Financial Statements, Statistics Yearbook of Electric Energy

Figure 3-23 Average Selling Price

16 Almost all residential customers are supplied with low-voltage (400/230V) and thus have to pay the cost of using low-voltage distribution lines while many non-residential customers do not need to share the cost of low-voltage lines because they are supplied electricity from 11kV distribution lines. In addition, load factor of non-residential customers, especially industrial, is generally apt to be higher than that of residential customers, and high load factor helps reduce average fixed cost (= fixed cost divided by electricity consumption).

3.4.2. Metering and Billing

In common with the practice in other countries, electricity consumption of ZESCO's metered customers have their meters read at regular intervals, and a bill is issued to each customer monthly. ZESCO's meter readers, called "Client Service Accounts Assistants (CSAA)" off-load the metered data to ZESCO's customer database at District Office, which is linked to the company's billing system. According to ZESCO, this "metering – billing" process takes a few days to complete. In some regions, especially in urban area, ZESCO started using a handheld metering terminal so that the collected readings are easily off-loaded to the customer database.

Electricity bills may be paid either in cash or by cheque at ZESCO's Customer Service Centres or it is also possible to debit the amount automatically from a customers' bank account. ZESCO is encouraging the customers to make use of this Direct Debit and Credit Clearing (DDACC) service, offering incentives that include a 5% discount on the bill.

ZESCO's power cut policy against customers who fail to pay electricity bills is generally the same as the one adopted by power utilities of other countries. Customers that fail to pay bills for more than two months receive a notice of disconnection. Another notice to urge the payment may be issued again 48 hours prior to the disconnection in some cases. Disconnected customers have to pay at least 75% of the total bill, together with some penalties, for reconnection. The remaining 25% of the bill has to be paid within 3 months for supply to be maintained. Figure 3-24 illustrates a workflow of ZESCO's Power Cut Policy[17], though actual implementation of the policy might be more flexible case by case.

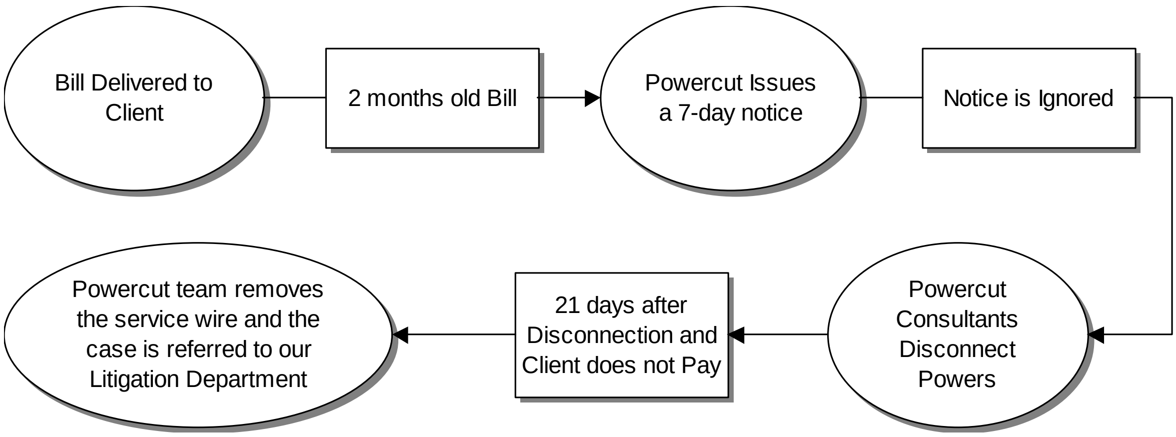


Figure 3-24 ZESCO's Powercut Workflow

Figure 3-25 shows ZESCO's trade receivables, i.e. uncollected revenue that is accounted for as current assets in balance sheet, for the past 5 years, and its annual increase or decrease. In FY 2001/02 the trade receivables increased by K175 billion (about +50%) and the remaining balance reached K524 billion, which reached almost the same amount as ZESCO's revenue of that year (K537 billion). In other words, about one third of ZESCO's revenue of that year was not collected. It was not until then that ZESCO seriously took on managing non-performing trade receivables.

There are two factors that affect the increase and decrease of trade receivables:

- Failure to collect revenue of the year (= increase) or collection of trade receivables in the past (= decrease)
- Writing-off of a part of trade receivables as "provisions for doubtful debt", which is accounted for as "loss" in income statement (= decrease)

ZESCO continuously needs to write off a part of its trade receivables that it does not expect to be able

[17] Source: ZECSO Website http://www.zesco.co.zm/p-cut.html

to collect in the future by offsetting this with the profit, in order to prevent the swelling of non-performing assets.

The bar chart in the lower half of Figure 3-25 is the breakdown of increase/decrease of trade receivables by abovementioned factors. During FY2002/03 ZESCO's trade receivables decreased by K183 billion, which is mostly due to ZESCO's writing-off of K180 billion trade receivables. This K180 billion is equal to 28% of ZESCO's total revenue of the year and roughly corresponds to the huge increase of trade receivables in the previous fiscal year (K175 billion). ZESCO wrote off K140 billion out of K180 billion through "Debt Swap" with GRZ, by which ZESCO's receivables from GRZ were offset with the interest-bearing borrowings that the company owed to GRZ. Improvement of revenue collection also helped the decrease of trade receivables in FY2002/03: this -K3 billion appears modest compared to the remaining amount, but is a remarkable improvement taking into account the rapidly worsened revenue collection in the past. Since then, outstanding trade receivables have been kept relatively stable.

In order to enhance revenue collection and thus to reduce trade receivables, ZESCO embarked on a project to install prepayment meters. The pilot scheme started in 2002 with 1,000 customers in Lusaka, and in March 2006 the project moved on to Phase 1, in which 24,000 prepaid meters were installed.

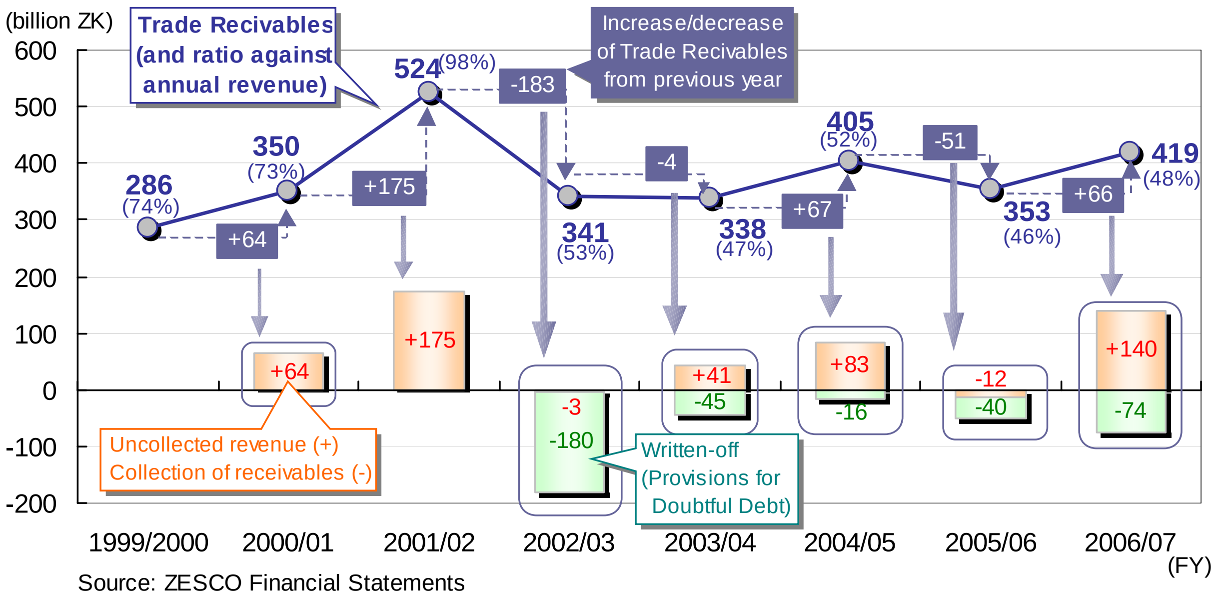


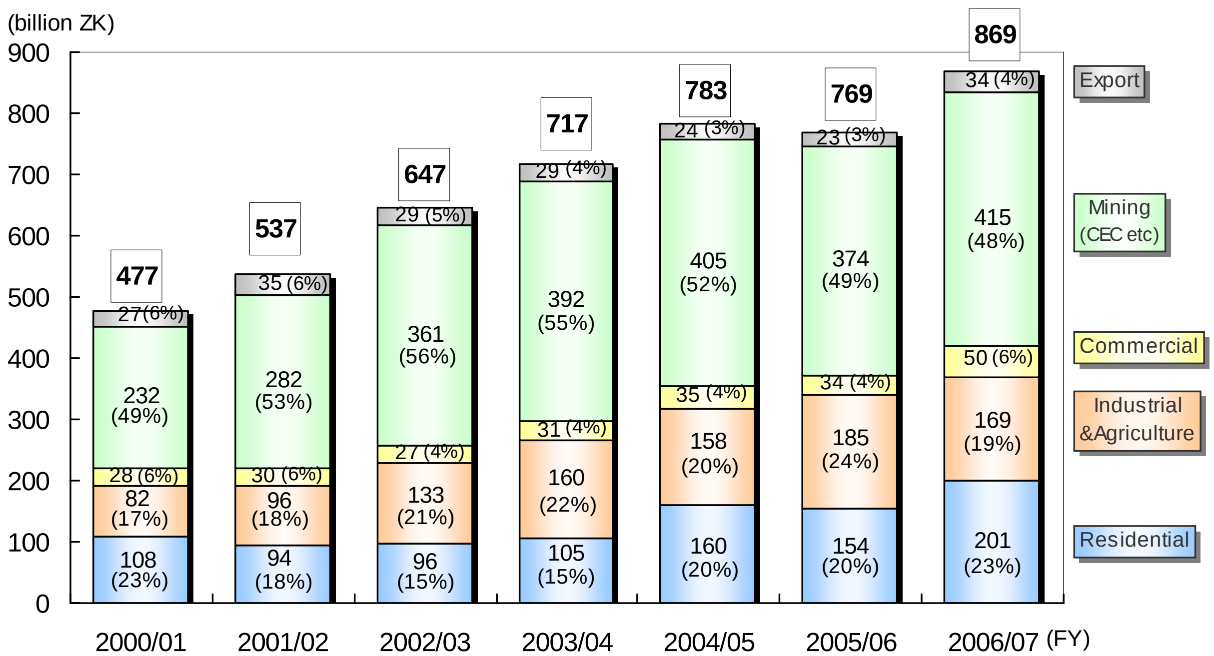
Figure 3-25 Increase / Decrease of ZESCO's Trade Receivables

3.5. Financial Status of the Power Sector

3.5.1. Financial Status of ZESCO

(1) Electricity Revenue and Cost

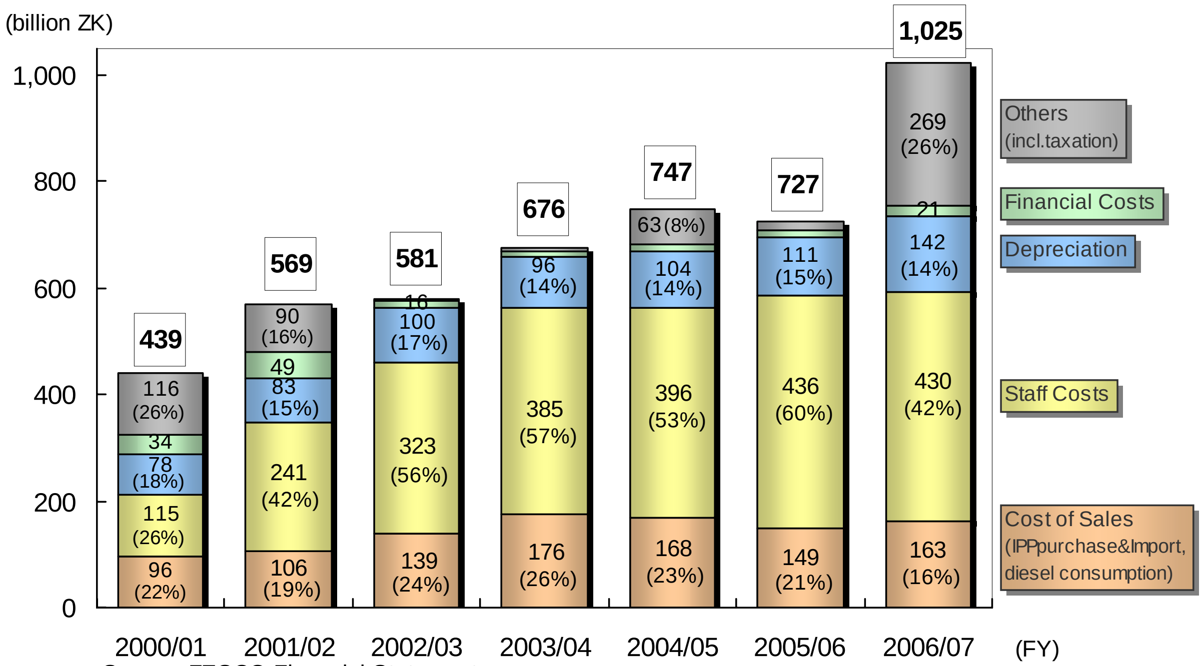
In line with the growth of electricity demand, ZESCO's annual revenue has seen a rapid increase, with 82% growth from K477 billion in FY2000/01 to K869 billion in FY2006/07. The increase in revenue owes considerably to the mining sector (mostly CEC), which accounts for about half of ZESCO's total revenue. The dip of total revenue in FY2005/06, decreasing from K783 billion in the previous year, is mainly due to the -8% drop in the revenue from mining sector (K374 billion). The revenue from mining sector decreased despite the steady increase of the sector's electricity consumption (3.5% increase from 3,952GWh in FY2004/05 to 4,091GWh in FY2005/06: refer to Figure 3-14). The dip was caused by the fact that the CEC tariff was denominated in US$ and for that year the Zambia Kwacha appreciated against US$, thus decreasing the Kwacha revenues. Similarly, the Kwacha's depreciation against US$ in FY2006/07 raised ZESCO's revenue from mining sector of the year, as well as its total revenue. Revenue from ZESCO's retail customers, i.e. revenue excluding export and mining, continued increasing as a whole, though there has been some fluctuation for each customer category.



Source: ZESCO Financial Statements

Figure 3-26 ZESCO's Annual Revenue

ZESCO's total cost of electricity supply, which comprises not only direct costs (e.g. power purchase, import, fuel cost) but also indirect costs (e.g. staff costs, depreciation, financial costs) and taxation, is shown in Figure 3-27. A conspicuous increase can be seen in staff costs, swelling about 3.8 times from K115 billion in FY 2000/01 to K430 billion in FY2006/07, despite that the number of employees decreased from 3,963 as at end of FY 2000/01 to 3,603 as at end of FY2006/07. According to ZESCO, the growth of staff cost is due to the increase of temporary employees who are not counted in the "number of employees", and to the rise in their unit cost following the Government's instruction. The financial cost decreased from K49 billion in FY 2001/02 to K21 billion in FY2006/07, which is due to the company's reduced dependence on bridging loans such as bank overdraft and short-term borrowings that have high interest rates. The total cost of supply is also affected by foreign exchange gains/losses (changed from K183 gain in FY2005/06 to K173 loss in FY2006/07), which mainly derives from the fluctuation in Kwacha value of long-term loans.



Source: ZESCO Financial Statements

Figure 3-27 Total Cost of Electricity Supply

The difference between annual revenue (Figure 3-26) and total cost (Figure 3-27) is equal to "profit after taxation". In FY 2006/07, ZESCO made the loss of K156 billion, which is mainly due to the abovementioned huge foreign exchange loss, but it should be noted that ZESCO's profitability fundamentals have been weak even without foreign exchange effects considering that the operating profit/loss subtracting foreign exchange gain/loss was negative in FY2005/06 and FY2006/07.

ZESCO's financial statements are summarized in Table 3-11.

Table 3-11 Summary of ZESCO's Financial Statements

(K million)

	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07
Turnover (A)	**477,398**	**536,583**	**646,515**	**717,373**	**782,641**	**768,915**	**868,725**
Cost of Sales (B)	96,359	106,355	138,954	176,362	-168,384	149,487	163,011
Gross Profit (C) = (A) - (B)	**381,039**	**430,228**	**507,561**	**541,011**	**614,257**	**619,428**	**705,714**
Other Operating Costs (D) *	267,644	358,182	388,852	452,444	563,141	489,207	902,650
Operating Profit (E) = (C) - (D)	**113,395**	**72,046**	**118,709**	**88,567**	**51,116**	**130,221**	**-196,936**
Financial Cost (F)	33,870	49,277	15,764	12,063	15,412	11,070	21,276
Exceptional Items (G)	–	8,395	–	–	–	–	–
Profit before Tax (H)=(E)-(F)-(G)	**79,525**	**14,374**	**102,945**	**76,504**	**35,704**	**119,151**	**-218,212**
Taxation (I)	41,420	47,151	37,732	34,828	71	76,812	-62,117
Profit after Tax (J) = (H) - (I)	**38,105**	**-32,777**	**65,213**	**41,676**	**35,633**	**42,339**	**-156,095**
Assets (K)	**1,831,680**	**2,133,633**	**2,271,147**	**2,636,002**	**3,499,240**	**3,693,644**	**3,979,596**
ROA = (E) / average(K) **	6.4%	3.6%	5.4%	3.6%	1.7%	3.6%	-5.1%
Equities	**1,271,965**	**1,239,188**	**1,276,535**	**1,303,211**	**1,688,291**	**1,730,630**	**1,574,535**
Liabilities	**559,715**	**894,445**	**994,612**	**1,332,791**	**1,810,949**	**1,963,014**	**2,405,061**

Source: ZESCO Financial Statements

Note: Miscellaneous incomes (e.g. interest income) are subtracted in "Other Operating Costs"
ROA = Operating profit / {(this year's total asset + previous year's total assets) / 2}

(2) Capital Structure

ZESCO spent heavily on capital projects such as rehabilitation of hydropower stations, which led to the rapid growth of total assets (more than twice from K1,832 billin in FY2000/01 to K3,980 billion in FY2006/07). Little of the capital expenditure was covered by ZESCO's own funds[18], as shown in Figure 3-28., The company's financing has been dependent on liabilities, such as borrowings, capital grants and customers' contribution, than equities, which is evidenced as a gradually worsening Debt/Equity ratio seen in Figure 3-29.

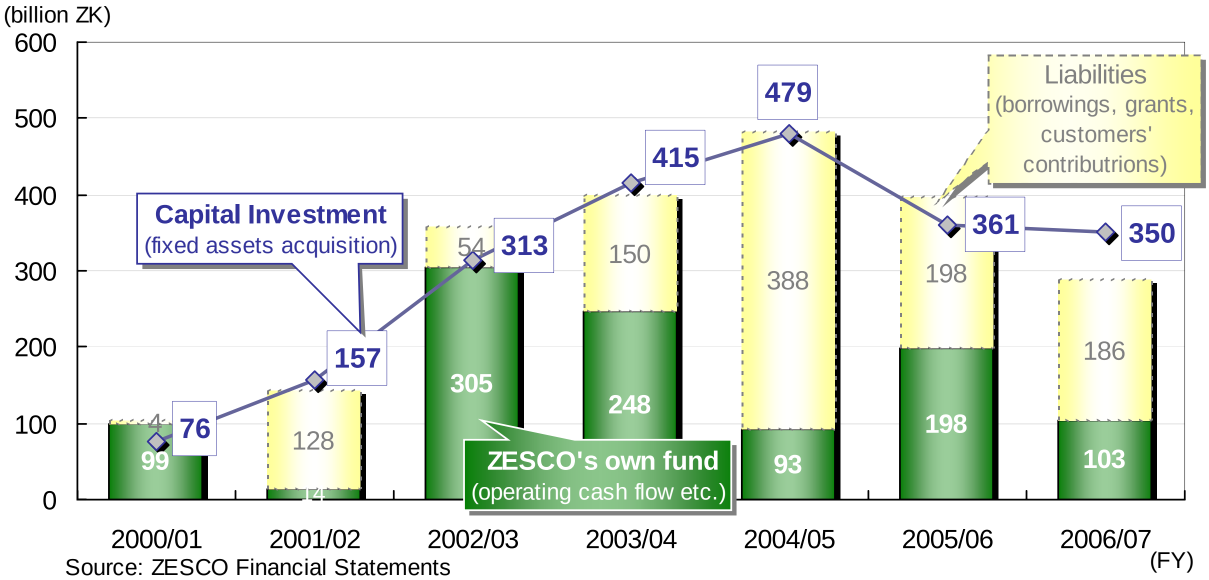


Figure 3-28 Capital Investment Financing

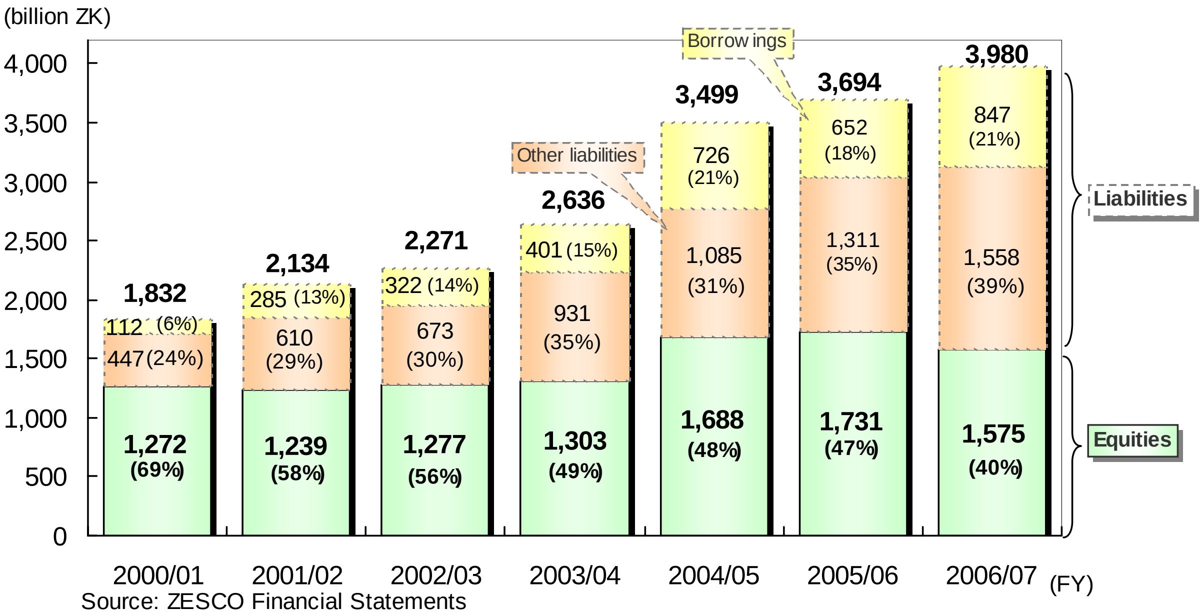
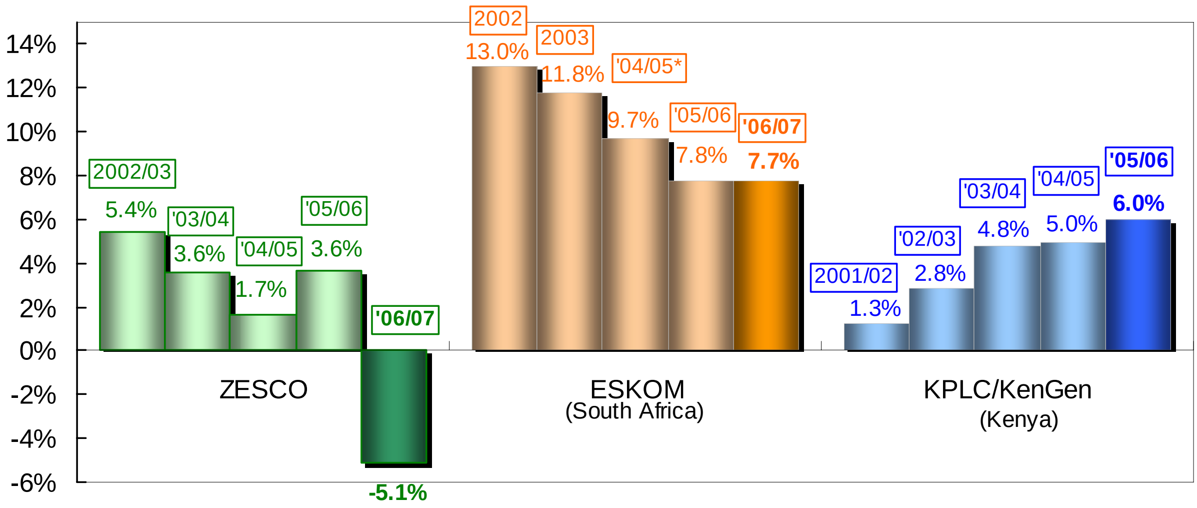


Figure 3-29 ZESCO's Capital Structure (Equities & Liabilities)

[18] Here defined as "Operating cash flow + Disposal of tangible assets + Interest received" in the cash flow statement

(3) International Comparison (Profitability Indicator)

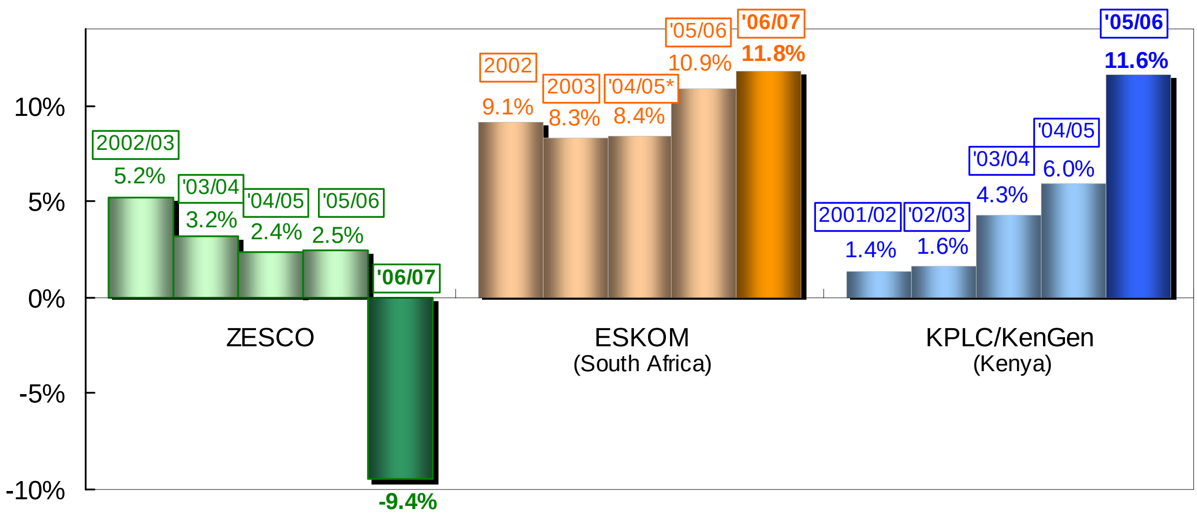
Figure 3-30 and Figure 3-31 show ZESCO's return on assets (ROA) and return on equity (ROE) for the past 4 years, in comparison with that of ESKOM (South Africa)[19] and KPLC/KenGen (Kenya)[20], who have relatively advanced management in the region and disclose their financial statements to the public. Both ROA and ROE show a similar trend. ESKOM, the largest power utility in Africa, keeps around 8-12% of ROA and ROE, and has the highest profitability among these three countries. The profitability of Kenyan sector is at close level to that of ZESCO's, but while Kenya's electricity sector has steadily improved profitability, ZESCO's profitability has seen a decreasing trend.



Source: Financial Statements of each company

Figure 3-30 Return on Assets (ROA) – International Comparison

Note: ROA = Operating profit / {(this year's total asset + previous year's total assets) / 2}



Source: Financial Statements of each company

Figure 3-31 Return on Equity (ROE) – International Comparison

Note: ROE = Profit after tax / {(this year's shareholders' equities + previous year's shareholders' equities) / 2}

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19 ESKOM shifted its fiscal year from "January-December" to "April-March" in 2004, and FY2004/05 as transition period lasted irregularly 15-months long (Jan 2004-Mar 2005). ESKOM's indicators of FY2004/05 were amended to 12-months base for comparison.

20 Kenya's electricity sector has two major utilities, KPLC (transmission/distribution) and KenGen (generation). For evaluating the performance of power sector as a "vertically integrated utility", financial statements of these two utilities are consolidated by offsetting transactions between them. Kenya's fiscal year starts 1st July and ends 30th June.

3.5.2. Financial Status of Other Players in the Sector

(1) Copperbelt Energy Corporation (CEC)

Copperbelt Energy Corporation Plc (CEC) also publicizes its financial statements annually like ZESCO. CEC, which used to be a division of the defunct Zambia Consolidated Copper Mines (ZCCM), the Government-led company, and whose revenue mostly depends on the mining industry, the largest export industry of Zambia, records its financial statements in US$. The unit prices of power purchase from ZESCO and sales to its customers are also set in US$, which means that mining companies, whose cost of production depends a lot on electricity, hedges the risk of exchange rate fluctuation regarding electricity cost in US$ value, and so does CEC the cost of power purchase from ZESCO, and as a result the risk is borne by ZESCO in the end, which is evidenced as the dip in ZESCO's revenue in FY2005/06 (refer to Section 3.5.1). CEC's unit selling price to its customers was around 3US¢/kWh for some years in the past.

Table 3-12 CEC's Electricity Demand and Sales

	2001	2002	2003	2004	2005
Maximum Demand (MW)	451.70	475.86	491.31	505.08	503.89
Electricity Sales to Customers (GWh)	3,354	3,578	3,689	3,818	3,734
Unit Selling Price (US¢/kWh)	3.15	3.08	3.11	3.15	3.27

Source: CEC Financial Statements

Table 3-13 is the summary of CEC's financial statements for the past 5 years. The gross profit margin, i.e. the ratio of gross profit against revenue, has been stable at around 30%. This fact indicates that CEC's selling price to its customers is linked to the purchase price from ZESCO, which accounts for most of CEC's cost of sales, so that CEC receives 30% gross profit margin.

Table 3-13 Summary of CEC's Financial Statements

(1,000 US$)

	2001	2002	2003	2004	2005
Revenue (A)	105,624	110,128	114,874	120,348	122,164
Cost of Sales (B)	73,217	78,506	82,097	85,239	85,797
Gross Profit (C) = (A)–(B)	**32,407**	**31,622**	**32,777**	**35,109**	**36,367**
Gross Profit Margin (C) / (A)	30.7%	28.7%	28.5%	29.2%	29.8%
Other Operating Costs (D)	17,397	7,469	17,551	16,444	21,127
Operating Profit (E) = (C)–(D)	**15,010**	**24,153**	**15,226**	**18,665**	**15,240**
Profit after Tax (F)	**8,547**	**15,012**	**10,069**	**11,842**	**8,241**
Dividends (G)	**18,000**	**25,000**	**20,000**	**20,500**	**9,900**
Payout Ratio = (G) / (F)	211%	167%	199%	173%	120%
Assets (H)	**168,574**	**157,123**	**148,566**	**142,361**	**136,505**
ROA = (E) / average(H)*	N.A.	14.8%	10.0%	12.8%	10.9%

Source: CEC Financial Statements

Another issue to be noted regarding the financial statements is that CEC's payout ratio, which is the ratio of dividends for shareholders against profit after tax, has been higher than 100%, which means that CEC has paid higher dividends than a year's profit retained for shareholders. The additional source of high dividends derives from the following:

- Depreciation of fixed assets: CEC's annual capital investment has been almost below the depreciation of the year
- Collection of trade receivables in the past

Return on Assets (ROA) of CEC for the past 4 years has been above 10%, which is by far higher than that of ZESCO during the same period (1.7%–5.4%).

CEC plays an important role in Zambia's electricity sector, not only because CEC purchases about half of ZESCO's electricity sales but also it owns a part of transmission lines interconnected with DR Congo to wheel electricity from DR Congo to Zimbabwe and South Africa and, in part, Zambia. In February 2006, Zambian Energy Corporation (Zam-En), a consortium of Zambian and foreign investors, acquired 77% stake in CEC from National Grid of the United Kingdom and Cinergy Global Power of the United States. The remaining shares are owned by the Zambian Government through. ZCCM-Investment Holdings Plc (20%) and Local Technical Team of Power Division (3%).

(2) Others

Other players in Zambia's electricity sector, such as Lunsemfwa Hydro Power Company, an IPP in which ESKOM of South Africa has 51% stake, and some small ESCOs that installs solar home system on customers' premises, do no disclose their financial statements. According to an interview that the Study Team had with some ESCOs operating in Eastern Province, their financial performance has been worsening due to the sluggish revenue collection.

Chapter 4

Current Situation
of
Rural Society

Chapter 4. Current Situation of Rural Society

4.1. Functions of Rural Growth Centres and Local Communities

Villages in Zambia are in general located along the roads and rivers. A typical rural village consists of group of houses and in many cases does not include core facilities, such as schools, clinics, churches, and market. The style of these villages reflects cultural factors especially the long-established tradition by which relatives tend to live together. Government has defined a Rural Growth Centres (RGC) as a rural locality with a high concentration of residential settlements and which is the centre of rural economic activities. An RGC provides services to residents of the RGC and those in the catchment area (CA) that surrounds the RGC. Typically people go to an RGC in order to sell their agricultural produce and handicrafts, to purchase daily necessities and to access public services (refer to Figure 4-1).

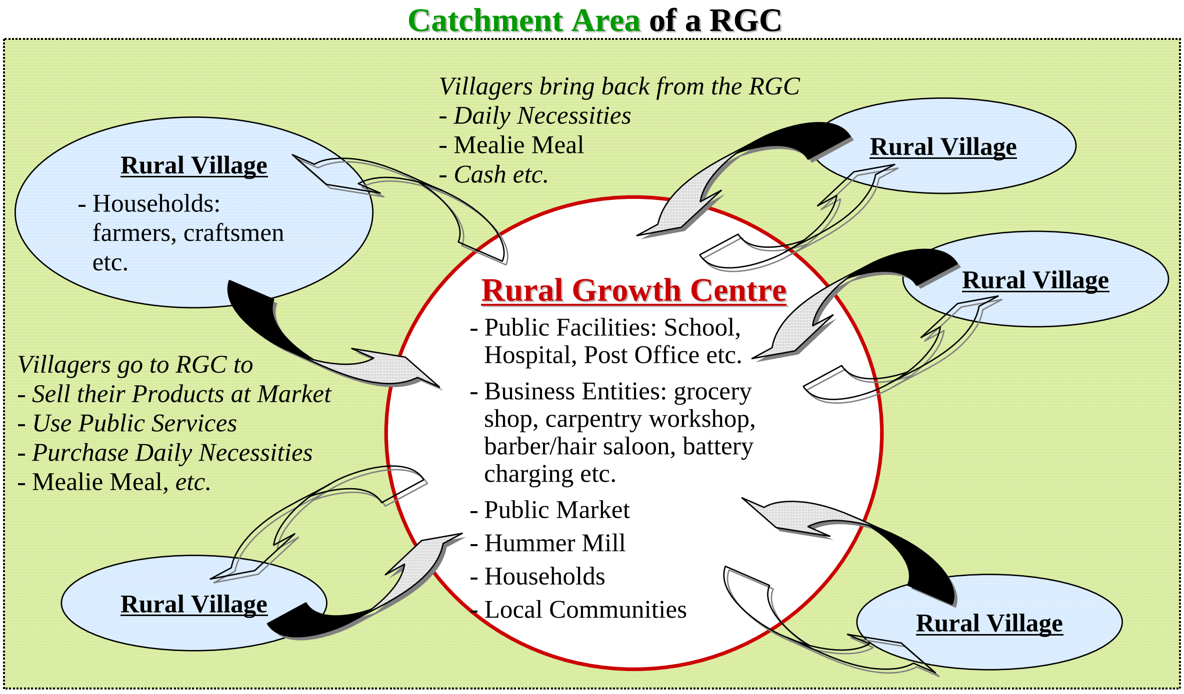


Figure 4-1 Concept of Rural Growth Centre and Catchment Area

In addition to the grocery shops and markets found at RGCs, there are also electrified hammer mills, which are used to produce maize meal for making “Nsima”, the Zambian staple. In larger RGCs, there are also small factories, restaurants, bars and other social services. The RGCs function as a centre of daily life and activities in rural areas. Among the residents of the RGC are to be found public workers like doctors, nurses, teachers and police officers.

Local community groups have been established and they operate from public places like community halls or recreation centres within RGCs. In many cases, there are also local community groups that contribute to the development of infrastructure and public facilities, acting as recipient organizations of funds from NGOs and international donors.

For example, the Zambia Social Investment Fund (ZAMSIF), established with the assistance of the World Bank, supports the development of infrastructure like schools, clinics, boreholes, roads and bridges. In order to receive funds from ZAMSIF, the resident community establishes a committee for each project, known as the ZAMSIF Project Management Committee. Besides receiving construction materials from ZAMSIF, the Committee is required to provide a construction labour force drawn from the villages and to contribute any necessary additional materials. On completion, the maintenance of the facility is primarily the responsibility of the Committee; however the Zambian government dispatches salaried doctors for newly constructed clinics and teachers for newly constructed schools. This model could be adapted for rural electrification projects by entrusting a village cooperative with the operation and maintenance works of electric facilities and/or tariff collection.

The size of the CA seems to vary from one district to another: for example, in the North-Western Province a CA is within approximately 8 km radius of the RGC, while that in Eastern Province is within 10 to 16 km radius of the RGC. In addition, for the Eastern Province, a kind of sub-RGC is observed within the CA. This is a much smaller and less developed unit than the main RGC and typically consists of grocery shops only.

4.2. Economic Activity in Rural Areas and Expected Effects after Electrification

Villagers wishing to sell their crops and products at the RGC market pay a fee. They purchase miscellaneous goods at grocery shops, or have their maize ground at electrified hammer mills in the RGCs. It can be expected therefore that there is potential demand in the unelectrified RGCs, from economic activities such as refrigeration in grocery shops and the addition of electric hammer mills.

In unelectrified RGCs, paraffin is utilized as fuel for refrigerators in grocery shops. Supply of stable electricity is expected to provide a strong possibility that paraffin refrigerator users will shift to electric refrigerators. Clinics and dairy farmers in unelectrified RGCs, that store vaccines (for human and livestock respectively) in refrigerators powered by unstable SHS, will also be the beneficiaries of electrification.

In unelectrified RGCs, hammer/maize mills with capacity of about 15kW are driven by privately owned diesel generators, and the owners charge K800 to K3,000 as the fee for grinding a bucket of maize. An increase of hammer/maize mill businesses may be expected if electricity is supplied through by extending the distribution lines at reasonable costs. Price reduction of milling fees, as a result of market competition, may also occur with entrance of mill owners, which is also expected to trigger other secondary impacts.

4.3. Rural Electrification and Energy Consumption

As shown in Table 4-1, the electrification rate for households is 20.3% in Zambia as of 2004. Of the 61% of the population that live in rural areas, only 3.1% currently has access to electricity. Broken down regionally, electrification rate in each Province is as follows in the descending order: 46.1% in Lusaka, 44.3% in Copperbelt, 15.7% in Southern, 12.4% in Central, 11.1% in North Western, 9.6% in Northern, 8.2% in Eastern, 4.4% in Luapula, and 4.2% in Western (refer to Figure 4-2).

Households using kerosene/paraffin as a major source of lighting are 45.7% of total households countrywide. Candle is used by 18.1 % of the households. The remaining are the households using diesel at 7.4%, wood fire at 6.1% and other energy sources at 1.4% for lighting. In rural area, kerosene/paraffin is the most commonly used source of lighting energy with 62.3% of households (especially high in Luapula Province by 80.9% and Northern Province by 70.4%), and diesel is the secondary major source of it. Since fossil fuel is expensive, especially in rural area, kerosene/paraffin and diesel users for their lighting energy are likely to be able to pay for the electricity tariff, once it has become available.

In order to receive electricity supply from ZESCO, however, expensive down payment is charged as the connection fee: Single-phase overhead for K2,873,000 and three-phase overhead for

K4,887,000 in rural area as of 2005. This initial cost is one of the big hurdles for the promotion of rural electrification.

According to the "*Living Conditions Monitoring Survey 2004*" conducted by the Central Statistics Office (CSO), the majority of Zambians (84.9% in rural area and 54.2% in whole country) use collected firewood and only 1.7 % of households in rural area use electricity as their main source of energy for cooking (refer to Table 4-2).

Table 4-1 Percentage Distribution of Households by Main Source of Energy for Lighting

		Kerosene / Paraffin	Electricity	Candle	Diesel	Wood Fire	Others	None	Total	Total No. of Households	% of Total Population
Zambia Total	**Total**	**45.7%**	**20.3%**	**18.1%**	**7.4%**	**6.1%**	**1.4%**	**0.9%**	**100.0%**	**2,110,640**	**100.0%**
	Rural	62.3%	3.1%	9.7%	11.6%	9.9%	2.0%	1.5%	100.0%	1,288,065	61.0%
	Urban	19.5%	47.6%	31.5%	0.9%	0.2%	0.3%	0.1%	100.0%	822,575	39.0%
Provinces	Central	53.8%	12.4%	16.8%	13.3%	1.9%	1.3%	0.6%	100.0%	207,197	9.8%
	Copperbelt	29.2%	44.3%	20.7%	4.2%	0.9%	0.6%	0.1%	100.0%	311,712	14.8%
	Eastern	61.3%	8.2%	13.3%	8.7%	5.4%	1.6%	1.5%	100.0%	290,224	13.8%
	Luapula	80.9%	4.4%	4.1%	0.4%	9.5%	0.4%	0.4%	100.0%	171,659	8.1%
	Lusaka	12.6%	46.1%	39.8%	0.5%	0.2%	0.6%	0.2%	100.0%	309,949	14.7%
	Northern	70.4%	9.6%	5.3%	5.3%	7.4%	1.2%	0.9%	100.0%	275,266	13.0%
	North-Western	36.7%	11.1%	14.3%	22.0%	13.7%	1.4%	0.8%	100.0%	125,814	6.0%
	Southern	41.4%	15.7%	19.5%	15.5%	5.3%	1.1%	1.4%	100.0%	252,423	12.0%
	Western	39.2%	4.2%	19.3%	4.5%	23.9%	5.5%	3.4%	100.0%	166,219	7.9%

Source: Living Conditions Monitoring Survey Report 2004
(Central Statistical Office, December 2006)

Table 4-2 Percentage Distribution of Households by Main Source of Energy for Cooking

		Collected Firewood	Purchased Firewood	Own Produced Charcoal	Purchased Charcoal	Coal	Kerosene / Paraffin / Gas	Electricity	Others	Total
Zambia Total	**Total**	**54.2%**	**1.9%**	**3.5%**	**23.8%**	**0.0%**	**0.2%**	**16.2%**	**0.1%**	**100.0%**
	Rural	84.9%	1.7%	4.7%	6.6%	0.0%	0.2%	1.7%	0.2%	100.0%
	Urban	5.6%	2.2%	1.5%	51.1%	0.0%	0.2%	39.3%	0.0%	100.0%
Provinces	Central	68.2%	1.8%	1.0%	19.4%	0.0%	0.2%	9.3%	0.1%	100.0%
	Copperbelt	16.0%	1.4%	3.6%	41.7%	–	0.2%	37.0%	0.1%	100.0%
	Eastern	76.9%	2.7%	0.5%	14.6%	–	0.3%	4.9%	0.3%	100.0%
	Luapula	45.8%	3.1%	24.0%	24.4%	–	0.1%	2.4%	0.2%	100.0%
	Lusaka	10.7%	0.8%	0.8%	47.3%	0.0%	0.2%	40.2%	0.0%	100.0%
	Northern	75.2%	1.0%	3.2%	14.0%	0.1%	0.2%	6.4%	0.0%	100.0%
	North-Western	71.7%	1.5%	2.3%	15.9%	0.1%	0.5%	7.7%	0.2%	100.0%
	Southern	71.1%	2.5%	0.7%	13.4%	0.1%	0.2%	12.0%	0.1%	100.0%
	Western	88.3%	3.8%	0.6%	3.6%	–	0.2%	3.2%	0.4%	100.0%

Source: Living Conditions Monitoring Survey Report 2004
(Central Statistical Office, December 2006)

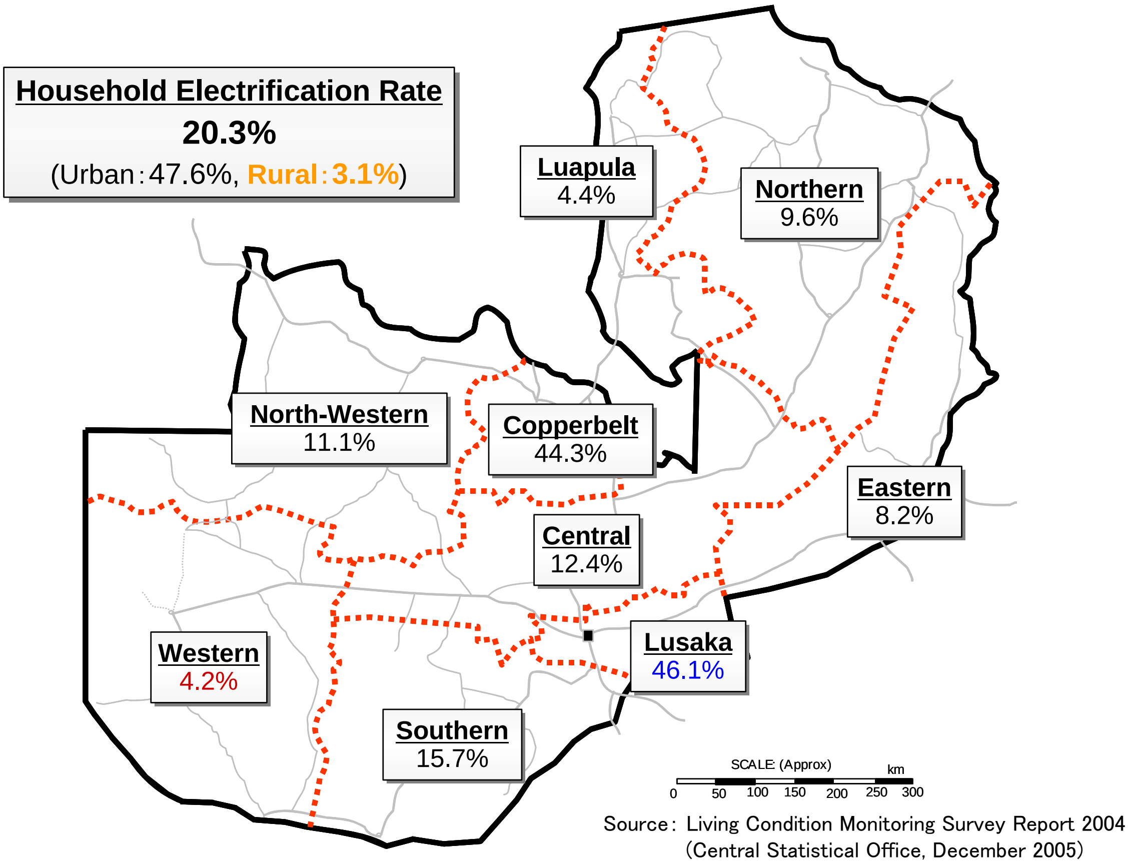


Figure 4-2 Electrification Rate (for Lighting) by Province

4.4. Rural Development Plan

The Fifth National Development Plan 2006 - 2010 (FNDP) states that the overall goal of the energy sector is "To ensure availability and accessibility to adequate and reliable supply of energy from various sources at the lowest total economic, social and environmental cost consistent with national development goals of sustained growth, employment generation and poverty reduction."

Rural development plans, however, tend to be drafted by each District in accordance with the decentralization policy. Thus, all information regarding rural development plans is neither aggregated in the Central Government nor shared among related Ministries/Organizations, such as Ministry of Local Government and Housing, Ministry of Health, Ministry of Education, Ministry of Agriculture and Cooperatives, Ministry of Energy and Water Development, and Rural Electrification Authority. These Ministries involved with the development of rural areas do not possess even basic information, such as number, names, location, and electrification status of RGCs in each District, population and number of households/business entities/public facilities in each RGC, etc. Although the Ministry of Education and the Ministry of Health have plans for the improvement of schools and hospitals/clinics, there is no centralized information regarding rural development plans and very little information is shared among Ministries. In addition, sharing of information regarding rural electrification and arrangements among DoE, REA and ZESCO have not been satisfactorily.

4.5. Selection of Electrification Target

Household access to electricity in the rural areas of Zambia is very low and was estimated as 3.1% in 2004. Even RGCs, which are the centers for rural economic activities and where public facilities such as schools and clinics are in place, are mostly not electrified. Electrification of a RGC contributes to the growth of the community market and improves the quality of public services such as education and health care that the Zambian government accords high priority. In other words, electrification of an RGC will benefit residents not only in the RGC but also in its CA. In addition, business entities generally have sufficient income to afford the connection fee and the monthly electricity tariff, resulting in a boost to the local economy. Therefore, the first REMP Workshop held in Lusaka in June 2006 resolved that the RGCs shall be the main targets of the Rural Electrification Master Plan.

Three basic strategies, listed below, were defined for executing the Rural Electrification Master Plan Study. The goals were 1) maintaining transparency in the selection of electrification targets, 2) providing equal framework for the electrification of the whole country, and 3) being consistent with national policies of decentralized planning.

- Make a long list of all unelectrified RGCs in the country based on the data submitted from each District
- Verify the electrification priority of RGCs in each district submitted by District planners
- Finalize the electrification priority of all RGCs based on the size of potential demand, economical efficiency, and socio-economical consideration

To compile a comprehensive list of all unelectrified RGCs nation-wide, it was necessary to collect the data of all the existing unelectrified RGCs in each of the 72 Districts. As stated in the previous section, this information is not available anywhere in the Government structure. Therefore, as an important task of this Study, basic demographic data and locations of both electrified and unelectrified RGCs in each District were investigated and compiled in a systematic uniformed format. At the First REMP Workshop held in Lusaka, Data Collection Sheets and Topographic Maps were distributed to each Provincial representative, who then forwarded them to District Planners to fill in the information of unelectrified RGCs that district planners consider should be given priority for electrification. These data sheets were submitted by District Planners during the Second REMP Workshop held at each of 9 Provincial Centres in November 2006 (except the one in Northern Province that was held in August 2006). The location, demographical data and their electrification status, as well as the priority of RGCs for electrification in each District, are specified in the Data Collection Sheets. Among the long list of all 1,217 unelectrified RGCs, the first prioritised RGCs to be electrified in each District, together with their reasons for selection, are short listed in Table 4-3.

The first ranked RGC in each District (except Lusaka District, which is 100% urban area and thus shall be excluded from the Study's target) were also selected as the target of socio-economic survey executed as part of this Study: The seventy-one (71) unelectrified RGCs from each District, together with 19 electrified RGCs, were selected for the field survey. The selection of 19 electrified RGCs, summarized in Table 4-4, was based on the information (such as locations and duration after electrification) provided by ZESCO Regional Offices in parallel with the Provincial Workshops. Information of these electrified RGCs also needed to be checked thoroughly in order to develop profiles of electricity consumption from which estimates of potential electricity demand of unelectrified RGCs would be derived. Through the said processes, 90 RGCs in total were selected as survey targets. The main informants interviewed and the sample RGCs are summarized in Table 4-5.

Table 4-3 Unelectrified Rural Growth Centres with the Highest Priority in Each District

		District	Ward	Rural Growth Centre	Reasons for Selection
Central Province	1	Chibombo	Kakoma	Shimukuni	Population, schools, health, trading, farming (food reserve & tobacco Scheme), access road, distance from existing distribution line
	2	Kabwe	Mpima	Mpima	Schools, health, social services, farming (food reserve, irrigation), access road, distance from existing distribution line
	3	Kapiri Mposhi	Luanchele	Chipepo	School, chief palace, local court, rural health, agricultural activities
	4	Mkushi	Kamimbya	Old Mkushi	Population, schools, health, gem stone mining, shops/social services, farming (food reserve & tobacco Scheme), police post, access road, distance from existing distribution line
	5	Mumbwa	Kalwanyembe	Mumbwa Big Concession	Farming, mining, population, schools, rural health centres, tourism
	6	Serenje	Chibale	Chibale	Population, schools, health, shops/social services, farming (food reserve & tobacco Scheme)
Copperbelt Province	7	Chiliabombwe	Anoya Zulu	Mungomba	Population, schools, health, community centre, Farming/farming (food reserve), access road, distance from existing distribution line
	8	Chingola	Kapisha	Kamiteta	Population, schools, Farm Block/farming, Cooperative, access road
	9	Kalulushi	Ichimpe	Kameme	Schools, health, Farm Block, agriculture, access road
	10	Kitwe	Limaposa	Kakolo	Schools, health, community centre, orphanage, NGO cooperative for farmers, access road, distance from existing distribution line
	11	Luanshya	Chitwi	Kafubu	Population, schools, health, community centre, Farming Block/farming, Farmers Union
	12	Lufwanyama	(N.A.)	Emerald Mining Area	Mining emerald, schools, health, clubs cooperative, access road, shops/social services
	13	Masaiti	Mutaba	Mutaba	Population, schools, health, shops/social services, farmers cooperative (women's) access road
	14	Mpongwe	Mikata	Mikata	Schools, health, shops/social services, farming/cooperatives, distance from existing distribution line
	15	Mufulira	Mutundu	Mutundu North	Schools, health, shops/business, cooperative Farm Block, access road
	16	Ndola	Kavu	Kanglonga	Schools, health, shops/businesses, Farm Block/farming cooperative, access road, distance from existing distribution line
Eastern Province	17	Chadiza	Kamini	Mlolo	Population, schools, health, shops/businesses, resettlement scheme, farming cooperative, access road
	18	Chama	Kalinkhu	Kalinkhu	Population, schools, health, shops/businesses, hammer mill, farmers cooperative
	19	Chipata	(N.A.)	Chiparamba	Population, schools, health, social services, farming (food reserve & tobacco scheme), access road, distance from existing distribution line
	20	Katete	Kapangulula	Kagoro	Population, schools, health, shops/businesses, farm block, farmers union, food reserve, tobacco scheme, access road
	21	Lundazi	Chimaliro	Mwase	Population, schools, health, shops/businesses, hammer mills, NGO farmers cooperative,
	22	Mambwe	Mphomwa	Mphomwa Tse-tse	Schools, shops/businesses, farmers cooperative, access road distribution line
	23	Nyimba	Ngozi	Chipembe	Population, secondary schools, shops/businesses, restaurants, small factories, farmers cooperative, access road, distance from existing distribution line
	24	Petauke	Matambazi	Kapungwe	Population, schools, shops, farm block, farmers cooperative, access road from existing distribution line
Luapula Province	25	Chienge	Lunchinda	Lupiya	Schools, shops/businesses, hammer mills, farm blocks, farmers cooperatives, access road,
	26	Kawambwa	Mulunda	Chama	Population, schools/health, shops/businesses, hammer mill, farm block, access road,
	27	Mansa	Chibeleka	Kasongwa Sub Boma	Population, schools/health, shops/businesses, hammer mill, farmers cooperatives, access road
	28	Milenge	Mikula	Tayali	Population, schools/health, shops/businesses, hammer mill, farmers cooperatives, access road
	29	Mwense	Mpasa	Katuta	Schools/health, shops, hammer mill, farm block, farmers cooperatives, access road
	30	Nchelenge	Chilongo	Chilongo	Population, schools, small factory, hammer mill, access road
	31	Samfya	Kapata	Chinsanka	Population, primary schools, shops/businesses/market, hammer mill, farm block, farmers cooperatives, access road distribution line
Lusaka Province	32	Chongwe	Bunda Bunda	Chinyunyu	Schools/health, shops/businesses, market, hammer mill, farm block, farmers cooperatives, access road, distance from existing distribution line
	33	Kafue	Malundu	Chipapa	Population, schools/health, shops/businesses, market, hammer mill, farm block, farmers cooperatives, access road, distance from existing distribution line
	34	Luangwa	Dzalo	Luangwa Boma	Population, schools/health, shops/businesses, hammer mill, farm block, farmers cooperatives, access road, distance from existing distribution line
	-	*Lusaka*	-	-	** No candidate RGC was selected from Lusaka District, where 100% of the population lives in "urban" area.*
Northern Province	35	Chilubi	Santa Maria	Kambashi	Schools/health, shops/businesses, fishing, small industries, hammer mill, distance from existing distribution line
	36	Chinsali	Mukumbi	Shiwangandu	Micro-hydro potential, population, schools/health, shops/businesses/small industries, tourism, hammer mill, farmers cooperative, access road, distance from existing distribution line
	37	Isoka	Kalansa	Muyombe	Schools/health, shops/businesses/markets, hammer mill, access road
	38	Kaputa	(N.A.)	Nsama Sub Boma	(No info available)
	39	Kasama	Musowa	Kachuma	Population, schools, shops, hammer mill, farm block, farmers cooperatives, access road
	40	Luwingu	(N.A.)	Masonde	(No info available)
	41	Mbala	Lapisha	Chimula	Population, schools/health, shops/businesses, hammer mill, farm block, farmers cooperatives, access road
	42	Mpika	Chibwa	Kanchibiya	Schools/health, shops/businesses, hammer mill, farm block, farmers cooperatives, access road
	43	Mporokoso	Kalungwishi	Mukupakaoma	Micro-hydro potential, population, schools/health, shops/businesses/markets, hammer mill, farm block, farmers cooperatives
	44	Mpulungu	Kapembwa	Kasaba Bay	(No info available)
	45	Mungwi	Mpanda	Makasa	Schools/health, shops/businesses, farmers cooperatives, (food reserve & tobacco Scheme), access road, distance from existing distribution line
	46	Nakonde	Isunda	Wulongo	Population, schools/health, shops/businesses, hammer mill, farm block, farmers cooperatives, access road, distance from existing distribution line
North-Western Province	47	Chavuma	Chivombo	Chivombo	Micro-hydro potential, Population, schools/health, shops, hammer mill, farm block, farmers cooperatives, access road, distance from existing distribution line
	48	Kabompo	Kashinakazhi	Kashinakazhi	Population, schools/health, shops/market, farmers cooperatives, access road
	49	Kasempa	Nselauke	Nselauke	Population, schools/health, shops/businesses/market, hammer mill, farmers cooperatives, access road, distance from existing distribution line
	50	Mufumbwe	Matushi	Matushi	Population, schools/health, shops/market, hammer mill, farm block, farmers cooperatives, access road, distance from existing distribution line
	51	Mwinilunga	Ntambu	Ntambu	Micro-hydro potential, population, schools/health, shops/businesses/markets, hammer mill, farmers cooperatives, access road
	52	Solwezi	Mumena	Mumena	Population, schools/health, shops/businesses/market, hammer mill
	53	Zambezi	Chitokoloki	Chitokoloki	Micro-hydro potential, population, schools/health, shops/businesses/market/small factory, hammer mill, farm block, farmers cooperatives, access road
Southern Province	54	Choma	Hamaundu	Kachomba	Population, schools, Courts, health, community centre, farming (food reserve), access road
	55	Gwembe	Chibuwe	Siabwengo	Fishing camp, schools, health, social services, distance from existing distribution line
	56	Itezhi-tezhi	Lubanda	Lubanda	Schools, health, social services, Farm Block/farming, food reserve, agric camp, Vet Camp, groceries/shops, hammer mills
	57	Kalomo	Mbwiko	Napatizya	Schools, health, social services, Farm Block/farming, food reserve, agric camp, Vet Camp, groceries/shops, hammer mills
	58	Kazungula	Sekute	Mambova	Schools, health, community centre, Agric depot
	59	Livingstone	Kasiya	Kasiya	Population, schools, health, social services, farm Block/farming (food reserve & tobacco Scheme), access road, distance from existing distribution line
	60	Mazabuka	Magoye	Ngwezi	Population, schools, health, social services, farming (food reserve & tobacco Scheme), access road, distance from existing distribution line
	61	Monze	Choongo East	Kamuzya East	Agriculture, population, social amenities, schools, health, food reserve, distance from existing distribution line
	62	Namwala	Bambwe	Bambwe	Cattle faring, palaces, population, schools, health, (food reserve & tobacco Scheme), access road, distance from existing distribution line
	63	Siavonga	Nanyanga	Namoomba	Population, schools, health, social services, farming (food reserve & tobacco Scheme), access road, distance from existing distribution line
	64	Sinazongwe	Malima	Sinakaimbi	Farmers Training Centre, Population, schools, health, business facilities, farming, access road, distance from existing distribution line
Western Province	65	Kalabo	Maala	Sikongo	Population, schools/health, shops/businesses, hammer mill, farm block, farmers cooperatives, access road
	66	Kaoma	Nkeyama	Nkeyama	Population, schools/health, shops/businesses, hammer mills, farm block, farmers cooperatives, (tobacco Scheme), access road
	67	Lukulu	(N.A.)	Lukulu Boma	Population, schools/health, shops/businesses, markets, hammer mill, farm block, access road
	68	Mongu	Nangula	Nangula	Population, schools/health, shops/businesses/small industries, hammer mill, food reserve, access road
	69	Senanga	Muoyo	Sianda	Schools, shops/businesses, market, small factories, hammer mill, farmers cooperatives, access road, distance from existing distribution line
	70	Sesheke	Sichili	Sichili	Schools/health, shops/businesses/small industries, hammer mill, farmers cooperatives, access road
	71	Shang'ombo	Simu	Shang'ombo	Population, schools/health, shops/businesses/small industries, hammer mill, farm block, NGO farmers cooperatives, access road, distance from

Table 4-4 Electrified Rural Growth Centres for Socio-Economic Survey

		District	Ward	Rural Growth Centre
Central Province	1	Kapiri Mposhi	(N.A)	Mpula
	2	Kabwe	Mpunde	Mpunde
Copperbelt Province	3	Ndola	Kafulafuta	Mishikishi
	4	Ndola	Kafulafuta	Chiwala
Luapula Province	5	Nchelenge	Kasamba	Kambwali
	6	Mansa	Luapula	Chembe
	7	Kawambwa	(N.A)	Munkanta
	8	Mansa	(N.A)	Luamfumu
Lusaka Province	9	Chongwe	Nakatindi	Nchute
	10	Kafue	Chiawa	Chiawa
Northern Province	11	Kasama	Chamfubu	Nseluka
North-Western Province	12	Mwinilunga	(N.A)	Kabanda
	13	Solwezi	(N.A)	Kapinjimpanga
Southern Province	14	Livingstone	Mukuni	Mukuni Village
	15	Choma	Singani	Mochipapa
	16	Livingstone	Musokotwane	Musokotwane Village
	17	Livingstone	(N.A)	Mwandi Village
Western Province	18	Senanga	Imatonga	Senanga
	19	Mongu	Sefula	Sefula

Table 4-5 Sampling Targets and Numbers for Socioeconomic Survey

Type of RGCs	Sampling Items	Sampling Target & Number	Sampling Method
All RGCs	Characteristics of each RGC	90 RGCs (71 Unelectrified +19 Electrified)	- Data collection at Central Statistical Office (CSO) - Measurement by enumerators - Interview with key informants (any of the following institutions), using the prepared questionnaire: 1) District Commissioners 2) District ZESCO Managers 3) Local Institutions of Local Government and Housing officials in the RGC (Councils) 4) Local Ministry of Heath officials in the RGC 5) Local Ministry of Education officials in the RGC 6) Local Ministry of Agriculture officials in the RGC 7) Local Community Development Officials in the RGC 8) Representatives of Business Associations in the RGC 9) Representatives of Farmers' Associations in the RGC 10) Representatives of Residents in the RGC 11) Ministry of Community Development and Social Services
Unelectrified RGCs	Characteristics of unelectrified public facilities, households, and business entities, such as potential power demand	All public facilities in 71 Unelectrified RGCs	- Individual interview with representatives of all public facilities, such as hospitals, clinics, schools, police post, post office, immigration office and so on, using prepared questionnaires.
		13 interviewees (7 households + 6 business owners) per RGC Total sampling number: 923 (= 13 x 71RGCs)	- Individual interview with randomly selected unelectrified households and business owners in each RGC, using prepared questionnaires.
Electrified RGCs	Characteristics of electrified public facilities, households, and business entities, such as consumption record and demand growth	All public facilities in 19 Electrified RGCs	- Individual interview with representatives of all public facilities, such as hospital, clinic, school, police, post office, immigration office and so on, using prepared questionnaires
		20 interviewees (14 households + 6 business owners) per RGC Total sampling number: 380 (= 20 x 19RGCs)	- Individual interview with randomly selected electrified households and business owners in each RGC, using prepared questionnaires.
	Characteristics of unelectrified households and business entities, such as seasons why still not electrified	10 interviewees (6 households + 4 business owners) per RGC Total sampling number: 190 (= 10 x 19RGCs)	- Individual interview with randomly selected households and business owners in each RGC, who have not received electricity, using prepared questionnaires.

4.6. Collected Sample Sizes

In the socio-economic survey, data necessary for the analysis in both the technical and social aspects of the 90 RGCs – 71 unelectrified and 19 electrified – were collected from four different types of interviewees: 1) household representatives, 2) business owners, 3) representatives of each public facility, and 4) key-informants of each RGC. The socio-economic survey took place from December 2006 to February 2007. Among 71 targeted unelectrified RGCs, 11 RGCs were not accessible due to the heavy rains that made it impossible to use access roads. For these 11 unelectrified RGCs, 8 RGCs were replaced by other unelectrified RGCs in the same District of the originally targeted RGCs; 1 RGC was substituted by an electrified RGC; and 2 RGCs (Kalinku in Eastern Province and Ntambu in North Western Province, were unaccessible) were unable to be replaced at all, as shown in Table 4-6. In addition, 4 RGCs (Mpima in Central Province, Kangonga in Copperbelt Province, Luangwa Boma in Lusaka Province, and Lukulu Boma in Western Province) considered as unelectrified were found to be electrified, while 1 RGC (Nchute in Lusaka Province) considered as electrified were detected as unelectrified in the survey. As a result, data was collected from 23 electrified and 65 unelectrified RGCs: 4 more electrified and 6 less unelectrified RGCs than the targeted numbers. The number of surveyed RGCs by Province is summarised in Table 4-7.

Out of these 88 RGCs, socio-economic data were collected from 681 households, 379 business entities, 267 public facilities and 88 key-informants as summarized in Table 4-8. The actual collected data were less than the targeted numbers: 78% for households and 62% for business entities. The situations above arose because the connected households in electrified RGCs and the business entities existing in the surveyed RGCs were less than the targeted numbers.

Although the sample sizes were smaller than the targeted numbers, the analysis used these data as they were the only primary data available, no secondary data were substitutable, and they were the most reliable information collected using the questionnaire designed by the Study Team. No secondary data were available.

Table 4-6 Inaccessible RGCs and Diffirent Electrificatoin Status

		District	Ward	Rural Growth Centre	Note	Replacement	Elec. Status
Central Province	1	Chibombo	Kakoma	Shimukuni			
	2	Kabwe	Mpima	Mpima	Electrified		
	3	Kapiri Mposhi	Luanchele	Chipepo			
	4	Mkushi	Kamimbya	Old Mkushi			
	5	Mumbwa	Kalwanyembe	Mumbwa Big Concession			
	6	Serenje	Chibale	Chibale			
Copperbelt Province	7	Chiliabombwe	Anoya Zulu	Mungomba			
	8	Chingola	Kapisha	Kamiteta			
	9	Kalulushi	Ichimpe	Kameme			
	10	Kitwe	Limaposa	Kakolo			
	11	Luanshya	Chitwi	Kafubu			
	12	Lufwanyama	(N.A.)	Emerald Mining Area			
	13	Masaiti	Mutaba	Mutaba			
	14	Mpongwe	Mikata	Mikata			
	15	Mufulira	Mutundu	Mutundu North			
	16	Ndola	Kavu	Kanglonga	Electrified		
Eastern Province	17	Chadiza	Kamini	Mlolo			
	18	Chama	Kalinkhu	Kalinkhu	Inaccessible	No Place	-
	19	Chipata	(N.A.)	Chiparamba			
	20	Katete	Kapangulula	Kagoro			
	21	Lundazi	Chimaliro	Mwase			
	22	Mambwe	Mphomwa	Mphomwa Tse-tse			
	23	Nyimba	Ngozi	Chipembe			
	24	Petauke	Matambazi	Kapungwe			
Luapula Province	25	Chienge	Lunchinda	Lupiya	Inaccessible	Kalobwa	Electrified
	26	Kawambwa	Mulunda	Chama	Inaccessible	Mushota	Unelectrified
	27	Mansa	Chibeleka	Kasongwa Sub Boma			
	28	Milenge	Mikula	Tayali			
	29	Mwense	Mpasa	Katuta			
	30	Nchelenge	Chilongo	Chilongo			
	31	Samfya	Kapata	Chinsanka			
Lusaka Province	32	Chongwe	Bunda Bunda	Chinyunyu			
	33	Kafue	Malundu	Chipapa			
	34	Luangwa	Dzalo	Luangwa Boma	Electrified		
	-	Lusaka	-	-			
Northern Province	35	Chilubi	Santa Maria	Kambashi	Inaccessible	Matipa	Unelectrified
	36	Chinsali	Mukumbi	Shiwangandu			
	37	Isoka	Kalansa	Muyombe			
	38	Kaputa	(N.A.)	Nsama Sub Boma			
	39	Kasama	Musowa	Kachuma			
	40	Luwingu	(N.A.)	Masonde			
	41	Mbala	Lapisha	Chimula			
	42	Mpika	Chibwa	Kanchibiya			
	43	Mporokoso	Kalungwishi	Mukupakaoma			
	44	Mpulungu	Kapembwa	Kasaba Bay	Inaccessible	Chitimbwa	Unelectrified
	45	Mungwi	Mpanda	Makasa	Inaccessible	Rosa	Unelectrified
	46	Nakonde	Isunda	Wulongo			
North-Western Province	47	Chavuma	Chivombo	Chivombo			
	48	Kabompo	Kashinakazhi	Kashinakazhi			
	49	Kasempa	Nselauke	Nselauke			
	50	Mufumbwe	Matushi	Matushi			
	51	Mwinilunga	Ntambu	Ntambu	Inaccessible	No Place	-
	52	Solwezi	Mumena	Mumena			
	53	Zambezi	Chitokoloki	Chitokoloki			
Southern Province	54	Choma	Hamaundu	Kachomba			
	55	Gwembe	Chibuwe	Siabwengo			
	56	Itezhi-tezhi	Lubanda	Lubanda			
	57	Kalomo	Mbwiko	Napatizya	Inaccessible	Kabanga	Unelectrified
	58	Kazungula	Sekute	Mambova			
	59	Livingstone	Kasiya	Kasiya			
	60	Mazabuka	Magoye	Ngwezi			
	61	Monze	Choongo East	Kamuzya East			
	62	Namwala	Bambwe	Bambwe			
	63	Siavonga	Nanyanga	Namoomba			
	64	Sinazongwe	Malima	Sinakaimbi			
Western Province	65	Kalabo	Maala	Sikongo	Inaccessible	Nangweshi	Unelectrified
	66	Kaoma	Nkeyama	Nkeyama			
	67	Lukulu	(N.A.)	Lukulu Boma	Electrified		
	68	Mongu	Nangula	Nangula			
	69	Senanga	Muoyo	Sianda			
	70	Sesheke	Sichili	Sichili			
	71	Shang'ombo	Simu	Shang'ombo	Inaccessible	Sioma	Unelectrified

Table 4-7　Number of Surveyed RGCs by Province

Province	Electrified	Unelectrified	Total
Central	3	5	8
Copperbelt	3	9	12
Eastern	0	7	7
Luapula	5	6	11
Lusaka	2	2	5
Northern	1	12	13
North Western	2	6	8
Southern	4	11	15
Western	3	7	9
Total	23	65	88

Table 4-8　Collected Sample Sizes in Socio-economic Survey

	TARGET			ACHIEVEMENT			
	Electrified	Unelectrified	Total	Electrified	Unelectrified	Total	%
RGCs	19	71	90	23	65	88	98
1) Households	380	497	877	246	435	681	78
2) Business Entities	190	426	616	124	255	379	62
Sub-total	*570*	*923*	*1,493*	*370*	*690*	*1,060*	*71*
3) Public Facility	All	All	-	149	118	267	-

4.7. Ability and Willingness to Pay

In order to analyse the connection costs and the monthly electricity tariff, this socio-economic survey investigates the amount that customers pay in electrified RGCs. The ability to pay for a monthly tariff is estimated from the current expenditures by the interviewed households on alternative energy forms in unelectrified RGCs including firewood, paraffin, charcoal and storage batteries. To determine the amount that villagers in unelectrified RGCs are willing to pay for the initial connection cost and the monthly tariff, a randomly selected sample was interviewed applying the Contingent Valuation Method (CVM). To estimate how the interviewees value the initial cost and monthly tariff, in comparison with urgency (years that they are ready to wait until receiving electricity) and daily consumable duration, Conjoint Analysis was applied in the socio-economic survey. The technique was mainly developed as a widely used factor analysis method in the field of marketing research, to identify a product with the best combination of factors/attributes for consumers.

4.7.1. Methodology to Assess Ability to Pay for Monthly Tariff

In the socio-economic survey, data (or balance sheet) of a monthly income and expenditure was collected from households and business entities to assess income, energy cost, ZESCO tariff (only for electrified households), ratio of energy cost to income, ratio of ZESCO tariff to income (only for electrified households), and ratio of ZESCO tariff to energy cost (only for electrified households). The analysis was carried out by classifying respondents into 8 categories: 1) electrified households, 2) electrified business entities, 3) unconnected households, 4) unconnected business entities in electrified RGCs; and 5) unelectrified households, 6) unelectrified business entities, 7) households with stand alone generator, 8) business entities with stand alone generator in unelectrified RGCs. Unconnected households and business entities are those who are not connected to a ZESCO distribution line even though they live in electrified RGCs. Stand alone generator is either solar home system or diesel generator. Among all collected data, only reliable data, whose total income and total expenditures were balanced, were used in the analysis. Therefore, only 301 effective data out of 1,060 collected data were used for the analysis.

4.7.2. Evaluation of Ability to Pay for Monthly Tariff

The analysis results and significance different test results by non-parametric test (Mann-Whitney U) for all the possible combination of 8 respondent categories are summarized in Table 4-9. Key findings focusing on unelectrified households and business entities in unelectrified RGCs are as follows.

(A) Monthly Income (Section (A) in Table 4-9)

The average monthly income (AMI) for unelectrified households in unelectrified RGCs was determined as K910,757. This is significantly lower than the corresponding figures in electrified RGCs, which are K1,163,721 for electrified households and K1,299,833 for households with stand alone generator (with 5% level), but higher than for unconnected households in electrified RGCs at K640,000 (with 10% level). Thus, the average incomes in unelectrified households in unelectrified RGCs is better than those for unconnected ones in electrified RGCs, but not as good as the electrified ones in electrified RGCs. [Note: Average monthly household income as of 2004 is K334,308 in rural areas, K760,629 in urban areas, and K502,030 for the whole country. *Living Condition Monitoring Survey Report 2004, Central Statistical Office, December 2005*]

The AMI for business entities in unelectrified RGCs was K4,456,118, and this value is higher than that for electrified business entities in electrified RGCs at K2,805,067, for unconnected business entities in electrified RGCs at 2,403,667, and for business entities with stand alone generator at K2,800,000. These differences, however, are not significant even with 10% level. Therefore, income level for surveyed business entities in unelectrified RGCs is as good as that for electrified ones in electrified RGCs. As expected, the AMI for business entities was generally higher than that for households.

(B) Monthly Energy Cost (Section (B) in Table 4-9)

The Average Monthly Energy Cost (AMEC) for unelectrified households in unelectrified RGCs is K59,141, and this is significantly lower than that for electrified households in electrified RGCs at K87,118 (with 1% level), but is significantly different from neither that for households with stand alone generator at K63,025 nor that for unconnected households in electrified RGCs at K53,525 (even with 10% level). Since monthly income for unelectrified households is lower than electrified households, it is not surprising that AMEC for unelectrified households are also lower than electrified households.

The AMEC for business entities in unelectrified RGCs is K75,315, and this is significantly lower than that for electrified business entities in electrified RGCs at K308,653. While monthly income between electrified and unelectrified business entities are not significantly different (in fact, the value for unelectrified business entities are larger than unelectrified ones), it seems that surveyed unelectrified business entities are affordable to pay more for energy cost.

(C) Monthly ZESCO Tariff (Section (C) in Table 4-9)

Average Monthly ZESCO Tariff (AMZT) paid by households is K52,286, while that by business entities is K201,600: business entities expense approximately 4 times on monthly ZESCO tariffs compared to households. They are significantly different with 5% significance level.

(D) Ratio of Energy Cost to Income (Section (D) in Table 4-9)

The average Ratio of monthly Energy Cost to monthly Income (RECI) for unelectrified households in unelectrified RGCs is 0.108, and this is significantly larger than that for households with stand alone generator at 0.048 (with 1% significance level), but is not different from electrified households at 0.118 and unconnected ones at 0.134, even with 10% significance level. Thus, RECI is approximately 11% for both electrified households by ZESCO and unelectrified households.

RECI for business entities in unelectrified RGCs is 0.057, and this is significantly lower than that for electrified business entities in electrified RGCs at 0.165.

(E) Ratio of ZESCO Tariff to Income (Section (E) in Table 4-9)

The average Rate of monthly ZESCO Tariff to monthly Income (RZTI) for households is 0.066, while that for business entities is 0.081. They are not significantly different even with 10% significance level, and thus approximately 6 to 8% of income is consumed by ZESCO customers no matter whether they are households or business entities.

(F) Ratio of ZESCO Tariff to Energy Cost (Section (F) in Table 4-9)

The average Rate of monthly ZESCO Tariff to monthly Energy Cost (RZTEC) for households is 0.623, while that for business entities is 0.819. They are significantly different with 1% significance level. Therefore, both business entities and households still use energy other than electricity even after electrification, but business entities seem to shift from alternative energy to electricity more remarkably than households: business entities consume less than 20% of energy cost for alternative energy after the electrification, while households still spend approximately 40% of energy cost for it.

Based on the key findings above, it is estimated that unelectrified business entities are more likely to afford monthly electricity tariff than households. By assuming that 60% of the current monthly energy expenditure could be switched to the electricity consumption for unelectrified households and 80% for unelectrified business entities after the electrification, estimated ability to pay for monthly electricity tariffs are at least K35,485 (=K59,141*0.6) for households and K60,252 (=K75,315*0.8) for business entities respectively.

Table 4-9 Analysis Results of Monthly Balance Sheet (1/2)

(A) Monthly Income [= Monthly Expenditure]

		Sample #	Average	St. Dev.	Median	LB of 95% CI	UB of 95% CI	Skewness	Kurtosis
Electrified RGC	1. Electrified HH	28	1,163,721	705,739	970,000	890,065	1,437,378	0.408	-0.631
	2. Electrified BE	15	2,805,067	2,649,242	2,600,000	1,337,965	4,272,168	1.326	1.414
	3. Unconnected HH	20	640,000	816,488	350,000	257,872	1,022,128	2.747	8.158
	4. Unconnected BE	9	2,403,667	1,981,515	1,600,000	880,539	3,926,794	1.883	3.535
Unelectrified RGC	5. Unelectrified HH	129	910,757	1,228,944	680,000	696,660	1,124,854	4.673	27.841
	6. Unelectrified BE	81	4,456,118	7,255,342	2,100,000	2,851,830	6,060,406	3.330	12.207
	7. HH with Stand Alone Generator	12	1,299,833	572,480	1,180,000	936,097	1,663,570	0.966	0.260
	8. BE with Stand Alone Generator	7	2,800,000	1,802,776	2,800,000	1,132,711	4,467,289	0.484	-1.146

		Electrified RGC				Unelectrified RGC			
		1. Electrified HH	2. Electrified BE	3. Unconnected HH	4. Unconnectedd BE	5. Unelectrified HH	6. Unelectrified BE	7. HH with Generator	8. BE with Generator
Electrified RGC	1. Electrified HH		133.0 (0.050)**	135.0 (0.002)*	68.0 (0.040)**	1218.5 (0.007)*	662.5 (0.001)*	144.0 (0.479)	43.5 (0.025)**
	2. Electrified BE	133.0 (0.050)**		57.5 (0.002)*	64.0 (0.835)	476.0 (0.001)*	566.5 (0.679)	63.5 (0.196)	45.5 (0.622)
	3. Unconnected HH	135.0 (0.002)*	57.5 (0.002)*		15.5 (0.000)*	983.0 (0.087)***	222.0 (0.000)*	31.0 (0.001)*	10.0 (0.001)*
	4. Unconnected BE	68.0 (0.040)**	64.0 (0.835)	15.5 (0.000)*		170.0 (0.000)*	350.5 (0.851)	32.0 (0.117)	27.0 (0.633)
Unelectrified RGC	5. Unelectrified HH	1218.5 (0.007)*	476.0 (0.001)*	983.0 (0.087)***	170.0 (0.000)*		2143.5 (0.000)*	375.0 (0.003)*	113.5 (0.001)*
	6. Unelectrified BE	662.5 (0.001)*	566.5 (0.679)	222.0 (0.000)*	350.5 (0.851)	2143.5 (0.000)*		339.5 (0.093)	259.5 (0.711)
	7. HH with Generator	144.0 (0.479)	63.5 (0.196)	31.0 (0.001)*	32.0 (0.117)	375.0 (0.003)*	339.5 (0.093)		19.0 (0.052)***
	8. BE with Generator	43.5 (0.025)**	45.5 (0.622)	10.0 (0.001)*	27.0 (0.633)	113.5 (0.001)*	259.5 (0.711)	19.0 (0.052)***	

(B) Monthly Energy Cost

		Sample #	Average	St. Dev.	Median	LB of 95% CI	UB of 95% CI	Skewness	Kurtosis
Electrified RGC	1. Electrified HH	28	87,118	37,728	80,750	72,489	101,747	0.334	-0.586
	2. Electrified BE	15	308,653	501,705	116,000	30,819	586,488	2.408	5.335
	3. Unconnected HH	20	53,525	47,270	34,500	31,402	75,648	1.045	-0.309
	4. Unconnected BE	9	101,267	107,891	60,000	18,334	184,199	1.387	1.192
Unelectrified RGC	5. Unelectrified HH	129	59,141	49,182	50,600	50,573	67,709	2.395	10.373
	6. Unelectrified BE	81	75,315	70,731	53,000	59,675	90,955	1.887	4.311
	7. HH with Stand Alone Generator	12	63,025	63,909	51,500	22,419	103,631	2.024	4.909
	8. BE with Stand Alone Generator	7	736,000	1,460,099	100,000	-614,366	2,086,366	2.499	6.355

		Electrified RGC				Unelectrified RGC			
		1. Electrified HH	2. Electrified BE	3. Unconnected HH	4. Unconnectedd BE	5. Unelectrified HH	6. Unelectrified BE	7. HH with Generator	8. BE with Generator
Electrified RGC	1. Electrified HH		159.0 (0.194)	142.0 (0.004)*	105.0 (0.457)	1003.5 (0.000)*	801.5 (0.021)**	96.0 (0.034)**	92.5 (0.821)
	2. Electrified BE	159.0 (0.194)		67.5 (0.006)*	46.0 (0.199)	474.0 (0.001)*	356.5 (0.011)**	41.0 (0.017)**	50.5 (0.888)
	3. Unconnected HH	142.0 (0.004)*	67.5 (0.006)*		67.0 (0.278)	1145.0 (0.419)	660.5 (0.202)	115.0 (0.846)	45.5 (0.175)
	4. Unconnected BE	105.0 (0.457)	46.0 (0.199)	67.0 (0.278)		496.0 (0.466)	342.0 (0.762)	43.5 (0.454)	24.0 (0.427)
Unelectrified RGC	5. Unelectrified HH	1003.5 (0.000)*	474.0 (0.001)*	1145.0 (0.419)	496.0 (0.466)		4749.0 (0.267)	768.0 (0.965)	324.0 (0.209)
	6. Unelectrified BE	801.5 (0.021)**	356.5 (0.011)**	660.5 (0.202)	342.0 (0.762)	4749.0 (0.267)		426.0 (0.491)	212.0 (0.270)
	7. HH with Generator	96.0 (0.034)**	41.0 (0.017)**	115.0 (0.846)	43.5 (0.454)	768.0 (0.965)	426.0 (0.491)		29.0 (0.271)
	8. BE with Generator	92.5 (0.821)	50.5 (0.888)	45.5 (0.175)	24.0 (0.427)	324.0 (0.209)	212.0 (0.270)	29.0 (0.271)	

(C) Monthly ZESCO Tariff

		Sample #	Average	St. Dev.	Median	LB of 95% CI	UB of 95% CI	Skewness	Kurtosis
Electrified RGC	1. Electrified HH	28	52,286	31,061	46,500	40,241	64,330	1.407	2.465
	2. Electrified BE	15	201,600	419,889	87,000	-30,927	434,127	3.710	14.070
	3. Unconnected HH	-	-	-	-	-	-	-	-
	4. Unconnected BE	-	-	-	-	-	-	-	-
Unelectrified RGC	5. Unelectrified HH	-	-	-	-	-	-	-	-
	6. Unelectrified BE	-	-	-	-	-	-	-	-
	7. HH with Stand Alone Generator	-	-	-	-	-	-	-	-
	8. BE with Stand Alone Generator	-	-	-	-	-	-	-	-

		Electrified RGC				Unelectrified RGC			
		1. Electrified HH	2. Electrified BE	3. Unconnected HH	4. Unconnectedd BE	5. Unelectrified HH	6. Unelectrified BE	7. HH with Generator	8. BE with Generator
Electrified RGC	1. Electrified HH		113.5 (0.014)**						
	2. Electrified BE	113.5 (0.014)**							
	3. Unconnected HH								
	4. Unconnected BE								
Unelectrified RGC	5. Unelectrified HH								
	6. Unelectrified BE								
	7. HH with Generator								
	8. BE with Generator								

[Note]
Upper: Mann-Whitney's U Value
Lower: (P-Value)

* : Significantly different with 1% level
** : Significantly different with 5% level
***: Significantly different with 10% level

Table 4-9 Analysis Results of Monthly Balance Sheet (2/2)

(D) Energy Cost/Income Rate [= (B) / (A)]

		Sample #	Average	St. Dev.	Median	LB of 95% CI	UB of 95% CI	Skewness	Kurtosis
Electrified RGC	1. Electrified HH	28	0.118	0.105	0.078	0.077	0.159	1.888	3.093
	2. Electrified BE	15	0.165	0.246	0.057	0.029	0.302	2.830	8.919
	3. Unconnected HH	20	0.134	0.115	0.089	0.080	0.188	1.689	3.196
	4. Unconnected BE	9	0.056	0.069	0.029	0.003	0.109	2.012	3.982
Unelectrified RGC	5. Unelectrified HH	129	0.108	0.091	0.083	0.092	0.124	2.208	6.274
	6. Unelectrified BE	81	0.057	0.092	0.023	0.036	0.077	2.852	8.252
	7. HH with Stand Alone Generator	12	0.048	0.035	0.045	0.026	0.071	0.307	-1.608
	8. BE with Stand Alone Generator	7	0.167	0.251	0.083	-0.065	0.399	2.255	5.292

		Electrified RGC				Unelectrified RGC			
		1. Electrified HH	2. Electrified BE	3. Unconnected HH	4. Unconnectedd BE	5. Unelectrified HH	6. Unelectrified BE	7. HH with Generator	8. BE with Generator
Electrified RGC	1. Electrified HH		183.5 (0.499)	244.5 (0.458)	52.5 (0.009)*	1760.5 (0.835)	423.0 (0.000)*	84.0 (0.013)**	86.5 (0.635)
	2. Electrified BE	183.5 (0.499)		129.0 (0.484)	40.5 (0.107)	901.5 (0.666)	316.0 (0.003)*	60.0 (0.143)	49.0 (0.805)
	3. Unconnected HH	244.5 (0.458)	129.0 (0.484)		38.0 (0.014)**	1123.5 (0.354)	307.0 (0.000)*	55.0 (0.011)**	58.5 (0.524)
	4. Unconnected BE	52.5 (0.009)*	40.5 (0.107)	38.0 (0.014)**		289.0 (0.012)**	325.0 (0.595)	51.5 (0.859)	22.0 (0.315)
Unelectrified RGC	5. Unelectrified HH	1760.5 (0.835)	901.5 (0.666)	1123.5 (0.354)	289.0 (0.012)**		2175.5 (0.000)*	387.0 (0.004)*	418.5 (0.745)
	6. Unelectrified BE	423.0 (0.000)*	316.0 (0.003)*	307.0 (0.000)*	325.0 (0.595)	2175.5 (0.000)*		388.0 (0.261)	181.0 (0.114)
	7. HH with Generator	84.0 (0.013)**	60.0 (0.143)	55.0 (0.011)**	51.5 (0.859)	387.0 (0.004)*	388.0 (0.261)		29.0 (0.272)
	8. BE with Generator	86.5 (0.635)	49.0 (0.805)	58.5 (0.524)	22.0 (0.315)	418.5 (0.745)	181.0 (0.114)	29.0 (0.272)	

(E) ZESCO Tariff/Income Rate [= (C) / (A)]

		Sample #	Average	St. Dev.	Median	LB of 95% CI	UB of 95% CI	Skewness	Kurtosis
Electrified RGC	1. Electrified HH	28	0.066	0.058	0.053	0.044	0.088	2.878	10.900
	2. Electrified BE	15	0.081	0.069	0.054	0.043	0.119	0.974	-0.480
	3. Unconnected HH	-	-	-	-	-	-	-	-
	4. Unconnected BE	-	-	-	-	-	-	-	-
Unelectrified RGC	5. Unelectrified HH	-	-	-	-	-	-	-	-
	6. Unelectrified BE	-	-	-	-	-	-	-	-
	7. HH with Stand Alone Generator	-	-	-	-	-	-	-	-
	8. BE with Stand Alone Generator	-	-	-	-	-	-	-	-

		Electrified RGC				Unelectrified RGC			
		1. Electrified HH	2. Electrified BE	3. Unconnected HH	4. Unconnectedd BE	5. Unelectrified HH	6. Unelectrified BE	7. HH with Generator	8. BE with Generator
Electrified RGC	1. Electrified HH		198.0 (0.760)						
	2. Electrified BE	198.0 (0.760)							
	3. Unconnected HH								
	4. Unconnected BE								
Unelectrified RGC	5. Unelectrified HH								
	6. Unelectrified BE								
	7. HH with Generator								
	8. BE with Generator								

(F) ZESCO Tariff/Energy Cost Rate [= (C) / (B)]

		Sample #	Average	St. Dev.	Median	LB of 95% CI	UB of 95% CI	Skewness	Kurtosis
Electrified RGC	1. Electrified HH	28	0.623	0.235	0.686	0.532	0.714	-0.481	-0.751
	2. Electrified BE	15	0.819	0.296	0.958	0.655	0.983	-1.932	2.782
	3. Unconnected HH	-	-	-	-	-	-	-	-
	4. Unconnected BE	-	-	-	-	-	-	-	-
Unelectrified RGC	5. Unelectrified HH	-	-	-	-	-	-	-	-
	6. Unelectrified BE	-	-	-	-	-	-	-	-
	7. HH with Stand Alone Generator	-	-	-	-	-	-	-	-
	8. BE with Stand Alone Generator	-	-	-	-	-	-	-	-

		Electrified RGC				Unelectrified RGC			
		1. Electrified HH	2. Electrified BE	3. Unconnected HH	4. Unconnectedd BE	5. Unelectrified HH	6. Unelectrified BE	7. HH with Generator	8. BE with Generator
Electrified RGC	1. Electrified HH		96.0 (0.004)*						
	2. Electrified BE	96.0 (0.004)*							
	3. Unconnected HH								
	4. Unconnected BE								
Unelectrified RGC	5. Unelectrified HH								
	6. Unelectrified BE								
	7. HH with Generator								
	8. BE with Generator								

[Note]
Upper: Mann-Whitney's U Value
Lower: (P-Value)

* : Significantly different with 1% level
** : Significantly different with 5% level
***: Significantly different with 10% level

4.7.3. Methodology to Assess Willingness to Pay

To analyze residents' willingness to pay for initial cost (such as ZESCO line connection fee, contribution for micro/mini hydropower plant, and solar home system installation) and monthly tariff in unelectrified RGCs, Contingent Valuation Method (CVM) was adopted. Regarding the energy consumption mode, four (4) scenarios were prepared:

Scenario 1: No electricity

Scenario 2: Electricity supplied by Solar Home System (SHS)

Scenario 3: Electricity supplied by micro/mini hydropower plant with isolated distribution network

Scenario 4: Electricity supplied by ZESCO distribution line

Details of each scenario were explained to interviewees from enumerators, and by comparing Scenario 1 to each of Scenario 2, 3, and 4, their willingness to pay for initial cost and monthly tariff were asked by the double bound method. In the double bound method, the firstly asked prices were randomly selected either K1,000,000, K1,500,000, K2,000,000, K3,000,000, or K4,000,000 for initial cost; and either K10,000, K15,000, K20,000, K30,000, or K40,000 for monthly tariff. When an interviewee was willing to pay for the first asked price, one step higher price was asked; while when an interviewee was not willing to pay for the first asked price, one step lower price was asked. For example, if an interviewee was asked K4,000,000 for the initial cost in the first question and expressed the willingness to pay (or answered "yes") for the price, whether the interviewee is willing to pay at K5,000,000 for the initial cost is asked as the second question. Another example is that if an interviewee disagreed on the monthly tariff at K10,000, the interviewee is asked K5,000 in the second question (refer to Table 4-10). Data was collected from 784 households and business entities in total.

Table 4-10 Price Categories Used in Double Bound Method for CVM

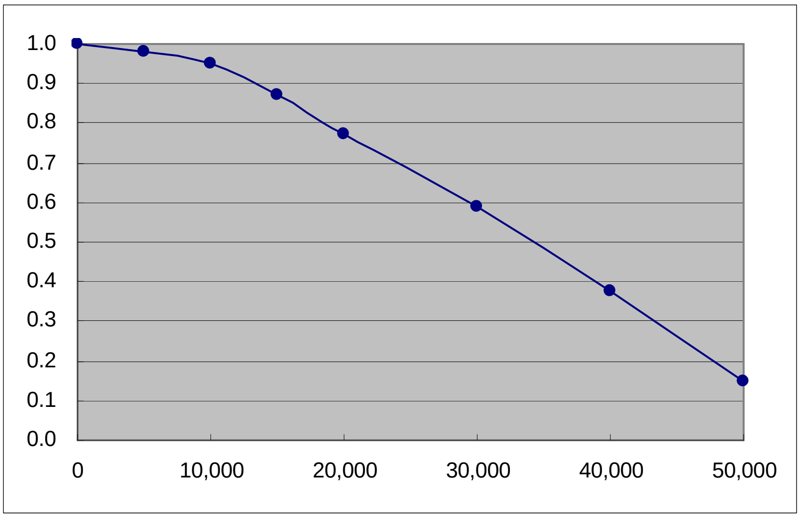
Initial Cost	K500,000, K1,000,000, K1,500,000, K2,000,000, K3,000,000, K4,000,000, K5,000,000
Monthly Tariff	K5,000, K10,000, K15,000, K20,000, K30,000, K40,000, K50,000

4.7.4. Willingness to Pay for Monthly Tariff

Analysis results regarding willingness to pay for monthly tariff for each of electrification methods (SHS, micro/mini hydro, and ZESCO distribution line) are summarized in Figure 4-3. By comparing the middle average values obtained by Turnbull method (non-parametric method) for each method, SHS at K32,634 is the lowest, micro/mini hydropower at K33,227 is the middle, and ZESCO distribution line at K37,194 is the highest. These results indicate that the willingness to pay for monthly tariff becomes higher as convenience (such as usable duration and amount) and reliability of supplied electricity are better. The willingness to pay for monthly tariff for ZESCO service shows quite close value to the estimated households' ability to pay at K35,485 in the section 4.7.2.

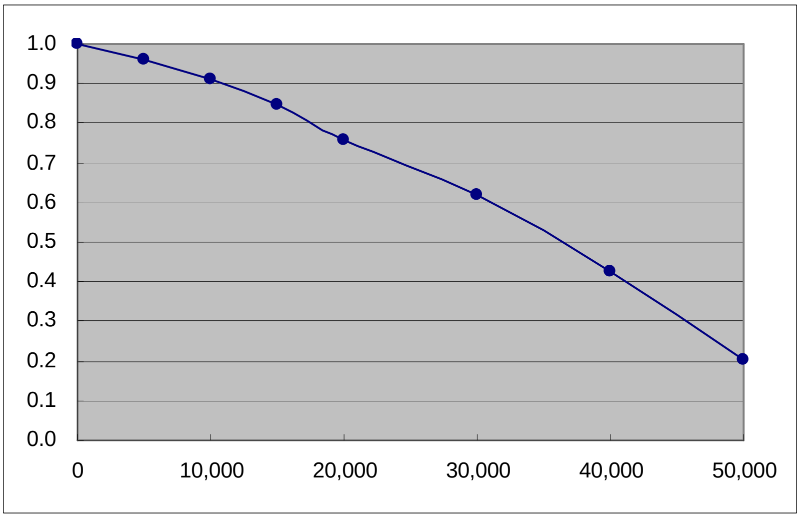
These values, however, could be underestimated as more than 30% of interviewees still expressed the willingness to pay at K50,000 for ZESCO service: price categories selected in double bound method for monthly tariff was low.

(A) Solar Home System



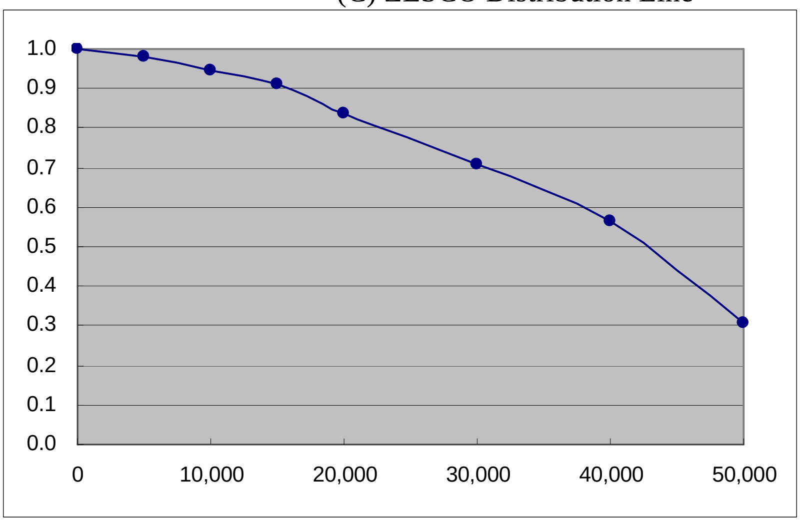
	Average
Lower Bound	28,949
Middle	32,634
Upper Bound	36,320

(B) Micro/Mini Hydropower Plant



	Average
Lower Bound	29,840
Middle	33,227
Upper Bound	36,615

(C) ZESCO Distribution Line



	Average
Lower Bound	34,131
Middle	37,197
Upper Bound	40,263

Figure 4-3 Willingness to Pay for Monthly Tariff

4.7.5. Willingness to Pay for Initial Cost

Analysis results regarding willingness to pay for initial cost for each of electrification methods (SHS, micro/mini hydro, and ZESCO distribution line) are summarized in Figure 4-4 (on the next page). By comparing the middle average values obtained by Turnbull method (non-parametric method) for each method, initial cost for SHS at K2,105,556 and that for micro/mini hydropower at K2,118,646 are similar, while that for ZESCO distribution line at K2,508,483 is much higher than the others. These results indicate that unelectrified residents wish to receive electricity from ZESCO distribution line, even if they need to pay more initial cost than SHS or micro/mini hydropower with isolated grid.

Figure 4-5 shows actual connection fee for both 1 phase and 3 phase charged by ZESCO in each of urban, peri-urban, and rural areas. ZESCO charges higher connection fee in rural areas (K4,887,000 for 3 phase and K2,873,000 for 1 phase) than urban and peri-urban. The connection fee for 1 phase in rural area is slightly more expensive than the average willingness to pay for ZESCO connection by the socio-economic surveyed residents in unelectrified RGCs. Since the average monthly household income in unelectrified RGCs is K910,757 (refer to section 4.7.2.), connection fee for 1 phase is about 3 times and that for 3 phase is more than 5 times of it. The average monthly business entity income in unelectrified RGCs (K4,456,118) is close to the 3 phase connection fee, and thus business entities seem to reasonably afford it.

As a socio-economic survey result, it was found that approximately 20% of households have connected to ZESCO in the electrified RGCs (details are shown in Table 5-1). In Figure 4-4, the willingness to pay for 20% of residents in unelectrified RGCs is approximately K3,800,000, which is coincidently similar to the average connection fee of 1 phase and 3 phase in rural areas.

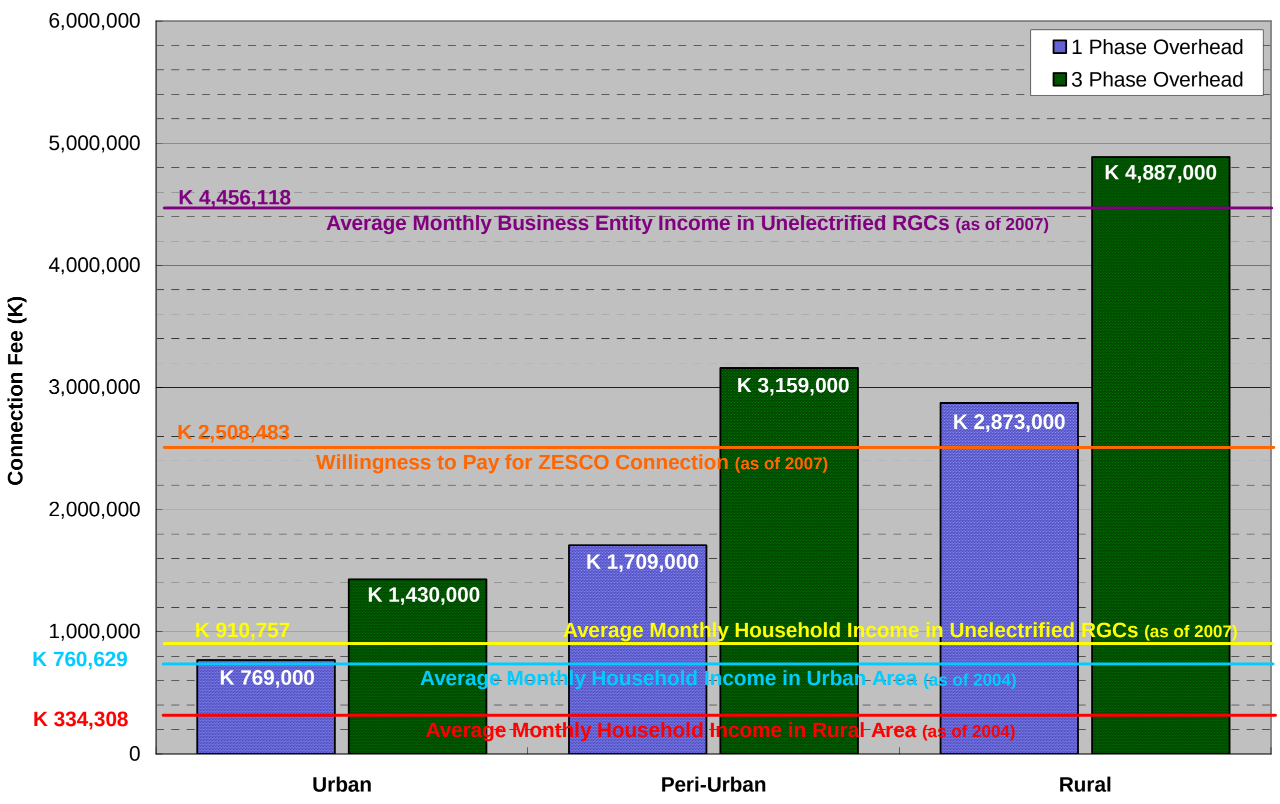
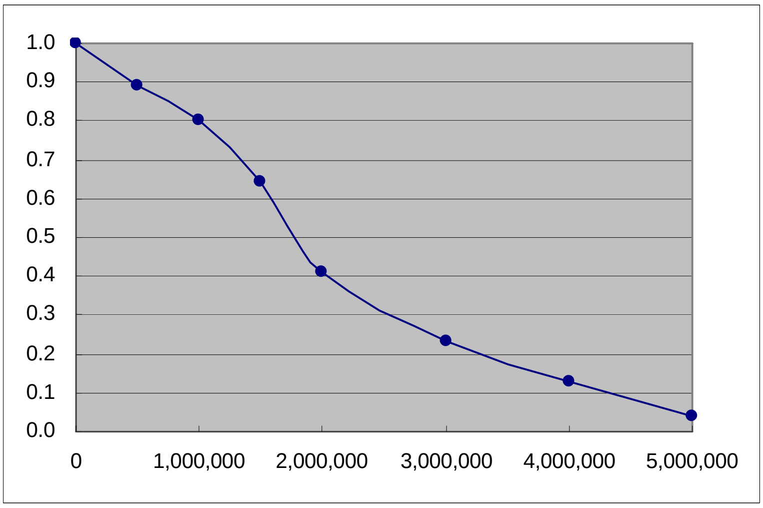


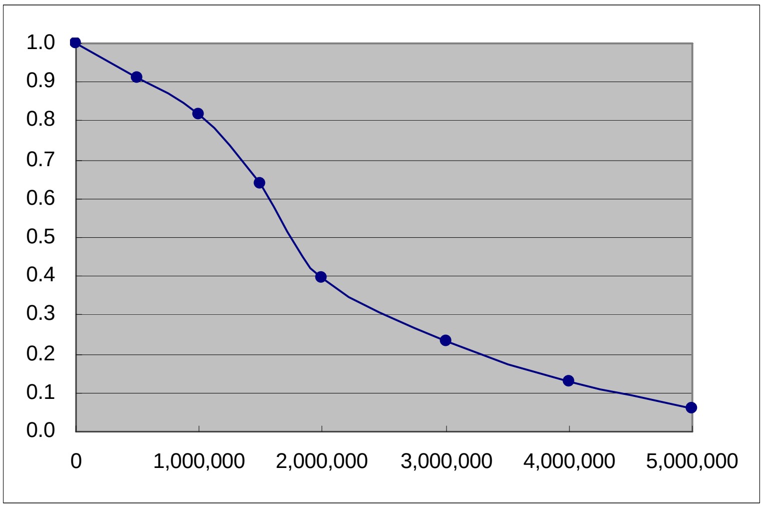
Figure 4-5 ZESCO Connection Fee, Average Income, and Willingness to Pay

(A) Solar Home System



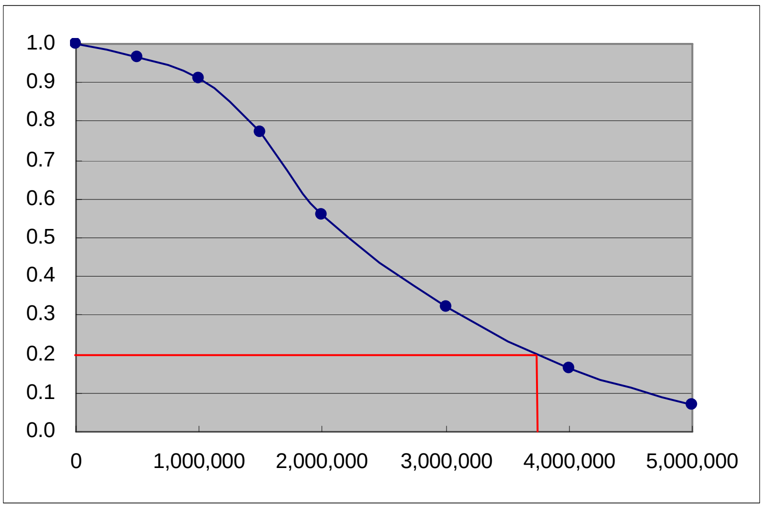
	Average
Lower Bound	1,771,541
Middle	2,105,566
Upper Bound	2,439,591

(B) Micro/Mini Hydropower Plant



	Average
Lower Bound	1,798,665
Middle	2,118,646
Upper Bound	2,438,627

(C) ZESCO Distribution Line



	Average
Lower Bound	2,153,636
Middle	2,508,483
Upper Bound	2,863,331

Figure 4-4 Willingness to Pay for Initial Cost

4.8. Prioritized Property for Electrification Perceived by Unelectrified Residents

The Study sought to establish for unconnected residents, which factors among the following they perceived to be most important for the future electrification: 1) urgency, 2) duration, 3) initial cost, and 4) monthly tariff. The information obtained was analyzed to provide a background for designing the necessary political interventions and measures to promote rural electrification. Conjoint Analysis, explained earlier in this report was applied to the collected data.

4.8.1. Conjoint Analysis Method

As shown in Table 4-11, three levels were used for each of the four selected factors. Among 81 (=3^4) possible combinations for 4 factors with each 3 levels, 11 combinations (including 2 hold out combinations to be used to confirm the accuracy of the data analysis) are selected by orthogonal design method (to minimize the number of combination necessary to the analysis) to create conjoint cards. Interviewees are asked to make a ranking order for these 11 cards based on their preference for the combinations shown in each card.

Table 4-11 Properties and Levels for Conjoint Analysis

Property	Definition	Levels
1) Urgency	How soon does an interviewee wish to receive electricity.	2, 5, 15 years
2) Duration	How many hours does an interviewee wish to use electricity per day.	5, 10, 24 hours/day
3) Initial Cost	One time cost, such as ZESCO line connection fee, contribution for micro/mini hydropower plant, and solar home system installation, required to commence using electricity.	K1,700,000, K3,200,000, K4,700,000
4) Monthly Tariff	Monthly electricity cost charged by electricity supplier or savings for the future maintenance of electrification facilities.	K8,000/month, K24,000/month, K40,000/month

4.8.2. Conjoint Analysis Results

Data from 761 interviewees were analyzed using statistical analysis package SPSS. As shown in Figure 4-6, Duration was the most important property (35%), followed by Urgency (26%), Monthly Tariff (20%), and Initial Cost (19%). Regarding Duration, usage of 24 hours per day was the most preferable (as shown in (B) in Figure 4-7). Interesting finding, however, was that the second favorable Duration was not 10 hours, but 5 hours. This result might be caused as most of interviewees live in place where is no hydro potential, and thus electrification by micro/mini hydro for 10 hours per day seems difficult to imagine. Other than Duration, analysis results are ordinary: unelectrified residents want to be electrified in short waiting time, with minimum initial cost and monthly tariff.

Among all the possible 81 combination, the most favourable one selected by the interviewees is “receive electricity within 2 years for 24 hours usage by K1,700,000 initial cost and K24,000 monthly tariff” based on BTL (Bradley-Terry-Luce) utility evaluation rate (refer to Table 4-12). The second preference is “receive electricity within 2 years for 5 hours usage by K1,700,000 initial cost and K24,000 monthly tariff.” Therefore, it could be said that even limited usage by SHS, unelectrified residents wish to be electrified soon by the minimum initial cost but reasonable monthly tariff.

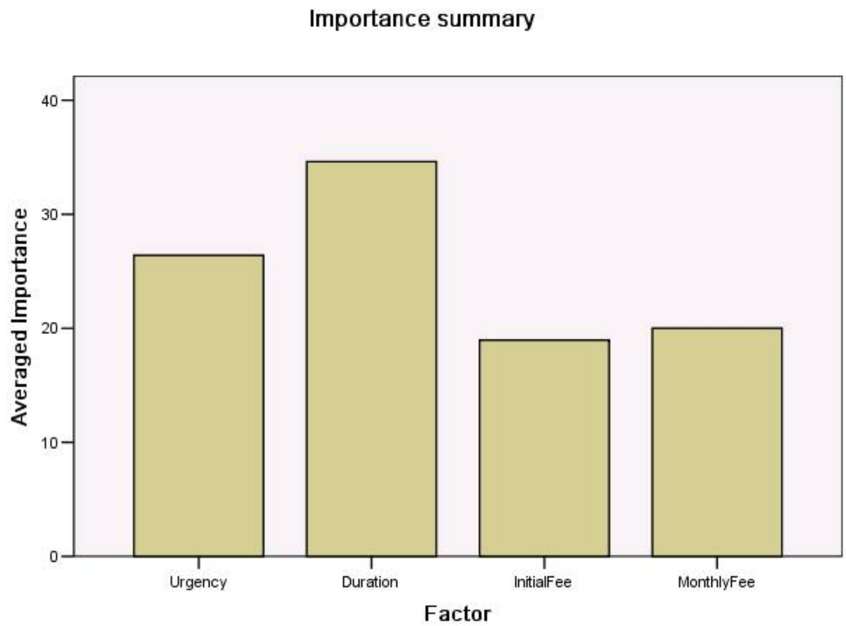


Figure 4-6 Importance of 4 Properties for Rural Electrification

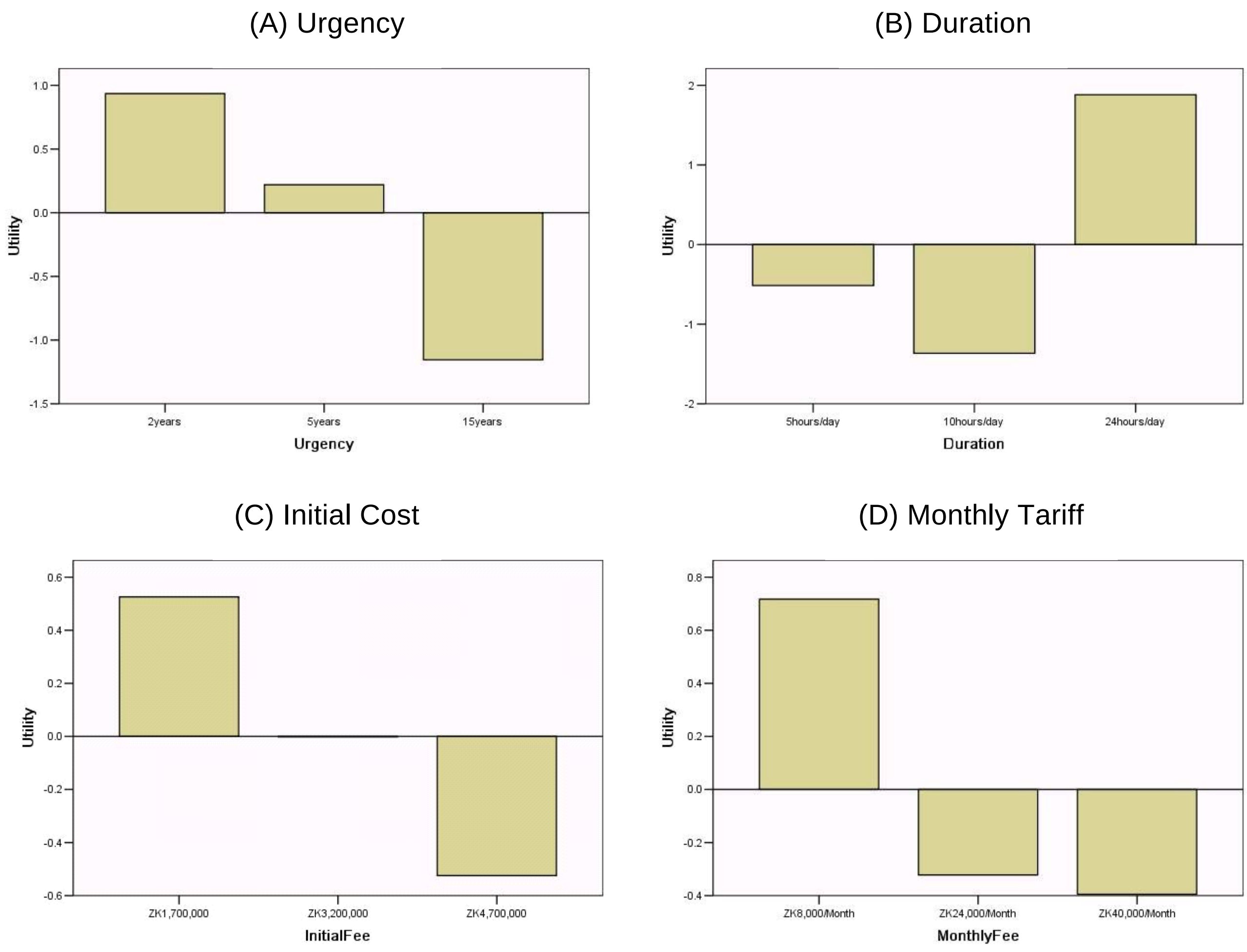


Figure 4-7 Summary of Utilities for Each Property

Table 4-12 Combination of Properties in Preference Order

Urgency	Duration	Initial Fee	Monthly Fee	BTL
2years	24hours	K 1,700,000	K 24,000/month	19.26%
2years	5hours	K 1,700,000	K 24,000/month	18.66%
5years	24hours	K 1,700,000	K 24,000/month	17.80%
5years	5hours	K 1,700,000	K 24,000/month	17.20%
15years	24hours	K 1,700,000	K 24,000/month	13.84%
15years	5hours	K 1,700,000	K 24,000/month	13.24%

Chapter 5

Potential Power Demand
of
Unelectrified RGCs

Chapter 5. Potential Power Demand of Unelectrified RGCs

5.1. Purposes of Potential Demand Forecast and Data Analysis Flow

To determine the required specifications of the electrification equipment and facilities, and to select the economically optimal electrification method for each unelectrified RGC, it was necessary to forecast the potential power demand for each unelectrified RGC. The potential demand would also be among the criteria for prioritizing the unelectrified RGCs: the greater the potential demand, the higher the priority accorded to an RGC.

In this study, the potential demand for each unelectrified RGC was forecasted based on the current consumption trends in electrified RGCs as captured by the socio-economic survey. A flow chart of data analysis for the potential demand forecast is shown in Figure 5-1. The first step of the analysis consisted of estimation of an average Daily Load Curve per unit of facility for each of the following four different types of consumers in electrified RGCs: 1) Public Facilities, 2) Business Entities, 3) Hammer Mills and 4) Households. By multiplying the unitary average daily load curve by the number of existing facilities in a RGC for each type and then adding them all together, the daily load curves and daily peak demands were estimated for all electrified RGCs participating in the survey. The second step of the analysis was the selection of a "Peak Demand Forecast Method". Adaptability of a linear regression model to estimate the daily peak demand in electrified RGCs, derived from the relationship between the number of households and the estimated peak demands in electrified RGCs (calculated in the first step), was tested. The third step of the analysis was to forecast the potential demand for each of 1,217 unelectrified RGCs based on the selected method in the second step. Details of each step are explained in the following sections.

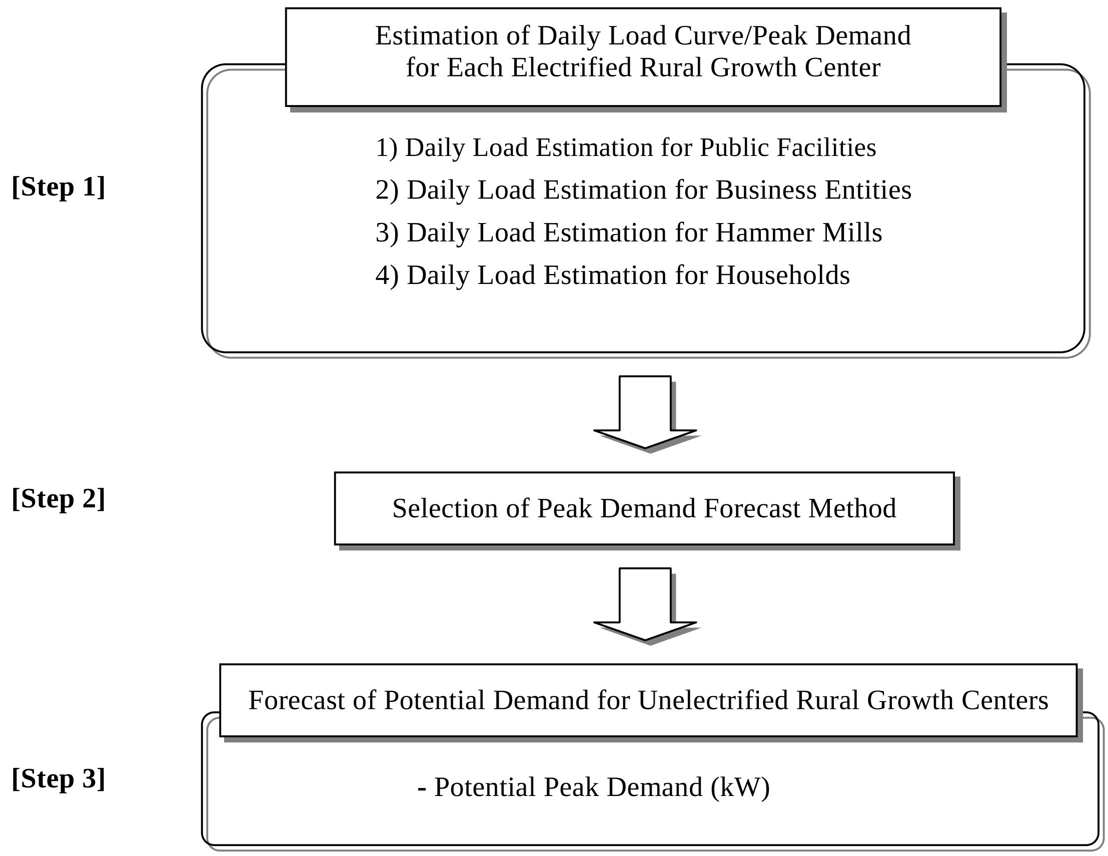


Figure 5-1 Flow Chart of Data Analysis for Potential Demand Forecast

5.2. Estimation of Daily Load Curve/Peak Demand for Each Electrified RGC [Step 1]

From the socio-economic survey results and the national census data, statistics regarding the number of existing facilities and the number of these facilities already electrified were obtained for each electrified RGC and for each type of consumer (Public Facilities, Business Entities, Hammer Mills and Households), as shown in Table 5-1 (on the next page). Firstly, an average daily load curve per unit for each type of customer was obtained. Then, the total daily demand of electrified RGCs studied in this survey was found by multiplying the curve data by the existing number of each type of facility in a RGC and adding them altogether.

5.3. Estimation of Daily Demand for Public Facilities

The socio-economic survey results showed that there are 249 public facilities in the investigated 23 electrified RGCs. Among the total of 249 facilities, 107 have been electrified. Data collected from 49 electrified public facilities were used to create the electricity demand curves. Table 5-2 summarizes the results of the investigation regarding public facilities.

On the data collection sheet used in the survey, public facilities were categorized in 18 types as indicated in Table 5-2. Significant data was collected from the following 14 types of public facilities: Basic/Primary School, Secondary School, Hospital, Health Center/Clinic, Police Post/Station, Post Office, Church, Community Center, Agriculture Depot, Orphanage, Central Government Office, District Government Office, and others. Data from four other types of public facilities – Mosque, Provincial Government Office, Local Administration Office and Court – could not be collected. Therefore a daily load curve per unit was created for each of the 14 specific types of public facilities. The average daily demand of these 14 types was applied to the four public facility types from which no data could be collected. Figure 5-1 shows the daily load curve for each of the 14 public facility types as well as an average curve representative for all these facility types except Hospital of which indicates much different (larger) power demand from others.

The daily load curve data per unit multiplied by the number of electrified units for each type in a RGC (shown in Table 8-2) resulted in the daily load curves of public facilities for electrified RGCs.

Table 5-2 Summary Table of Surveyed Public Facilities

Public Facility	Existing	Electrified	Elec. Rate	Available Load Data
1) Basic/Primary School	26	16	61.5%	13
2) Secondary School	13	12	92.3%	1
3) Tertiary School	5	3	60.0%	2
4) Hospital	2	2	100.0%	1
5) Health Center/Clinic	16	16	100.0%	14
6) Police Post/Station	8	8	100.0%	3
7) Post Office	4	3	75.0%	2
8) Church	113	13	11.5%	4
9) Mosque	1	0	0.0%	0
10) Community Center	5	2	40.0%	1
11) Agriculture Depot	10	5	50.0%	2
12) Orphanage	6	1	16.7%	1
13) Central Government Office	1	1	100.0%	1
14) Provincial Government Office	2	2	100.0%	0
15) District Government Office	15	14	93.3%	1
16) Local Administration Office	2	1	50.0%	0
17) Court	10	2	20.0%	0
18) Other	10	6	60.0%	3
Total	249	107	43.0%	49

Table 5-1 Summary of Surveyed Electrified Rural Growth Centers

RGC	Province	RGC	Public Facility			Business Entity			Maize Mill			Household			Year After
		Electrification Year	Existing in RGC	Electrified	Elec. Rate	Existing in RGC	Electrified	Elec. Rate	Existing in RGC	Electrified	Elec. Rate	Existing in RGC	Electrified	Elec. Rate	Elec.
MPIMA	CENTRAL	2006	8	2	25.0%	1	0	0.0%	4	0	0.0%	1	1	100.0%	1
MPULA	CENTRAL	1994	10	2	20.0%	729	434	59.5%	3	3	100.0%	70	0	0.0%	13
MPUNDE	CENTRAL	2003	1	0	0.0%	12	5	41.7%	2	0	0.0%	500	20	4.0%	4
MISHIKISHI	COPPERBELT	2002	11	3	27.3%	24	14	58.3%	4	3	75.0%	350	5	1.4%	5
CHIWALA	COPPERBELT	2005	20	4	20.0%	14	5	35.7%	2	2	100.0%	225	6	2.7%	2
KANGONGA	COPPERBELT	1996	7	7	100.0%	17	3	17.6%	1	1	100.0%	140	2	1.4%	11
CHEMBE	LUAPULA	2006	25	9	36.0%	18	3	16.7%	2	0	0.0%	215	27	12.6%	1
LUAMFUMU	LUAPULA	1973	3	2	66.7%	3	3	100.0%	1	0	0.0%	200	200	100.0%	34
KALOBWA	LUAPULA	2002	3	1	33.3%	5	4	80.0%	1	1	100.0%	50	6	12.0%	5
KAMBWALI	LUAPULA	1987	7	1	14.3%	4	3	75.0%	3	2	66.7%	400	12	3.0%	20
MUNKANTA	LUAPULA	2006	14	5	35.7%	27	15	55.6%	2	2	100.0%	777	59	7.6%	1
CHIAWA	LUSAKA	2001	14	5	35.7%	12	5	41.7%	1	1	100.0%	1,120	15	1.3%	6
LUANGWA BOMA	LUSAKA	1970	13	10	76.9%	95	40	42.1%	3	3	100.0%	580	214	36.9%	37
KAPIJIMPANGA	NORTH WESTERN	2004	10	4	40.0%	2	1	50.0%	1	1	100.0%	250	0	0.0%	3
KABANDA	NORTH WESTERN	-	14	2	14.3%	108	30	27.8%	15	5	33.3%	500	8	1.6%	-
NSELUKA	NORTHERN	2003	8	3	37.5%	28	7	25.0%	4	4	100.0%	486	20	4.1%	4
MOCHIPAPA	SOUTHERN	1966	8	3	37.5%	6	2	33.3%	1	1	100.0%	47	30	63.8%	41
MUSOKOTWANE	SOUTHERN	1970	10	3	30.0%	6	2	33.3%	1	1	100.0%	500	25	5.0%	37
MUKUNI VILLAGE	SOUTHERN	1996	10	3	30.0%	54	22	40.7%	2	2	100.0%	639	26	4.1%	11
MWANDI	SOUTHERN	-	11	5	45.5%	68	66	97.1%	2	2	100.0%	410	110	26.8%	-
LUKULU BOMA	WESTERN	1988	26	24	92.3%	43	33	76.7%	17	7	41.2%	323	100	31.0%	19
SEFULA	WESTERN	1989	8	7	87.5%	31	14	45.2%	3	3	100.0%	170	130	76.5%	18
SENANGA	WESTERN	1976	8	2	25.0%	12	1	8.3%	2	0	0.0%	800	26	3.3%	31
Total			249	107	-	1,319	712	-	77	44	-	8,753	1,042	-	-
Average			10.8	4.7	40.5%	57.3	31.0	46.1%	3.3	1.9	70.3%	380.6	45.3	21.7%	-

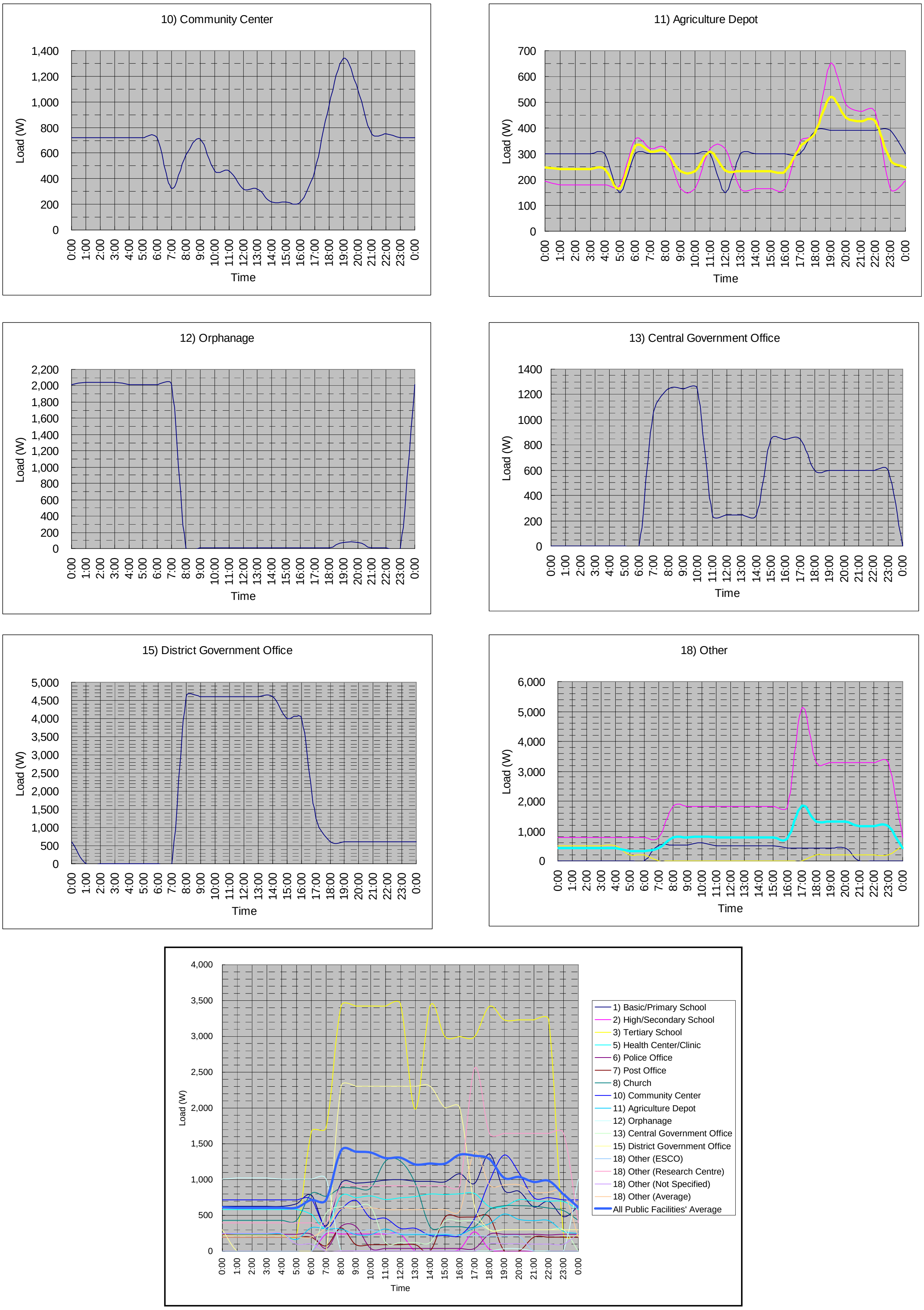


Figure 5-2 Public Facilities' Daily Load Curves for Electrified RGC (2/2)

5.4. Estimation of Daily Demand for Business Entities

Survey results indicated that there are 1,319 business entities operating in the electrified RGCs investigated in this survey. Among them, 712 have been electrified. Data utilized for the calculation of electricity demand curves was collected from 32 of these electrified business entities. Table 5-3 summarizes the investigation results regarding business entities.

Figure 5-3 shows the average daily load curves per business entity in each of the 8 electrified RGCs (from a total of 23 surveyed RGCs). Data from these average daily load curves multiplied by the number of electrified business entities in a RGC (indicated in Table 5-3) resulted in the daily load curves of business entities for electrified RGCs.

Table 5-3 Summary Table of Surveyed Business Entities

RGC	Province	Business Entity			Available Load Data
		Existing in RGC	Electrified	Elec. Rate	
MPIMA	CENTRAL	1	0	0.0%	-
MPULA	CENTRAL	729	434	59.5%	-
MPUNDE	CENTRAL	12	5	41.7%	-
MISHIKISHI	COPPERBELT	24	14	58.3%	5
CHIWALA	COPPERBELT	14	5	35.7%	-
KANGONGA	COPPERBELT	17	3	17.6%	-
CHEMBE	LUAPULA	18	3	16.7%	3
LUAMFUMU	LUAPULA	3	3	100.0%	2
KALOBWA	LUAPULA	5	4	80.0%	3
KAMBWALI	LUAPULA	4	3	75.0%	3
MUNKANTA	LUAPULA	27	15	55.6%	4
CHIAWA	LUSAKA	12	5	41.7%	5
LUANGWA BOMA	LUSAKA	95	40	42.1%	-
KAPIJIMPANGA	NORTH WESTERN	2	1	50.0%	-
KABANDA	NORTH WESTERN	108	30	27.8%	-
NSELUKA	NORTHERN	28	7	25.0%	7
MOCHIPAPA	SOUTHERN	6	2	33.3%	-
MUSOKOTWANE	SOUTHERN	6	2	33.3%	-
MUKUNI VILLAGE	SOUTHERN	54	22	40.7%	-
MWANDI	SOUTHERN	68	66	97.1%	-
LUKULU BOMA	WESTERN	43	33	76.7%	-
SEFULA	WESTERN	31	14	45.2%	-
SENANGA	WESTERN	12	1	8.3%	-
Total		1,319	712	-	32
Average		57.3	31.0	46.1%	4.0

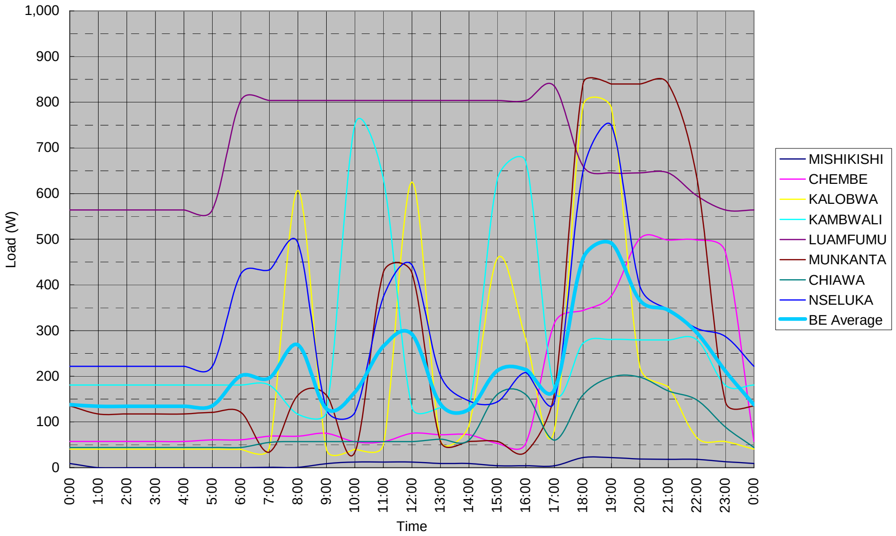


Figure 5-3 Business Entity's Unit Average Daily Load Curve for Each Electrified RGC

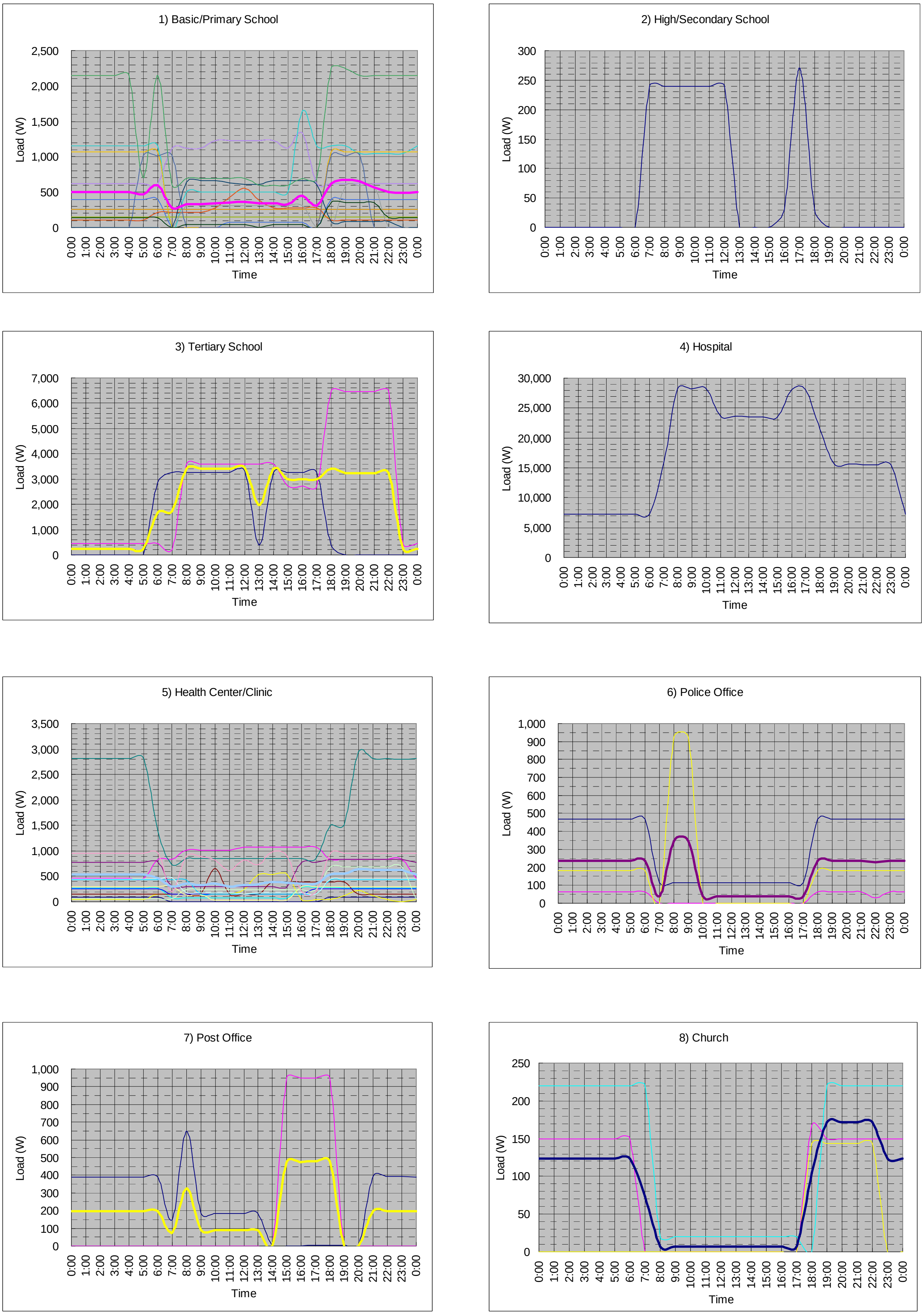


Figure 5-2 Public Facilities' Daily Load Curves for Electrified RGC (1/2)

5.5. Estimation of Daily Demand for Hammer Mills

Results showed that there are 77 hammer mills in the electrified RGCs surveyed, and 44 of them were electrified. The average electrification rate is 70.3%, which is relatively high compared to the rate of 46.1% for business entities (refer to Table 5-3). The unitary capacity of 15 kW/unit for hammer mills is large, and 3.3 units are installed in each RGC on average. Therefore, hammer mills are considered to be one of the major electricity users, probably the largest consumers, in a RGC, thus necessitating distinction from other business entities in this study. Table 5-4 summarizes the study results on hammer mills.

The unit capacity of hammer mills – 15 kW – multiplied by the number of electrified hammer mills in a RGC (shown in Table 5-4) and by the operation hours – generally from 7:00 to 19:00 – resulted in the daily load curves of hammer mills for the electrified RGCs.

Table 5-4 Summary Table of Surveyed Hammer Mills

RGC	Province	Business Entity			Available Load Data
		Existing in RGC	Electrified	Elec. Rate	
MPIMA	CENTRAL	4	0	0.0%	-
MPULA	CENTRAL	3	3	100.0%	-
MPUNDE	CENTRAL	2	0	0.0%	-
MISHIKISHI	COPPERBELT	4	3	75.0%	1
CHIWALA	COPPERBELT	2	2	100.0%	-
KANGONGA	COPPERBELT	1	1	100.0%	-
CHEMBE	LUAPULA	2	0	0.0%	-
LUAMFUMU	LUAPULA	1	0	0.0%	-
KALOBWA	LUAPULA	1	1	100.0%	1
KAMBWALI	LUAPULA	3	2	66.7%	2
MUNKANTA	LUAPULA	2	2	100.0%	-
CHIAWA	LUSAKA	1	1	100.0%	1
LUANGWA BOMA	LUSAKA	3	3	100.0%	-
KAPIJIMPANGA	NORTH WESTERN	1	1	100.0%	-
KABANDA	NORTH WESTERN	15	5	33.3%	-
NSELUKA	NORTHERN	4	4	100.0%	-
MOCHIPAPA	SOUTHERN	1	1	100.0%	-
MUSOKOTWANE	SOUTHERN	1	1	100.0%	-
MUKUNI VILLAGE	SOUTHERN	2	2	100.0%	-
MWANDI	SOUTHERN	2	2	100.0%	-
LUKULU BOMA	WESTERN	17	7	41.2%	-
SEFULA	WESTERN	3	3	100.0%	-
SENANGA	WESTERN	2	0	0.0%	-
Total		77	44	-	5
Average		3.3	1.9	70.3%	1.3

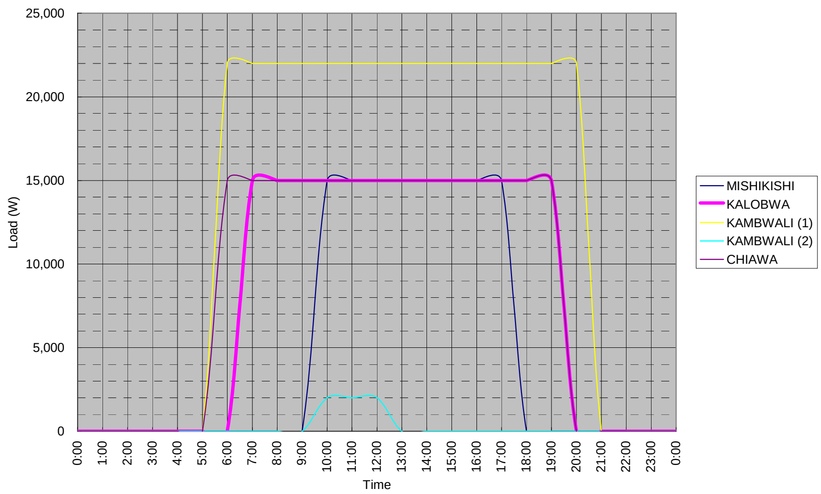


Figure 5-4 Hammer Mill's Unit Daily Load Curve for Each Electrified RGC

5.6. Estimation of Daily Demand for Households

The results showed that there were 8,753 households in the 23 electrified RGCs surveyed. Of these, 1,042 households have been electrified. The data utilized for the calculation of electricity demand curves were collected from 83 of the electrified households. Table 5-5 summarizes the study results on households.

Figure 5-5 shows the average daily load curves of households in each of the 10 electrified RGCs (from a total of 23 surveyed RGCs). Data from these average daily load curves multiplied by the number of electrified households in a RGC (shown in Table 5-5), resulted in the daily load curves of households for the electrified RGCs.

Table 5-5 Summary Table of Surveyed Households

RGC	Province	Household			Available Load Data
		Existing in RGC	Electrified	Elec. Rate	
MPIMA	CENTRAL	1	1	100.0%	-
MPULA	CENTRAL	70	0	0.0%	-
MPUNDE	CENTRAL	500	20	4.0%	-
MISHIKISHI	COPPERBELT	350	5	1.4%	4
CHIWALA	COPPERBELT	225	6	2.7%	6
KANGONGA	COPPERBELT	140	2	1.4%	2
CHEMBE	LUAPULA	215	27	12.6%	14
LUAMFUMU	LUAPULA	200	200	100.0%	5
KALOBWA	LUAPULA	50	6	12.0%	6
KAMBWALI	LUAPULA	400	12	3.0%	12
MUNKANTA	LUAPULA	777	59	7.6%	8
CHIAWA	LUSAKA	1,120	15	1.3%	7
LUANGWA BOMA	LUSAKA	580	214	36.9%	-
KAPIJIMPANGA	NORTH WESTERN	250	0	0.0%	-
KABANDA	NORTH WESTERN	500	8	1.6%	-
NSELUKA	NORTHERN	486	20	4.1%	19
MOCHIPAPA	SOUTHERN	47	30	63.8%	-
MUSOKOTWANE	SOUTHERN	500	25	5.0%	-
MUKUNI VILLAGE	SOUTHERN	639	26	4.1%	-
MWANDI	SOUTHERN	410	110	26.8%	-
LUKULU BOMA	WESTERN	323	100	31.0%	-
SEFULA	WESTERN	170	130	76.5%	-
SENANGA	WESTERN	800	26	3.3%	-
Total		8,753	1,042	-	83
Average		380.6	45.3	21.7%	8.3

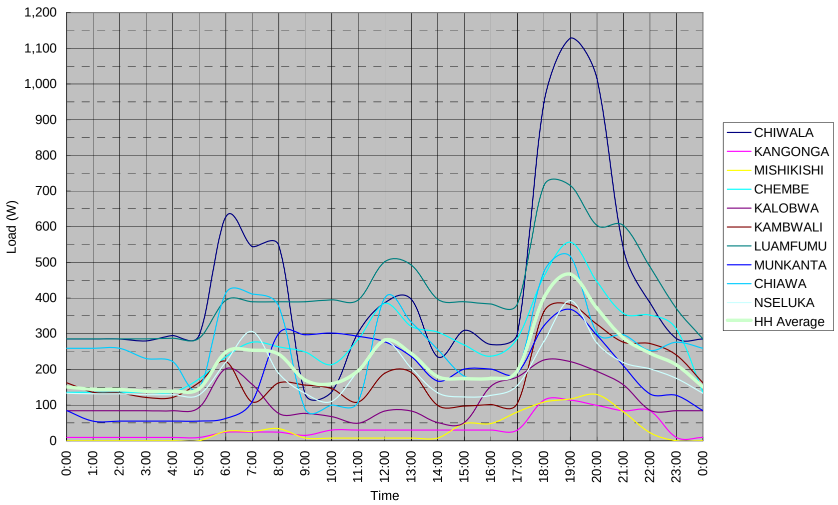


Figure 5-5 Household's Unit Daily Load Curve for Each Electrified RGC

5.7. Estimated Daily Load Curve and Peak Demand for Each Electrified RGC

A daily load curve for each electrified RGC surveyed was estimated by adding up the daily load curves of the four different types of consumer: 1) Public Facilities, 2) Business Entities, 3) Hammer Mills and 4) Households. The results of this calculation are shown in Figure 5-6, identifying the estimated daily load curves for each electrified RGC included in the survey. The daily load curves for only 8 of the 23 electrified RGCs surveyed, are plotted, since data of the 15 RGCs was insufficient to create demand curves. Hourly loads for all RGCs, which are related to the demand curves, are shown in Table5-6. In this table, the daily peak demand for each electrified RGCs is underlined.

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

1) Of the total amount of electricity consumption in a RGC, the contribution of hammer mills is high.
2) The daily peak demand of a RGC occurs mostly in the evening from 18:00 to 19:00, coinciding with dinnertime, during which the electricity consumption for food preparation overlaps with the operation of hammer mills.

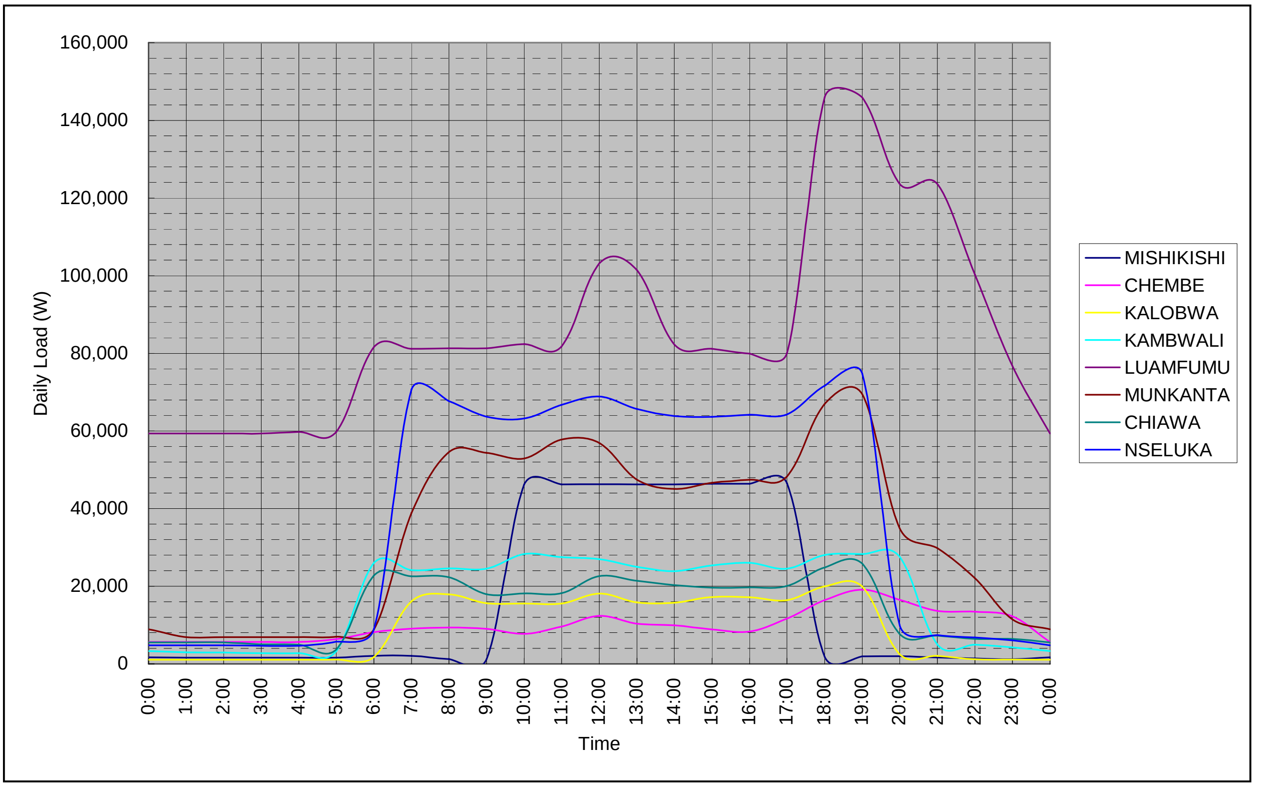


Figure 5-6 Daily Load Curves for Electrified RGCs

Table 5-6 Time Table of Daily Demand in Surveyed Electrified RGCs (1/2)

RGC (Province)	Type of Users	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
MISHIKISHI	Public Facility	1,583	1,601	1,601	1,601	1,583	1,583	1,961	1,911	1,025	1,025	1,025	1,025	1,077	1,077	1,077	1,077	1,077	1,077	942	1,039	1,039	1,009	1,009	961
(COPPERBELT)	Business Entity	126	0	0	0	0	0	0	7	7	119	168	168	168	126	126	56	56	56	307	307	265	249	249	182
	Hammer Mill	0	0	0	0	0	0	0	0	0	0	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000	0	0	0	0	0	0
	Household	0	0	0	0	0	0	131	131	169	38	38	38	38	38	38	240	240	401	542	586	647	407	114	0
	Daily Load	1,709	1,601	1,601	1,601	1,583	1,583	2,093	2,050	1,200	1,181	46,230	46,230	46,282	46,240	46,240	46,373	46,373	46,534	1,790	1,932	1,951	1,665	1,373	1,143
	DL exc. Hammer Mill	1,709	1,601	1,601	1,601	1,583	1,583	2,093	2,050	1,200	1,181	1,230	1,230	1,282	1,240	1,240	1,373	1,373	1,534	1,790	1,932	1,951	1,665	1,373	1,143
CHEMBE	Public Facility	1,808	1,808	1,808	1,808	1,808	1,523	1,652	1,412	2,053	2,054	1,809	1,742	1,751	1,486	1,485	1,476	1,788	2,984	2,893	2,965	2,949	2,506	2,428	2,383
(LUAPULA)	Business Entity	173	173	173	173	173	182	182	206	206	225	169	169	225	216	216	159	159	950	1,032	1,130	1,505	1,496	1,496	1,417
	Hammer Mill	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Household	3,664	3,664	3,664	3,664	3,664	4,677	6,347	7,457	7,102	6,719	5,758	7,681	10,400	8,657	8,211	7,245	6,391	7,748	12,446	15,024	12,045	9,628	9,503	8,462
	Daily Load	5,645	5,645	5,645	5,645	5,645	6,381	8,181	9,075	9,361	8,998	7,735	9,591	12,376	10,359	9,911	8,881	8,338	11,682	16,372	19,118	16,499	13,629	13,427	12,262
	DL exc. Hammer Mill	5,645	5,645	5,645	5,645	5,645	6,381	8,181	9,075	9,361	8,998	7,735	9,591	12,376	10,359	9,911	8,881	8,338	11,682	16,372	19,118	16,499	13,629	13,427	12,262
KALOBWA	Public Facility	400	400	400	400	400	400	400	0	0	0	0	80	80	80	80	80	80	0	400	400	400	400	400	400
(LUAPULA)	Business Entity	161	161	161	161	161	161	160	173	2,427	160	160	200	2,500	240	367	1,833	1,127	327	3,169	3,149	883	708	261	228
	Hammer Mill	0	0	0	0	0	0	0	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	0	0	0	0
	Household	504	504	504	504	504	559	1,212	948	458	458	405	295	500	500	305	305	915	1,073	1,358	1,332	1,167	942	514	504
	Daily Load	1,065	1,065	1,065	1,065	1,065	1,120	1,772	16,121	17,884	15,618	15,565	15,575	18,080	15,820	15,752	17,218	17,122	16,400	19,927	19,881	2,449	2,050	1,175	1,132
	DL exc. Hammer Mill	1,065	1,065	1,065	1,065	1,065	1,120	1,772	1,121	2,884	618	565	575	3,080	820	752	2,218	2,122	1,400	4,927	4,881	2,449	2,050	1,175	1,132
KAMBWALI	Public Facility	780	780	780	780	780	780	780	300	300	300	300	300	300	300	300	300	780	780	835	835	835	835	835	835
(LUAPULA)	Business Entity	542	542	542	542	542	542	542	542	350	367	2,251	1,901	395	395	395	1,895	2,008	508	817	843	840	840	840	541
	Hammer Mill	0	0	0	0	0	0	22,000	22,000	22,000	22,000	24,000	24,000	24,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	0	0	0
	Household	1,948	1,628	1,608	1,458	1,458	1,958	2,670	1,305	1,946	1,873	1,755	1,300	2,269	2,299	1,185	1,165	1,220	1,256	4,348	4,583	3,916	3,318	3,267	2,879
	Daily Load	3,270	2,950	2,930	2,780	2,780	3,280	25,992	24,147	24,596	24,540	28,305	27,501	26,963	24,993	23,879	25,359	26,007	24,543	28,000	28,261	27,591	4,992	4,941	4,255
	DL exc. Hammer Mill	3,270	2,950	2,930	2,780	2,780	3,280	3,992	2,147	2,596	2,540	4,305	3,501	2,963	2,993	1,879	3,359	4,007	2,543	6,000	6,261	5,591	4,992	4,941	4,255
LUAMFUMU	Public Facility	541	541	541	541	541	541	467	826	974	952	977	423	448	466	504	797	780	785	842	846	948	929	923	919
(LUAPULA)	Business Entity	1,692	1,692	1,692	1,692	1,692	1,692	2,412	2,412	2,412	2,412	2,412	2,412	2,412	2,412	2,412	2,412	2,412	2,506	1,981	1,936	1,936	1,936	1,786	1,692
	Hammer Mill	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Household	57,120	57,120	57,120	57,120	57,520	57,520	78,720	77,920	77,920	77,960	78,960	78,920	100,320	98,520	79,320	77,920	76,720	76,720	143,120	143,120	120,720	120,720	97,520	74,120
	Daily Load	59,353	59,353	59,353	59,353	59,753	59,753	81,599	81,158	81,306	81,324	82,349	81,755	103,180	101,398	82,236	81,129	79,912	80,010	145,943	145,902	123,603	123,584	100,229	76,731
	DL exc. Hammer Mill	59,353	59,353	59,353	59,353	59,753	59,753	81,599	81,158	81,306	81,324	82,349	81,755	103,180	101,398	82,236	81,129	79,912	80,010	145,943	145,902	123,603	123,584	100,229	76,731
MUNKANTA	Public Facility	1,917	1,917	1,917	1,917	1,917	1,917	3,357	1,917	4,421	4,421	4,612	4,112	4,142	2,672	4,352	3,925	5,075	4,575	5,364	5,157	4,817	4,817	4,806	1,817
(LUAPULA)	Business Entity	2,025	1,763	1,763	1,763	1,763	1,819	1,819	506	2,381	2,381	506	6,416	6,394	863	863	863	506	2,456	12,600	12,600	12,600	12,600	9,506	2,156
	Hammer Mill	0	0	0	0	0	0	0	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	0	0	0	0
	Household	4,986	3,245	3,245	3,245	3,245	3,245	3,688	6,453	17,755	17,534	17,803	17,276	16,361	13,913	9,857	11,848	11,848	11,203	19,020	21,719	17,423	12,408	7,762	7,493
	Daily Load	8,928	6,925	6,925	6,925	6,925	6,981	8,863	38,877	54,557	54,336	52,922	57,805	56,898	47,448	45,072	46,635	47,429	48,234	66,984	69,476	34,840	29,825	22,075	11,466
	DL exc. Hammer Mill	8,928	6,925	6,925	6,925	6,925	6,981	8,863	8,877	24,557	24,336	22,922	27,805	26,898	17,448	15,072	16,635	17,429	18,234	36,984	39,476	34,840	29,825	22,075	11,466

Table 5-6 Time Table of Daily Demand in Surveyed Electrified RGCs (2/2)

RGC (Province)	Type of Users	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
CHIAWA	Public Facility	1,383	1,383	1,383	1,383	1,383	1,298	1,353	1,111	1,320	1,299	1,348	1,293	1,328	1,081	1,118	1,102	1,226	1,878	1,951	2,041	2,127	1,951	1,879	1,819
(LUSAKA)	Business Entity	220	220	220	220	220	220	220	275	285	285	285	285	285	310	301	801	800	300	795	990	990	840	740	445
	Hammer Mill	0	0	0	0	0	0	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	0	0	0	0
	Household	3,889	3,889	3,889	3,461	3,332	2,196	6,204	6,171	5,657	1,329	1,500	1,639	6,000	4,982	3,836	2,711	2,649	2,890	7,108	7,753	4,518	4,463	3,793	4,146
	Daily Load	5,493	5,493	5,493	5,064	4,936	3,714	22,777	22,558	22,262	17,913	18,133	18,218	22,613	21,373	20,254	19,614	19,675	20,068	24,853	25,784	7,635	7,254	6,412	6,411
	DL exc. Hammer Mill	*5,493*	*5,493*	*5,493*	*5,064*	*4,936*	*3,714*	*7,777*	*7,558*	*7,262*	*2,913*	*3,133*	*3,218*	*7,613*	*6,373*	*5,254*	*4,614*	*4,675*	*5,068*	*9,853*	*10,784*	*7,635*	*7,254*	*6,412*	*6,411*
NSELUKA	Public Facility	561	561	561	561	561	1,581	1,581	1,531	445	157	157	157	157	157	157	157	157	157	1,562	1,629	1,629	609	609	561
(NORTHERN)	Business Entity	1,552	1,552	1,552	1,552	1,552	1,552	2,967	3,030	3,442	897	844	2,613	3,105	1,412	1,023	1,007	1,457	1,010	4,541	5,244	2,782	2,424	2,131	2,009
	Hammer Mill	0	0	0	0	0	0	0	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	0	0	0	0
	Household	2,660	2,639	2,639	2,577	2,577	2,574	4,399	6,119	3,774	2,648	2,205	3,918	5,597	4,071	2,685	2,453	2,541	3,098	5,563	7,860	5,480	4,385	4,032	3,498
	Daily Load	4,773	4,752	4,752	4,690	4,690	5,708	8,948	70,681	67,661	63,701	63,205	66,688	68,859	65,640	63,864	63,617	64,155	64,265	71,667	74,733	9,891	7,418	6,773	6,068
	DL exc. Hammer Mill	*4,773*	*4,752*	*4,752*	*4,690*	*4,690*	*5,708*	*8,948*	*10,681*	*7,661*	*3,701*	*3,205*	*6,688*	*8,859*	*5,640*	*3,864*	*3,617*	*4,155*	*4,265*	*11,667*	*14,733*	*9,891*	*7,418*	*6,773*	*6,068*

5.8. Selection of a Daily Peak Demand Forecast Method [Step 2]

5.8.1. Relationship between Number of Households and Peak Demand of RGC

One of the characteristics of hammer mills is that they consume a considerably greater amount of electricity than other types of consumers – public facilities, business entities and households, as explained in a previous section. In addition to this characteristic, there is no significant correlation between the scale of RGCs and the number of hammer mills installed in them. Therefore, adaptability of a linear regression model to a daily peak demand forecast for an unelectrified RGC was tested in two cases: daily peak demand with and without consumption of hammer mills.

The relationship between the number of households and the daily peak demand, with hammer mills and without hammer mills, for each of the RGCs are plotted in Figure 5-7 and 5-8 respectively, based on Table 5-7 developed from data shown in Table 5-6. In both cases, no relation between the number of households and the daily peak demand were observed. Neither provincial/regional nor years after electrification tendency was found. Developed linear regression model for both cases showed negative slope, meaning the larger the number of households in a RGC, the less peak demand in a RGC, and this model indication was absolutely unrealistic. In fact, the model's coefficient of determination (R^2) is as low as 0.0135 and 0.0376 respectively. Therefore, it was safely concluded that the linear regression model having the number of households as an explanatory variable was not applicable to forecast the peak demand in a RGC.

Table 5-7 Peak Demand and Number of Households in Electrified RGCs

RGC	Province	Peak Load (W)	Peak Load Except Hammer Mills (W)	Number of Households	Year after Elec.
MISHIKISHI	COPPERBELT	46,534	2,093	350	5
CHEMBE	LUAPULA	19,118	19,118	215	1
KALOBWA	LUAPULA	19,927	4,927	50	5
KAMBWALI	LUAPULA	28,261	6,261	400	20
LUAMFUMU	LUAPULA	145,943	145,943	200	34
MUNKANTA	LUAPULA	69,476	39,476	777	1
CHIAWA	LUSAKA	25,784	10,784	1,120	6
NSELUKA	NORTHERN	74,733	14,733	486	4
All RGCs Average		53,722	30,417	450	9.5

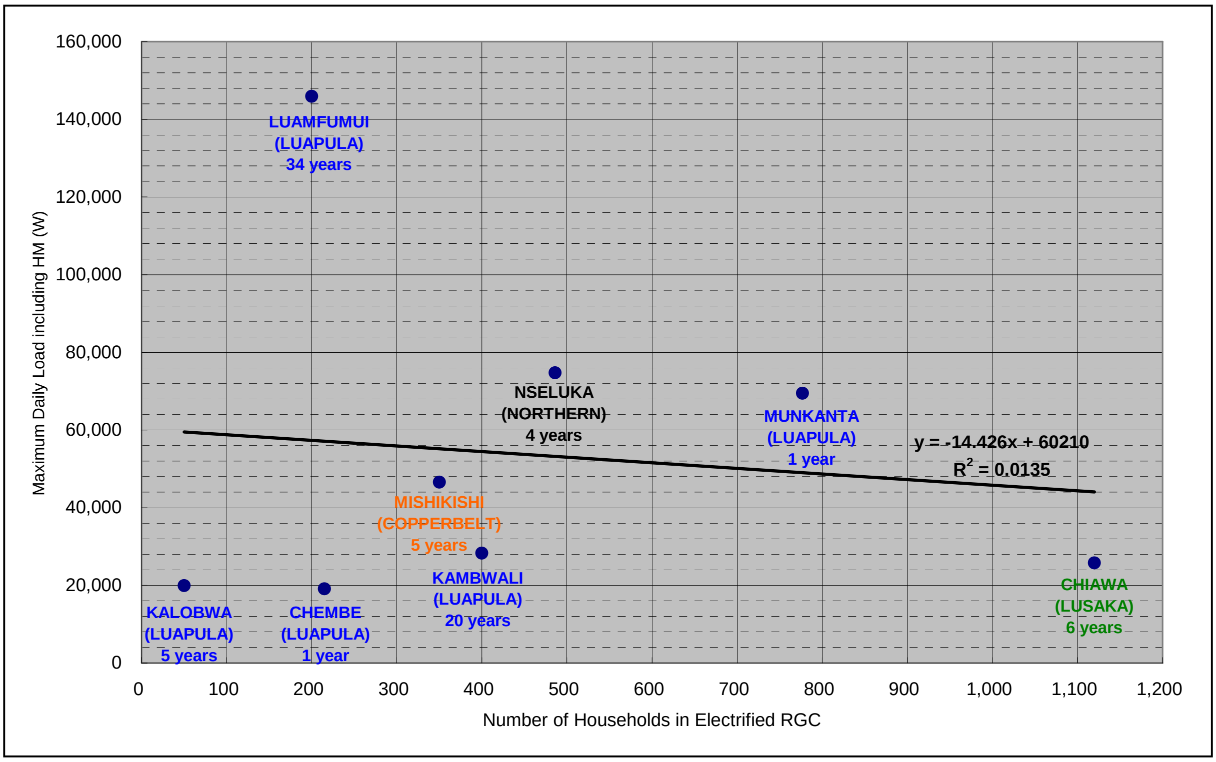


Figure 5-7 Linear Regression Model for Peak Demand with Hammer Mills

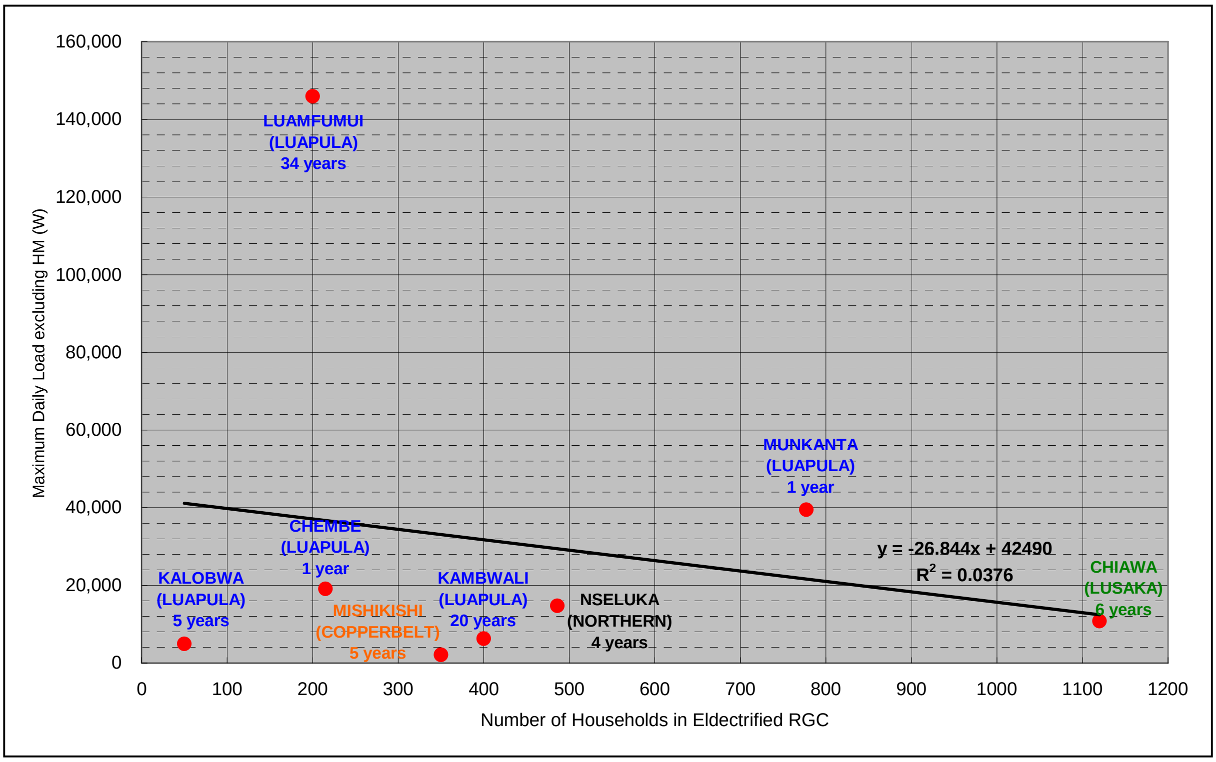


Figure 5-8 Linear Regression Model for Peak Demand without Hammer Mills

5.8.4. Number of Hammer Mills in Unelectrified RGCs

In order to forecast the potential demand in unelectrified RGCs in 2030, an increase in the number of hammer mills needs to be taken into account, as well as the number of households as explained in the section 5.8.2. The results of the socio-economic survey indicated that each hammer mill provides services to an average of 179 households in electrified RGCs, while it provides services to an average of 172 households in unelectrified RGCs, as shown in Tables 5-8 (on the next page). The average number of households served per hammer mill (179 in electrified RGC and 172 in unelectrified RGC), however, is not statistically different between electrified and unelectrified RGC with the significance level of 95%. Therefore, disregarding the electrification status, the total average of per unit hammer mill service ratio by 174 households are adopted to forecast installed number of hammer mill in each RGC in 2030.

Among 23 RGCs listed in Table 5-1, the relationship between the hammer mill electrification rates and the year after electrification for 19 electrified RGCs (except Kabanda and Mwandi RGCs that electrification years were uncertain) were plotted in Figure 5-10. As the figure shows, there is no relationship between them. Thus, the chronological transition (escalation) of hammer mill electrification rate is disregarded in the potential demand forecast.

Taken into account above findings, Equation 5-2 indicates how the number of hammer mills in each RGC in 2030 is forecasted by using the data as of 2006.

$$
\begin{aligned}
X_{HM\,[2030]} &= X_{HH\,[2030]} / HMSR \\
&= 1.986 \times X_{HH\,[2006]} / 174 \\
&= 0.0113 \times X_{HH\,[2006]} \qquad \text{(Equation 5-2)}
\end{aligned}
$$

$X_{HM\,[2030]}$: Forecasted Number of Hammer Mills in a RGC in 2030 (refer to Equation 5-1)
$X_{HH\,[2030]}$: Forecasted Number of Households in a RGC in 2030
$X_{HH\,[2006]}$: Number of Households in a RGC in 2006 (data submitted by district planners)
HMSR : A Unit Hammer Mill Service Ratio = 174 Household/Hammer Mill

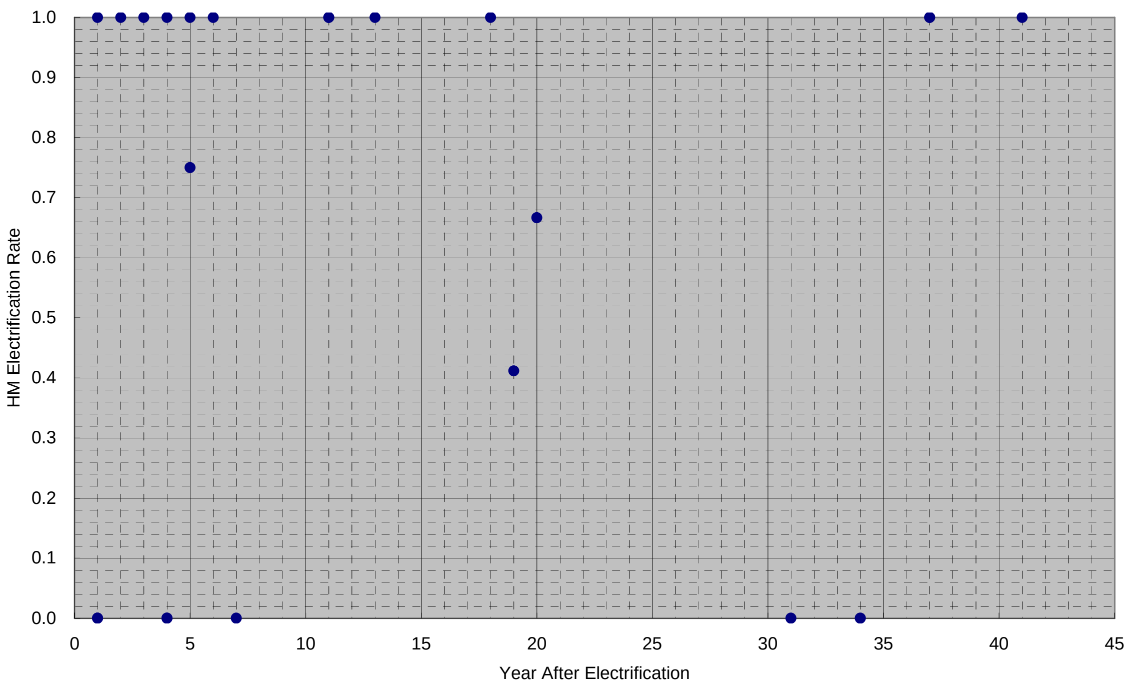


Figure 5-10 Chronological Transition of Hammer Mill Electrification Rate

5.8.2. Growth of Number of Households in Unelectrified RGCs

Number of households in each of 1,217 unelectrified RGCs as of 2006 has been obtained as a part of data submitted from the district planners in November 2006. To forecast potential demand in 2030, the target year of the rural electrification master plan, an increase rate in the number of households for unelectrified RGCs needs to be taken into account. Household growth rate, however, is not officially available even in the census report, while population growth rate with AIDs at 2.9% per annum up to 2025 is announced in "Population Projection Report" published by Central Statistics Office in November 2003. Therefore, this population growth rate is substituted as the household growth rate, and assumed to maintain at the same rate by 2030. Equation 5-1 indicates how the number of households in each RGC in 2030 is forecasted by using the data as of 2006.

$$X_{HH\,[2030]} = X_{HH\,[2006]} \times (1+0.029)^{24} = 1.986 \times X_{HH\,[2006]} \qquad \text{(Equation 5-1)}$$

$X_{HH\,[2030]}$: Forecasted Number of Households in a RGC in 2030

$X_{HH\,[2006]}$: Number of Households in a RGC in 2006 (data submitted by district planners)

5.8.3. Transition of Household Electrification Rate in Electrified RGCs

Among 23 RGCs listed in Table 5-1, the relationship between the household electrification rates and the year after electrification for 21 electrified RGCs (except Kabanda and Mwandi RGCs that electrification years were uncertain) were plotted in Figure 5-9. In general, it is expected that the household electrification rate increases according to the length (or years) after the electrification. Based on the collected data by the socio-economic survey, however, there are no relationships between them, even if provincial/regional aspects and the total number of households in RGCs are taken into consideration. Therefore, there is no convincing information regarding the chronological transition (escalation) of household electrification rate considered in the potential demand forecast.

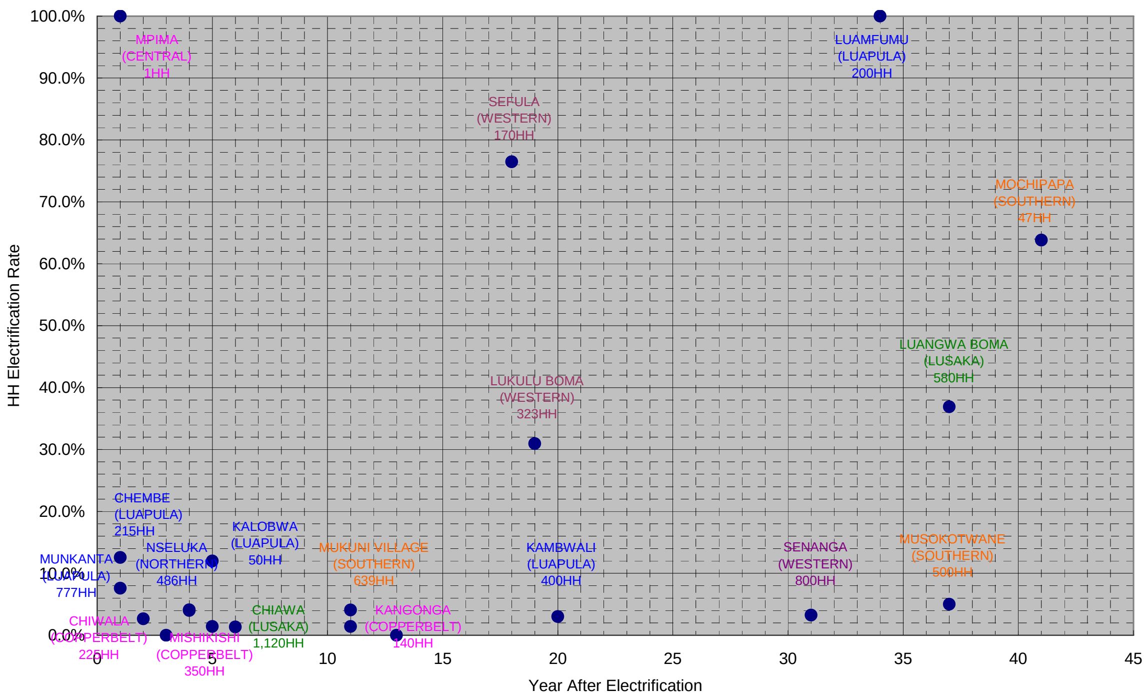


Figure 5-9 Chronological Transition of Household Electrification Rate

Table 5-8 Number of Hammer Mills and Unit Servicing Households in Surveyed RGCs

RGC	Province	Status	HM in RCG	HH in RGC	HH per HM
MPULA	CENTRAL	Electrified	3	70	23
CHIPEPO	CENTRAL	Un-Electrified	1	583	583
MPUNDE	CENTRAL	Electrified	2	500	250
CHIBALE	CENTRAL	Un-Electrified	2	250	125
OLD MKUSHI	CENTRAL	Un-Electrified	2	440	220
SHIMOKUNI	CENTRAL	Un-Electrified	5	300	60
MUMBWA BIG CONCESSION	CENTRAL	Un-Electrified	4	85	21
MISHIKISHI	COPPERBELT	Electrified	4	350	88
MUTABA	COPPERBELT	Un-Electrified	2	30	15
MIKATA	COPPERBELT	Un-Electrified	2	38	19
CHIWALA	COPPERBELT	Electrified	2	225	113
KANGONGA	COPPERBELT	Electrified	1	750	750
KAMEME	COPPERBELT	Un-Electrified	0	100	-
KAKOLO	COPPERBELT	Un-Electrified	2	88	44
MUTUNDU	COPPERBELT	Un-Electrified	0	188	-
KAFUBU	COPPERBELT	Un-Electrified	2	100	50
LUFWANYAMA EMMARALD MINING AREA	COPPERBELT	Un-Electrified	-	0	-
MUNGOMBA	COPPERBELT	Un-Electrified	0	50	-
KAMITETA	COPPERBELT	Un-Electrified	-	10	-
KAPUNGWE	EASTERN	Un-Electrified	-	2,000	-
CHIPEMBE	EASTERN	Un-Electrified	1	128	128
MPOMWA TSE-TSE	EASTERN	Un-Electrified	3	750	250
MWASE	EASTERN	Un-Electrified	2	750	375
MLOLO	EASTERN	Un-Electrified	2	662	331
KAGORO	EASTERN	Un-Electrified	1	30	30
CHEMBE	LUAPULA	Electrified	2	215	108
KASONGWA SUB-BOMA	LUAPULA	Un-Electrified	2	474	237
LUAMFUMU	LUAPULA	Electrified	1	200	200
MILENGE	LUAPULA	Un-Electrified	0	780	-
CHINSANKA	LUAPULA	Un-Electrified	2	1,800	900
MUSHOTA	LUAPULA	Un-Electrified	2	443	222
KALOBWA	LUAPULA	Electrified	1	50	50
KATUTA	LUAPULA	Un-Electrified	1	155	155
CHILONGO	LUAPULA	Un-Electrified	-	950	-
KANBWALI	LUAPULA	Electrified	3	400	133
MUNKANTA	LUAPULA	Electrified	2	777	389
CHIAWA	LUSAKA	Electrified	1	112	112
NCHUTE	LUSAKA	Un-Electrified	1	93	93
CHINYUNYU	LUSAKA	Un-Electrified	1	247	247
CHIPAPA	LUSAKA	Un-Electrified	-	133	-
LUANGWA BOMA	LUSAKA	Electrified	3	580	193
KAPIJIMPANGA	NORTH WESTERN	Electrified	1	250	250
MUMEMA	NORTH WESTERN	Un-Electrified	4	163	41
NSELAUKE	NORTH WESTERN	Un-Electrified	9	275	31
MATUSHI	NORTH WESTERN	Un-Electrified	4	1,500	375
CHITOKOLOKI	NORTH WESTERN	Un-Electrified	3	1,000	333
CHIVOMBO	NORTH WESTERN	Un-Electrified	2	40	20
KASHINAKAZI	NORTH WESTERN	Un-Electrified	0	106	-
KABANDA	NORTH WESTERN	Electrified	15	500	33
SHIWANG'ANDU	NORTHERN	Un-Electrified	2	40	20
KANCHIBIYA	NORTHERN	Un-Electrified	-	50	-
CHITIMBWA	NORTHERN	Un-Electrified	4	230	58
CHIMULA	NORTHERN	Un-Electrified	0	100	-
ROSA	NORTHERN	Un-Electrified	1	416	416
MASONDE	NORTHERN	Un-Electrified	-	200	-
WULONGO	NORTHERN	Un-Electrified	0	200	-
NSAMA SUB-BOMA	NORTHERN	Un-Electrified	3	297	99
KACHUMU	NORTHERN	Un-Electrified	-	30	-
MUKUPA KAOMA	NORTHERN	Un-Electrified	3	202	67
MATIPA	NORTHERN	Un-Electrified	4	435	109
NSELUKA	NORTHERN	Electrified	4	486	122
NAMOOMBA	SOUTHERN	Un-Electrified	1	132	132
NGWEZI	SOUTHERN	Un-Electrified	-	15	-
KAUMUZYA EAST	SOUTHERN	Un-Electrified	-	69	-
SINAKAIMBI	SOUTHERN	Un-Electrified	-	17	-
MOCHIPAPA	SOUTHERN	Electrified	1	47	47
MAMBOVA	SOUTHERN	Un-Electrified	-	144	-
SIABWENGO	SOUTHERN	Un-Electrified	1	22	22
KASIYA	SOUTHERN	Un-Electrified	1	170	170
KANCHOMBA	SOUTHERN	Un-Electrified	0	600	-
MUSOKOTWANE	SOUTHERN	Electrified	1	71	71
KABANGA	SOUTHERN	Un-Electrified	2	422	211
MUKUNI VILLAGE	SOUTHERN	Electrified	2	639	320
BAMBWE	SOUTHERN	Un-Electrified	1	166	166
LUBANDA	SOUTHERN	Un-Electrified	2	200	100
MWANDI	SOUTHERN	Electrified	2	410	205
LUKULU BOMA	WESTERN	Electrified	17	323	19
SEFULA	WESTERN	Electrified	3	170	57
SIANDA	WESTERN	Un-Electrified	1	230	230
SIOMA	WESTERN	Un-Electrified	2	400	200
NANGWESHI	WESTERN	Un-Electrified	3	600	200
SENANGA	WESTERN	Electrified	2	800	400
NANGULA	WESTERN	Un-Electrified	0	26	-
NKEYEMA	WESTERN	Un-Electrified	5	428	86
SICHILI	WESTERN	Un-Electrified	7	150	21
Average			2	337	174
(St. Dev)			(2.8)	(370.4)	(171.4)
Average for Electrified RGC			3	360	179
(St. Dev)			(4.2)	(243.3)	(170.4)
Average for Unelectrified RGC			2	329	172
(St. Dev)			(1.8)	(406.9)	(174.0)

5.8.5. Other Assumptions for Demand Forecast

In addition to the numbers of households and hammer mills in a RGC, the numbers of public facilities and business entities in a RGC in 2030 also need to be assumed to forecast potential electricity demand. However, neither baseline data, such as the numbers of public facilities and business entities in each of RGCs before electrified, nor the official increase rate of these numbers are available as a secondary data. Therefore, as a most intelligent estimation, the population growth rate (2.9% per annum) is substituted as the growth rates of both public facilities and business entities. Equation 5-3 and 5-4 indicates how the number of each type of public facilities and business entities in each RGC in 2030 are forecasted by using the data as of 2006. Since the chronological transitions (escalations) of household and hammer mill electrification rate are disregarded, those for public facilities and business entities are also neglected in the potential demand forecast.

$$X_{PFi\,[2030]} = X_{PFi\,[2006]} \times (1+0.029)^{24} = 1.986 \times X_{PFi\,[2006]} \qquad \text{(Equation 5-3)}$$

$X_{PFi\,[2030]}$: Forecasted Number of Public Facility Type i in a RGC in 2030
$X_{PFi\,[2006]}$: Number of Public Facility Type i in a RGC in 2006 (data submitted by district planners)
i: Type of Public Facility shown in Table 5-2 (i = 1 ~ 18)

$$X_{BE\,[2030]} = X_{BE\,[2006]} \times (1+0.029)^{24} = 1.986 \times X_{BE\,[2006]} \qquad \text{(Equation 5-4)}$$

$X_{BE\,[2030]}$: Forecasted Number of Business Entities in a RGC in 2030
$X_{BE\,[2006]}$: Number of Business Entities in a RGC in 2006 (data submitted by district planners)

5.8.6. Daily Peak Demand Forecast Method

As studied in the section 5.8.1., the linear regression model does not work to forecast the daily peak demand in a RGC. On the other hand, unit daily load curves for all types of consumers – each type of Public Facilities, Business Entities, Hammer Mills, and Households – have been captured utilizing data collected by the socio-economic survey. In addition, the numbers of each type of Public Facilities, Business Entities, Hammer Mills, and Households in each of 1,217 unelectrified RGCs in 2030 are assumable based on the obtained basic RGC data as of 2006 from the district planners (refer to Equation 5-1, 5-2, 5-3 and 5-4). Therefore, in the same manner explained in the Section 5.7 to estimate daily load curve and peak demand for 8 electrified RGCs, the method of adding up the daily load curves for different types of consumers will be adopted. Assumptions for demand forecast, such as growth rates and unit daily load timetables for each type of consumers, are summarized in Table 5-9. Steps to create potential daily load curve for each of 1,217 RGCs are explained as follows and illustrated with a sample sheet shown in Table 5-10.

Step A: Assume the numbers of Public Facilities, Business Entities, Hammer Mills, and Households in a RGC in 2030 by using Equation 5-1, 5-2, 5-3 and 5-4

Step B: Multiply electrification rates of Public Facilities in each type, Business Entities, Hammer Mills, and Households by the number of them in 2030 obtained in Step A. Then, the numbers of electrified Public Facilities, Business Entities, Hammer Mills, and Households in a RGC in 2030 will be obtained.

Step C: Multiply the numbers of electrified consumers obtained in Step B by the unit daily load timetables for each type of consumers shown in Table 5-9 to create the daily load timetables.

Step D: Sum up the daily load timetables for each type of consumers and create the potential daily load table for a RGC.

Step E: Select the maximum daily load as the daily peak demand for each RGC and use it as a design capacity of electrification facilities.

Table 5-9 Assumptions for Demand Forecast

	per Year	by 2030
HH Growth Rate	0.029	0.986
BE Growth Rate	0.029	0.986
PF Growth Rate	0.029	0.986
# of HH per HM	174	

Time	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	0:00
Hammer Mill Daily Load (Av.)	0	0	0	0	0	0	0	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	0	0	0	0	0
HH Daily Load (Av.)	151	144	144	138	139	146	249	254	243	170	159	196	282	245	180	174	175	196	401	467	371	288	246	212	151
BE Daily Load (Av. Excl. HM)	138	134	134	134	134	135	201	196	269	129	165	266	292	139	127	212	214	170	457	492	366	345	295	211	138
PF Daily Load (Av.)																									
1) Basic/Primary School	503	503	503	503	503	468	597	280	327	328	342	358	367	342	341	332	454	313	621	670	654	569	503	495	503
2) High/Secondary School	0	0	0	0	0	0	0	240	240	240	240	240	240	0	0	0	30	270	30	0	0	0	0	0	0
3) Tertiary School	230	230	230	230	230	230	1,670	1,729	3,424	3,424	3,424	3,424	3,454	1,984	3,424	2,997	2,997	2,997	3,419	3,230	3,230	3,230	3,230	230	230
4) Hospital	7,240	7,240	7,240	7,240	7,240	7,240	7,240	15,890	28,170	28,170	28,170	23,630	23,630	23,530	23,530	23,530	28,070	28,070	21,520	15,590	15,590	15,490	15,490	15,490	7,240
5) Health Center/Clinic	541	541	541	541	541	541	467	296	351	329	354	300	325	344	382	375	357	362	542	546	648	629	623	619	541
6) Police Office	237	237	237	237	237	237	237	38	347	347	38	38	38	38	38	38	38	38	237	237	237	237	226	237	237
7) Post Office	195	195	195	195	195	195	195	75	325	92	92	92	92	92	0	475	475	477	477	2	2	197	197	197	195
8) Church	123	123	123	123	123	123	123	73	7	7	7	7	7	7	7	7	7	7	104	171	171	171	171	123	123
9) Mosque	123	123	123	123	123	123	123	73	7	7	7	7	7	7	7	7	7	7	104	171	171	171	171	123	123
10) Community Center	718	718	718	718	718	718	723	325	583	710	460	460	320	320	220	220	220	460	975	1,343	1,093	748	748	718	718
11) Agriculture Depot	248	240	240	240	240	165	328	310	310	233	233	310	235	233	233	233	233	325	385	520	443	428	428	278	248
12) Orphanage	1,005	1,023	1,023	1,023	1,005	1,005	1,005	1,005	5	5	5	5	5	5	5	5	5	5	5	35	35	5	5	5	1,005
13) Central Government Office	0	0	0	0	0	0	0	530	623	623	623	123	123	123	123	423	423	423	300	300	300	300	300	300	0
14) Provincial Government Office	150	0	0	0	0	0	0	265	1,464	1,464	1,464	1,214	1,214	1,214	1,214	1,214	1,214	524	300	300	300	300	300	300	150
15) District Government Office	300	0	0	0	0	0	0	0	2,305	2,305	2,305	2,305	2,305	2,305	2,305	2,005	2,005	625	300	300	300	300	300	300	300
16) Other Local Administration Office	150	0	0	0	0	0	0	265	1,464	1,464	1,464	1,214	1,214	1,214	1,214	1,214	1,214	524	300	300	300	300	300	300	150
17) Court	215	215	215	215	215	165	165	221	395	395	405	389	389	389	389	389	379	927	654	654	654	582	582	582	215
18) Other (Average)	215	215	215	215	215	165	165	221	395	395	405	389	389	389	389	389	379	927	654	654	654	582	582	582	215

Table 5-10 Sample Sheet to Select Daily Peak Demand in a RGC

RGC	Shimukuni		
District	Chibombo	Priority	1
Province	Central		
Ward	Kakoma		

Step C

Step D

Step E

	Exist in 2006	Exist in 2030	Elec.# in 2030	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	0:00	Max Load
RGC Load	-	-	-	**130,743**	**125,027**	**124,836**	**120,631**	**121,014**	**126,085**	**212,136**	**289,483**	**285,565**	**219,949**	**212,955**	**247,926**	**317,558**	**279,146**	**226,900**	**227,575**	**228,002**	**242,346**	**422,805**	**477,899**	**319,748**	**252,200**	**215,301**	**184,009**	**130,743**	**477,899**
Hammer Mill Daily Load	1	5	5	0	0	0	0	0	0	0	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	0	0	0	0	0	-
Sub Total (HH, BE excl. HM, PF)	-	-	-	130,743	125,027	124,836	120,631	121,014	126,085	212,136	214,483	210,565	144,949	137,955	172,926	242,558	204,146	151,900	152,575	153,002	167,346	347,805	402,899	319,748	252,200	215,301	184,009	130,743	402,899
	Exist in 2006	Exist in 2030	Elec.# in 2030	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	0:00	
HH Daily Load	400	795	795	119,971	114,454	114,262	110,057	110,440	115,689	197,625	201,652	192,854	135,259	126,793	156,034	224,275	194,439	142,783	138,722	138,837	155,729	318,645	371,426	295,274	229,178	195,224	168,917	119,971	
BE Daily Load (Excl. HM)	28	56	56	7,714	7,530	7,530	7,530	7,530	7,574	11,252	10,981	15,042	7,216	9,229	14,878	16,351	7,793	7,130	11,897	12,002	9,541	25,590	27,526	20,511	19,297	16,518	11,835	7,714	
Total PF Daily Load	-	-	-	3,059	3,044	3,044	3,044	3,044	2,822	3,260	1,850	2,670	2,474	1,933	2,013	1,932	1,914	1,986	1,956	2,163	2,076	3,570	3,947	3,962	3,725	3,559	3,257	3,059	
1) Basic/Primary School	1	2	2	1,007	1,007	1,007	1,007	1,007	935	1,195	561	654	657	683	716	735	685	682	665	908	625	1,242	1,340	1,308	1,138	1,005	990	1,007	
2) High/Secondary School	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3) Tertiary School	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4) Hospital	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5) Health Center/Clinic	1	2	2	1,083	1,083	1,083	1,083	1,083	1,083	935	593	703	659	708	601	650	687	763	750	714	724	1,084	1,093	1,295	1,257	1,246	1,237	1,083	
6) Police Office	1	2	2	474	474	474	474	474	474	474	77	693	693	77	77	77	77	77	77	77	77	474	474	474	474	453	474	474	
7) Post Office	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
8) Church	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
9) Mosque	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
10) Community Center	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
11) Agriculture Depot	1	2	2	495	480	480	480	480	330	656	620	620	465	465	620	470	465	465	465	465	650	770	1,040	885	855	855	555	495	
12) Orphanage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
13) Central Government Office	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
14) Provincial Government Office	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
15) District Government Office	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
16) Other Local Administration Office	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
17) Court	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
18) Other (Average)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Step A Step B

In the electrified RGCs, actual electrification rates of Business Entities, Hammer Mills, and Households are shown in Table 5-1, and these of Public Facilities in different types are summarized on Table 5-2. In Step B, however, 100% of electrification rates, instead of the actual electrification rates, for all types of consumers are adopted. This assumption that all of the Public Facilities, Business Entities, Hammer Mills, and Households in the 1,217 RGCs are electrified by 2030 seems to result in over estimation of the potential demand. However, as DoE and REA are planning to extend the electrification area from the 1,217 RGCs to the villages in the catchment areas of these RGCs after 2030, some supply margin on the design capacity of the electrification facilities needs to be considered, to be on the safe side. Therefore, after the discussions with DoE and REA, it was decided to apply 100% electrification rates for all the types of consumers to forecast the daily load of each RGC.

5.9. Forecast of Potential Demand for Unelectrified RGCs [Step 3]

Table 5-11 (from next page) shows the calculation result of the forecasted potential daily peak demand for the long listed 1,217 unelectrified RGCs. Among these unelectrified RGCs, BOMA (District Center) are give priority over the other RGCs. Then, RGCs other than BOMA are ranked by the size of potential demand (application of "Demand Criteria"). This is the temporary electrification order for 1,217 RGCs.

Table 5-11 Temporary Electrification Priority of RGCs Based on Demand Criteria (1/13)

Ranking	RGC	District	Priority	Province	# of HHs (2006)	# of HHs (2030)	Daily Max Load
1	Mpulungu Central	Mpulungu	4	Northern	2,000	3,972	2,200,731
2	Mwinilunga Boma	Mwinilunga	0	North-Western	1,900	3,774	2,093,225
3	Shangombo	Shangombo	1	Western	1,100	2,185	1,277,541
4	Boma	Luangwa	1	Lusaka	580	1,152	752,118
5	Chienge	Chienge	6	Luapula	560	1,113	642,046
6	Mpongwe	Mpongwe	22	Copperbelt	441	876	499,270
7	Nsama Sub Boma	Kaputa	1	Northern	441	876	499,270
8	Talayi	Milenge	1	Luapula	202	402	241,663
9	KPG Market	Kapiri Mposhi	22	Central	7,400	14,697	8,141,484
10	Chisanga	Kasama	9	Northern	5,000	9,930	5,530,061
11	Chindenza School	Katete	3	Eastern	5,000	9,930	5,515,225
12	Mtandaza RHC	Katete	5	Eastern	5,000	9,930	5,509,327
13	Kagoro	Katete	1	Eastern	4,000	7,944	4,401,462
14	Sikapila	Mporokoso	2	Northern	3,646	7,241	4,012,551
15	Kauwe	Kazungula	14	Southern	3,511	6,973	3,927,399
16	Palace Chipepo Mukuni-Ngombe	Kapiri Mposhi	23	Central	3,500	6,951	3,847,529
17	Twapia	Ndola	2	Copperbelt	3,333	6,620	3,735,864
18	Nchembwe	Kapiri Mposhi	20	Central	3,100	6,157	3,416,570
19	Kapungwe	Petauke	1	Eastern	3,084	6,125	3,407,622
20	Nyamphinga	Petauke	10	Eastern	3,084	6,125	3,405,327
21	Chikalawa	Petauke	12	Eastern	3,084	6,125	3,402,990
22	Mwanjawanthu	Petauke	3	Eastern	3,036	6,030	3,345,943
23	Kasenengwa Rural Centre	Chipata	5	Eastern	3,000	5,958	3,321,933
24	Kamphambe	Katete	7	Eastern	3,000	5,958	3,308,596
25	Sikatengwa	Lundazi	22	Eastern	2,949	5,857	3,246,409
26	Mushili	Samfa	18	Luapula	2,751	5,464	3,032,798
27	Madimawe Rural Health Centre	Chipata	8	Eastern	2,667	5,297	2,953,674
28	Matonje	Petauke	13	Eastern	2,587	5,138	2,851,518
29	Mumbi	Petauke	5	Eastern	2,503	4,971	2,762,099
30	Kawama East	Mufulira	6	Copperbelt	2,448	4,862	2,732,408
31	Chimutende,	Katete	2	Eastern	2,472	4,910	2,728,967
32	Thendere	Isoka	4	Northern	2,400	4,767	2,698,020
33	Ntipo	Isoka	7	Northern	2,420	4,807	2,685,921
34	Chinkhombe	Katete	13	Eastern	2,385	4,737	2,634,234
35	Mushindomo	Solwezi	21	North-Western	2,380	4,727	2,628,469
36	Mulekatembo	Isoka	5	Northern	2,350	4,667	2,618,045
37	Kaula	Kabompo	14	North-Western	2,350	4,667	2,585,437
38	Lukulu Township	Lukulu	1	Western	2,012	3,996	2,512,048
39	Nande	Senanga	8	Western	2,148	4,266	2,393,483
40	George Camp	Ndola	4	Copperbelt	2,165	4,300	2,383,973
41	Sansamwente	Isoka	8	Northern	2,120	4,211	2,368,121
42	Chipashi Island	Nchelenge	13	Luapula	2,114	4,199	2,341,746
43	Kasheke	Mongu	38	Western	2,100	4,171	2,308,704
44	Musakashi	Kalulushi	2	Copperbelt	2,000	3,972	2,251,135
45	Nyembe	Katete	10	Eastern	2,000	3,972	2,210,561
46	Sinunga	Senanga	5	Western	1,990	3,953	2,207,358
47	Muchabi	Mumbwa	8	Central	2,000	3,972	2,202,071
48	Mng'omba School	Katete	4	Eastern	2,000	3,972	2,200,731
49	Makuku	Mongu	36	Western	2,000	3,972	2,200,731
50	Kaulu	Petauke	7	Eastern	1,988	3,949	2,192,975
51	Mukupakaoma	Mporokoso	1	Northern	1,974	3,921	2,176,903
52	Lui-mwemba	Senanga	4	Western	1,935	3,843	2,165,744
53	Namabuka	Senanga	18	Western	1,935	3,843	2,154,070
54	Chishamwamba	Mporokoso	5	Northern	1,930	3,833	2,135,790
55	Mwimba	Lundazi	24	Eastern	1,842	3,659	2,039,496
56	Lukulu HC, Sch, Mkt	Mpika	8	Northern	1,800	3,575	2,011,559
57	Matipa	Chilubi	2	Northern	1,817	3,609	2,001,136
58	Ikelenge	Mwinilunga	2	North-Western	1,763	3,502	1,995,148
59	Likondwana	Shangombo	17	Western	1,800	3,575	1,990,633
60	Chitoshi	Mporokoso	3	Northern	1,730	3,436	1,905,310
61	Nasilimwe	Senanga	13	Western	1,634	3,246	1,823,877
62	Mulundu	Mwense	20	Luapula	1,584	3,146	1,822,353
63	Nyamphande NSS	Petauke	4	Eastern	1,650	3,277	1,819,103
64	Monde	Petauke	9	Eastern	1,650	3,277	1,817,477
65	Nasilimwe_	Senanga	15	Western	1,634	3,246	1,817,115
66	Nalolo	Senanga	7	Western	1,634	3,246	1,810,953
67	Sasali	Petauke	6	Eastern	1,608	3,194	1,781,938
68	Chikowa	Petauke	8	Eastern	1,608	3,194	1,780,008
69	Liliachi	Senanga	3	Western	1,533	3,045	1,715,109
70	Nangucha	Senanga	9	Western	1,511	3,001	1,699,508
71	Chitawe RHC	Katete	6	Eastern	1,500	2,979	1,661,798
72	Bwalinde	Luwingu	25	Northern	1,500	2,979	1,661,798
73	Murundu	Mufulira	4	Copperbelt	1,476	2,932	1,658,437
74	Luansobe	Mufulira	2	Copperbelt	1,488	2,956	1,651,057
75	Kaunga Mashi	Shangombo	15	Western	1,474	2,928	1,626,387
76	SITULU	Kalabo	29	Western	1,472	2,924	1,621,102
77	Big Concession	Mumbwa	1	Central	1,463	2,906	1,612,692
78	Township	Kawambwa	9	Luapula	1,281	2,545	1,608,850
79	Chasela	Lundazi	25	Eastern	1,444	2,868	1,594,939
80	Lwanda	Kalabo	22	Western	1,436	2,852	1,591,204
81	Ngundi	Senanga	14	Western	1,398	2,777	1,557,863
82	Silumbi	Senanga	6	Western	1,398	2,777	1,554,040
83	Muyombe	Isoka	1	Northern	1,340	2,662	1,543,584
84	Misolo	Petauke	11	Eastern	1,398	2,777	1,541,581
85	Kazabami	Kaoma	42	Western	1,385	2,751	1,525,276
86	Kafumbwe School	Katete	14	Eastern	1,308	2,598	1,468,131
87	Natukoma	Shangombo	8	Western	1,312	2,606	1,452,188
88	Chinyingi	Zambezi	18	North-Western	1,307	2,596	1,437,859
89	Mbeza	Namwala	5	Southern	1,283	2,548	1,433,278
90	Kawanda	Kabompo	13	North-Western	1,300	2,582	1,431,318
91	Kaba Hill	Kaoma	39	Western	1,287	2,556	1,420,511
92	Mulela	Mpongwe	12	Copperbelt	1,270	2,523	1,408,669
93	St. Anthony	Mpongwe	21	Copperbelt	1,270	2,523	1,403,754
94	Nakamboma (Namakaka)	Namwala	11	Southern	1,250	2,483	1,398,475
95	Kafwimbi	Isoka	2	Northern	1,230	2,443	1,388,576
96	Kapatu	Mporokoso	14	Northern	1,200	2,384	1,369,252
97	Chilasa	Katete	8	Eastern	1,215	2,413	1,337,361
98	Katibunga	Mpika	5	Northern	1,200	2,384	1,335,519
99	Lukali Community School	Kabwe	6	Central	1,200	2,384	1,328,418
100	Sinde	Kazungula	15	Southern	1,200	2,384	1,323,812

Table 5-11 Temporary Electrification Priority of RGCs Based on Demand Criteria (2/13)

Ranking	RGC	District	Priority	Province	# of HHs (2006)	# of HHs (2030)	Daily Max Load
101	Mwiima	Chilubi	14	Northern	1,192	2,368	1,316,337
102	Chalabesa Hospital	Mpika	4	Northern	1,167	2,318	1,303,700
103	Kawngu	Isoka	3	Northern	1,125	2,235	1,251,248
104	Kampumbu (Kamrinsu)	Isoka	6	Northern	1,102	2,189	1,231,982
105	Muwele	Mpika	17	Northern	1,100	2,185	1,228,814
106	Moobola	Namwala	2	Southern	1,083	2,151	1,221,232
107	Mupamadzi Farm Block	Mpika	3	Northern	1,100	2,185	1,221,213
108	Chilanga_	Mambwe	13	Eastern	1,100	2,185	1,215,839
109	Katutwa	Mporokoso	9	Northern	1,100	2,185	1,215,839
110	Mwense	Mwense	18	Luapula	1,013	2,012	1,212,634
111	Ukwimi	Petauke	2	Eastern	1,070	2,125	1,194,181
112	Kasaba	Samfa	16	Luapula	1,023	2,032	1,193,337
113	Mpepo HC, Sch, Palace	Mpika	6	Northern	1,050	2,086	1,178,152
114	Itapa	Namwala	3	Southern	1,000	1,986	1,146,383
115	Mbati	Mpika	18	Northern	1,000	1,986	1,145,733
116	Sipuma	Shangombo	16	Western	1,023	2,032	1,132,773
117	Mulele	Shangombo	9	Western	1,017	2,020	1,128,725
118	Kaindu	Mumbwa	11	Central	1,000	1,986	1,125,917
119	Baambwe	Namwala	1	Southern	1,000	1,986	1,125,502
120	Simakumba	Lukulu	7	Western	1,000	1,986	1,116,242
121	Kaunga Lueti	Senanga	11	Western	992	1,971	1,115,114
122	Mansha Farm Block	Mpika	2	Northern	1,000	1,986	1,114,908
123	Tuuwa	Kalabo	26	Western	1,006	1,998	1,113,472
124	Nile Kapambwe	Nchelenge	4	Luapula	1,000	1,986	1,112,230
125	Matunga School	Katete	12	Eastern	1,000	1,986	1,108,465
126	Naviluri	Chadiza	7	Eastern	1,000	1,986	1,107,865
127	Mano	Samfa	19	Luapula	1,000	1,986	1,107,865
128	Munshinga	Luwingu	23	Northern	1,000	1,986	1,107,865
129	Likutwe	Mongu	37	Western	1,000	1,986	1,107,865
130	Chifulube	Luanshya	2	Copperbelt	992	1,971	1,106,950
131	Kalilo	Chingola	3	Copperbelt	953	1,893	1,079,160
132	Mutenda	Chingola	6	Copperbelt	954	1,895	1,078,866
133	Kamiteta	Chingola	1	Copperbelt	950	1,887	1,069,442
134	Mutaba	Masaiti	1	Copperbelt	960	1,907	1,061,796
135	Mutundu North (Conner Bar)	Mufulira	1	Copperbelt	952	1,891	1,061,520
136	Chinsanka	Samfa	1	Luapula	914	1,816	1,049,654
137	Lukwesa	Mwense	14	Luapula	944	1,875	1,040,539
138	Mabo Kafutuma	Nchelenge	14	Luapula	932	1,851	1,036,124
139	Musangu	Mwense	15	Luapula	917	1,822	1,034,612
140	Ngabo	Namwala	7	Southern	917	1,822	1,021,934
141	Beshe	Shangombo	10	Western	912	1,812	1,017,937
142	Chilese	Masaiti	13	Copperbelt	909	1,806	1,017,488
143	Lubwe	Samfa	17	Luapula	841	1,671	1,015,104
144	Kaf GRZ	Masaiti	3	Copperbelt	909	1,806	1,013,898
145	Mupambe	Mufulira	7	Copperbelt	900	1,788	1,000,359
146	Ncheka_	Mambwe	12	Eastern	900	1,788	1,000,359
147	Kanfinsa	Luwingu	24	Northern	900	1,788	1,000,359
148	Chilwa	Kapiri Mposhi	9	Central	892	1,772	996,433
149	Mata	Senanga	10	Western	878	1,744	993,470
150	Songa	Senanga	12	Western	878	1,744	992,378
151	Mwanamwalye	Senanga	16	Western	878	1,744	988,485
152	Kantanta	Chilubi	13	Northern	887	1,762	988,212
153	Chichile	Chilubi	6	Northern	863	1,714	950,786
154	Luamba	Kaoma	40	Western	860	1,708	947,983
155	Mwase	Lundazi	1	Eastern	797	1,583	947,541
156	Mumba	Mumbwa	14	Central	850	1,689	940,446
157	Mofu R4	Chilubi	16	Northern	849	1,687	938,172
158	Muchila	Namwala	6	Southern	833	1,655	937,271
159	Kantengwa	Namwala	9	Southern	833	1,655	935,323
160	Nangula	Mongu	1	Western	821	1,631	930,972
161	Matondo	Zambezi	14	North-Western	840	1,669	929,762
162	Liangati	Senanga	21	Western	800	1,589	927,702
163	Ipafu	Chingola	4	Copperbelt	800	1,589	926,433
164	Emusa	Lundazi	2	Eastern	797	1,583	926,078
165	Lukalanys	Mongu	4	Western	834	1,657	925,496
166	Kalengola	Shangombo	6	Western	826	1,641	925,019
167	Nangweshi	Shangombo	4	Western	800	1,589	924,841
168	Chiwele	Chilubi	11	Northern	824	1,637	914,812
169	Josias Chiwala Farm	Kabwe	7	Central	820	1,629	914,309
170	Mupapa	Masaiti	5	Copperbelt	818	1,625	913,649
171	Kataba	Senanga	17	Western	799	1,587	910,948
172	Kachuma	Kasama	1	Northern	805	1,599	900,733
173	Chilanga	Mambwe	9	Eastern	800	1,589	897,768
174	Mwansabombwe	Kawambwa	15	Luapula	750	1,490	893,832
175	keezwa	Mumbwa	7	Central	800	1,589	893,726
176	Katanhsya	Samfa	7	Luapula	786	1,561	893,334
177	Maimwene settlement	Mumbwa	5	Central	800	1,589	892,386
178	Kawasa	Chilubi	15	Northern	800	1,589	892,386
179	Isoko	Mpulungu	6	Northern	800	1,589	892,386
180	Chilumba	Mpulungu	12	Northern	800	1,589	892,386
181	Dipalata	Zambezi	5	North-Western	800	1,589	892,386
182	Ikabako	Mongu	40	Western	800	1,589	892,386
183	Mimbula Block	Chingola	2	Copperbelt	780	1,550	870,943
184	Kabole	Chienge	7	Luapula	730	1,450	867,114
185	Chabukasansha	Chilubi	23	Northern	787	1,563	865,238
186	Kambashi	Chilubi	1	Northern	715	1,420	861,662
187	Mwansakombe	Samfa	14	Luapula	767	1,524	856,639
188	Kangomba Health Centre	Kabwe	10	Central	770	1,530	852,925
189	Mayuka	Chilubi	5	Northern	762	1,514	842,346
190	Ichila	Namwala	13	Southern	750	1,490	839,343
191	Siluwe	Kalabo	23	Western	755	1,500	835,805
192	Mokambo	Mufulira	3	Copperbelt	719	1,428	832,900
193	Lambwe Chomba	Chienge	2	Luapula	720	1,430	832,044
194	Kaande	Mongu	13	Western	746	1,482	827,395
195	Mundubi	Samfa	15	Luapula	716	1,422	815,642
196	Sianda	Senanga	1	Western	711	1,413	807,323
197	Mununga	Chienge	9	Luapula	710	1,411	805,208
198	Sitoti	Shangombo	5	Western	710	1,411	799,948
199	Mutomena	Shangombo	7	Western	706	1,403	797,194
200	Madziayera	Chadiza	13	Eastern	710	1,411	794,224

Table 5-11 Temporary Electrification Priority of RGCs Based on Demand Criteria (3/13)

Ranking	RGC	District	Priority	Province	# of HHs (2006)	# of HHs (2030)	Daily Max Load
201	Kashitu	Chilubi	18	Northern	705	1,401	792,232
202	Katima	Sesheke	3	Western	685	1,361	790,330
203	Kasamanda	Mambwe	4	Eastern	670	1,331	784,002
204	Chiwena	Mumbwa	15	Central	700	1,391	775,152
205	Chibwika	Mwinilunga	8	North-Western	697	1,385	773,525
206	Sakandingo	Kabompo	2	North-Western	685	1,361	771,159
207	Mutamba	Mufulira	8	Copperbelt	700	1,391	769,880
208	Zingalume	Chadiza	15	Eastern	700	1,391	769,880
209	Isunga	Mpulungu	13	Northern	700	1,391	769,880
210	Milomboyi	Zambezi	12	North-Western	700	1,391	769,880
211	Mubili	Chilubi	7	Northern	691	1,373	761,470
212	Shinono	Kaoma	7	Western	656	1,303	760,211
213	Matebele	Shangombo	11	Western	680	1,351	759,172
214	Nyela	Nakonde	6	Northern	656	1,303	758,766
215	Mabo-Ninge	Samfa	6	Luapula	648	1,287	758,703
216	Lubunda	Mwense	17	Luapula	664	1,319	751,284
217	Puta	Chienge	5	Luapula	620	1,232	749,854
218	Katongo Kapala	Mpika	12	Northern	650	1,291	729,504
219	Egichakeni	Lundazi	5	Eastern	638	1,268	728,160
220	Miulwe	Mongu	22	Western	655	1,301	727,831
221	Kambowa	Masaiti	8	Copperbelt	650	1,291	727,603
222	Twingi	Samfa	3	Luapula	640	1,272	726,560
223	Magumwi	Sesheke	11	Western	651	1,293	726,119
224	Mufubushi Resettlement	Mpika	7	Northern	650	1,291	725,870
225	Nkhanga	Lundazi	19	Eastern	640	1,272	723,299
226	Mukangu	Mongu	30	Western	648	1,287	721,290
227	Chilolwa	Nakonde	4	Northern	600	1,192	721,029
228	M_Mphanga	Lundazi	4	Eastern	618	1,228	718,733
229	Nakato	Mongu	16	Western	645	1,281	718,487
230	Lucembe	Mpika	11	Northern	620	1,232	709,285
231	Lupiya	Chienge	1	Luapula	600	1,192	708,616
232	Mulenga M	Mporokoso	16	Northern	600	1,192	707,346
233	Lwata	Luwingu	25	Northern	630	1,252	704,938
234	Chilubula	Kasama	11	Northern	615	1,222	704,161
235	Mchereka	Lundazi	13	Eastern	618	1,228	701,009
236	Kawena	Chilubi	9	Northern	623	1,238	698,397
237	Mwenda	Mwense	21	Luapula	600	1,192	687,254
238	Kakolo	Kitwe	1	Copperbelt	600	1,192	679,323
239	Nawinda	Sesheke	10	Western	613	1,218	676,829
240	Kasembe	Chienge	3	Luapula	590	1,172	675,608
241	Chiunda Ponde	Mpika	15	Northern	590	1,172	674,171
242	Chipepa	Kawambwa	13	Luapula	603	1,198	672,612
243	Mpusu	Mumbwa	12	Central	600	1,192	671,111
244	Keyana	Shangombo	18	Western	601	1,194	666,256
245	Kapeya Farms	Katete	9	Eastern	600	1,192	665,346
246	Ndau	Mongu	20	Western	603	1,198	664,709
247	Nambolomoka	Shangombo	20	Western	600	1,192	664,229
248	Chinunda	Chipata	11	Eastern	600	1,192	663,246
249	Lukulu RR Scheme	Kasama	13	Northern	600	1,192	662,506
250	Mbilimamwenge	Samfa	5	Luapula	586	1,164	662,018
251	Mawawa	Mongu	10	Western	600	1,192	661,906
252	Sinjembela	Shangombo	14	Western	593	1,178	659,764
253	Makaba	Namwala	8	Southern	583	1,158	657,604
254	Kasanka	Samfa	2	Luapula	565	1,123	655,828
255	Chalabesa	Mporokoso	11	Northern	590	1,172	653,590
256	Lukweta	Mongu	12	Western	584	1,160	646,956
257	Mayukwayukwa	Kaoma	9	Western	564	1,121	644,531
258	Kaloko	Masaiti	2	Copperbelt	571	1,134	644,123
259	Mnauke	Lundazi	15	Eastern	571	1,134	637,758
260	Henry Kapata	Kasama	10	Northern	570	1,132	636,868
261	Mutotosho	Mporokoso	7	Northern	573	1,138	636,677
262	Muchinshi	Chingola	5	Copperbelt	537	1,067	636,432
263	Sibukali	Senanga	2	Western	554	1,101	635,651
264	Nalwei	Mongu	2	Western	566	1,125	631,696
265	Kapala	Mwense	13	Luapula	567	1,127	630,604
266	Kalumwange	Kaoma	3	Western	553	1,099	629,225
267	Luampungu	Sesheke	16	Western	554	1,101	621,073
268	Mule	Chilubi	21	Northern	551	1,095	616,587
269	Chikumbi	Masaiti	9	Copperbelt	539	1,071	613,110
270	Malaila	Mporokoso	15	Northern	510	1,013	608,717
271	Kanama	Chilubi	20	Northern	542	1,077	608,178
272	Kanama_	Chilubi	24	Northern	542	1,077	608,178
273	Ilendela	Nakonde	2	Northern	514	1,021	607,530
274	Chinondo	Masaiti	4	Copperbelt	530	1,053	606,768
275	Kaf Miss	Masaiti	12	Copperbelt	532	1,057	604,603
276	Likungu	Zambezi	15	North-Western	534	1,061	600,703
277	Mporokoso	Mporokoso	13	Northern	500	993	599,994
278	Wulongo	Nakonde	1	Northern	500	993	599,967
279	Kantongo	Nakonde	3	Northern	500	993	589,901
280	Mushota	Kawambwa	2	Luapula	500	993	587,344
281	Nsefu	Mambwe	7	Eastern	523	1,039	583,496
282	Shibuyunji	Mumbwa	2	Central	500	993	580,710
283	Namakube	Monze	22	Southern	514	1,021	579,258
284	Mwewa	Samfa	13	Luapula	501	995	579,257
285	Sakania	Ndola	3	Copperbelt	500	993	578,859
286	Kaanja	Shangombo	13	Western	518	1,029	577,460
287	Nasange	Mongu	28	Western	525	1,043	577,293
288	Salanga	Kawambwa	8	Luapula	500	993	577,010
289	Kanchibiya Farm Block	Mpika	1	Northern	515	1,023	573,628
290	Sioma	Shangombo	2	Western	500	993	573,556
291	Makunka	Kazungula	4	Southern	482	958	573,137
292	Kamphasa_	Mambwe	14	Eastern	520	1,033	572,621
293	Niko	Namwala	4	Southern	500	993	571,985
294	Mukungule	Mpika	14	Northern	492	978	569,414
295	Kawiku	Mwinilunga	20	North-Western	512	1,017	568,904
296	St. Joseph	Lufwanyama	42	Copperbelt	500	993	568,157
297	Namono	Shangombo	19	Western	512	1,017	567,469
298	Malama	Mporokoso	12	Northern	513	1,019	566,080
299	Kabinga	Mpika	16	Northern	493	980	564,767
300	Rufunsa	Chongwe	2	Lusaka	507	1,007	563,380

Table 5-11 Temporary Electrification Priority of RGCs Based on Demand Criteria (4/13)

Ranking	RGC	District	Priority	Province	# of HHs (2006)	# of HHs (2030)	Daily Max Load
301	Mukumbo	Lufwanyama	12	Copperbelt	500	993	562,696
302	Kanyemba	Mwense	8	Luapula	500	993	559,250
303	Ncheka	Mambwe	8	Eastern	500	993	558,267
304	Kapofu	Chilubi	10	Northern	504	1,001	557,670
305	Kalundwans	Mongu	5	Western	502	997	555,802
306	Lukanga	Mpongwe	4	Copperbelt	500	993	553,933
307	Kapirimphika	Chadiza	12	Eastern	500	993	553,933
308	Isangano	Luwingu	24	Northern	500	993	553,933
309	Mudunyama	Mwinilunga	21	North-Western	500	993	553,933
310	Chitupila	Chilubi	8	Northern	499	991	552,998
311	Luandui	Mongu	34	Western	499	991	552,998
312	Simulumbe	Mongu	3	Western	493	980	548,202
313	Mabumbu	Sesheke	7	Western	490	974	547,722
314	Kalobwa	Chienge	12	Luapula	475	944	547,328
315	Mweeke	Mongu	23	Western	490	974	545,056
316	Nkhoko	Mambwe	5	Eastern	480	954	542,995
317	Chasefu	Lundazi	6	Eastern	473	940	537,890
318	Chalata	Mkushi	2	Central	441	876	537,200
319	Emerald Mining Area	Lufwanyama	1	Copperbelt	441	876	535,746
320	Chambeshi Sch, Mkt	Mpika	9	Northern	450	894	534,029
321	Chipunka	Kawambwa	18	Luapula	455	904	533,907
322	Kalembwe	Chienge	10	Luapula	450	894	533,146
323	Ntambu	Mwinilunga	1	North-Western	416	827	532,399
324	Nsumbu RH	Chilubi	19	Northern	476	946	531,974
325	Namengo	Mongu	26	Western	476	946	531,974
326	Njola Camp	Monze	27	Southern	450	894	529,553
327	Ngoli	Mungwi	3	Northern	472	938	528,237
328	Chibale	Serenje	1	Central	441	876	521,726
329	Myooye	Mumbwa	3	Central	450	894	521,326
330	Mukando	Serenje	3	Central	441	876	519,945
331	Itumbi	Itezhi-tezhi	4	Southern	462	918	518,892
332	Kawama	Chiliabombwe	3	Copperbelt	450	894	518,757
333	Fikola	Kapiri Mposhi	15	Central	441	876	518,472
334	Chishimba	Kasama	12	Northern	450	894	516,229
335	Chilumba	Kapiri Mposhi	12	Central	441	876	514,483
336	Nankaga	Kafue	6	Lusaka	441	876	513,777
337	Bbombo	Monze	29	Southern	450	894	513,461
338	Fube	Chilubi	4	Northern	456	906	513,286
339	Nchimishi	Serenje	2	Central	441	876	512,769
340	Chankomo	Kapiri Mposhi	14	Central	441	876	512,245
341	Old Mkushi	Mkushi	1	Central	421	837	510,794
342	Kafulu	Kapiri Mposhi	18	Central	441	876	510,550
343	Mpelembe	Serenje	7	Central	441	876	509,458
344	Ndabala	Serenje	6	Central	441	876	508,668
345	Kabweza	Kafue	9	Lusaka	441	876	508,564
346	Kabanga	Kalomo	2	Southern	441	876	508,325
347	Muyembe	Zambezi	19	North-Western	450	894	507,680
348	Njelele	Serenje	4	Central	441	876	506,508
349	Chalilo	Serenje	5	Central	441	876	506,151
350	Liande	Mongu	29	Western	448	890	505,811
351	Nkandanzovu	Kalomo	3	Southern	441	876	505,526
352	Napatizya	Kalomo	1	Southern	441	876	505,143
353	Mbereshi	Kawambwa	17	Luapula	400	795	504,582
354	Lunchu	Kapiri Mposhi	4	Central	441	876	503,993
355	Mukubwe	Kapiri Mposhi	10	Central	441	876	503,993
356	Kaungeta	Mongu	14	Western	446	886	503,942
357	Gibson	Serenje	8	Central	441	876	503,726
358	Machende	Serenje	9	Central	441	876	503,202
359	Luyaba	Kalomo	4	Southern	441	876	503,085
360	Kanchele	Kalomo	6	Southern	441	876	503,085
361	Bbilili	Kalomo	7	Southern	441	876	503,085
362	Chilala	Kalomo	8	Southern	441	876	503,085
363	Mabombo	Kalomo	9	Southern	441	876	503,085
364	Likumbo	Kapiri Mposhi	3	Central	441	876	502,957
365	Kasukwe	Kalomo	5	Southern	441	876	502,593
366	Nakatambo	Serenje	13	Central	441	876	502,429
367	Kofi Kunda	Serenje	16	Central	441	876	502,219
368	Sichili	Sesheke	1	Western	402	799	502,063
369	Katikululu	Serenje	11	Central	441	876	501,955
370	Katongo	Serenje	12	Central	441	876	501,767
371	Kafumba	Kapiri Mposhi	13	Central	441	876	501,703
372	Mphamba	Lundazi	21	Eastern	441	876	501,670
373	Mubalashi	Kapiri Mposhi	16	Central	441	876	500,983
374	Simakakata	Kalomo	10	Southern	441	876	500,953
375	Mutala	Kalomo	11	Southern	441	876	500,953
376	Darphan	Kalomo	14	Southern	441	876	500,953
377	Lukanda	Kapiri Mposhi	6	Central	441	876	500,610
378	Chipundu	Serenje	10	Central	441	876	500,610
379	Mailo	Serenje	17	Central	441	876	500,610
380	C. Saili	Serenje	18	Central	441	876	500,610
381	Kawama	Serenje	19	Central	441	876	500,610
382	Masase	Serenje	20	Central	441	876	500,610
383	Mpande	Serenje	21	Central	441	876	500,610
384	C. Serenje	Serenje	22	Central	441	876	500,610
385	Chisale	Katete	15	Eastern	441	876	500,610
386	Kafunka	Katete	16	Eastern	441	876	500,610
387	Kazonde	Lundazi	23	Eastern	441	876	500,363
388	Chikoli	Kalomo	12	Southern	441	876	499,613
389	Kinnertone	Kalomo	13	Southern	441	876	499,613
390	Mubofwa	Kapiri Mposhi	5	Central	441	876	499,270
391	Lubuto	Kapiri Mposhi	17	Central	441	876	499,270
392	Kaswende	Kapiri Mposhi	19	Central	441	876	499,270
393	Masansa	Kapiri Mposhi	21	Central	441	876	499,270
394	Musangashi	Serenje	14	Central	441	876	499,270
395	Nsala	Serenje	15	Central	441	876	499,270
396	Ibenga	Mpongwe	23	Copperbelt	441	876	499,270
397	Chikonka	Chadiza	8	Eastern	441	876	499,270
398	Mchenjera	Chadiza	9	Eastern	441	876	499,270
399	Chigwe	Chadiza	10	Eastern	441	876	499,270
400	Kapachi	Chadiza	11	Eastern	441	876	499,270

Table 5-11 Temporary Electrification Priority of RGCs Based on Demand Criteria (5/13)

Ranking	RGC	District	Priority	Province	# of HHs (2006)	# of HHs (2030)	Daily Max Load
401	Kalemba	Chadiza	14	Eastern	441	876	499,270
402	Kaozi Settlement	Chama	2	Eastern	441	876	499,270
403	Kalimankonde	Samfa	20	Luapula	441	876	499,270
404	Kapilibila	Samfa	21	Luapula	441	876	499,270
405	Kapumbu	Samfa	22	Luapula	441	876	499,270
406	Maela	Chilubi	12	Northern	441	876	499,270
407	Bukotelo	Chilubi	17	Northern	441	876	499,270
408	Chilamba	Chilubi	22	Northern	441	876	499,270
409	Kampinda	Kaputa	2	Northern	441	876	499,270
410	Munwa	Kaputa	3	Northern	441	876	499,270
411	Masonde Farming Block	Luwingu	1	Northern	441	876	499,270
412	Ipusukilo Mission	Luwingu	2	Northern	441	876	499,270
413	Njeke Basic School	Luwingu	3	Northern	441	876	499,270
414	Chiponde Basic School and Chief Chipalo's Palace	Luwingu	4	Northern	441	876	499,270
415	Chitofwe Basic School	Luwingu	5	Northern	441	876	499,270
416	Tolopa Basic School	Luwingu	6	Northern	441	876	499,270
417	Nsanja Basic School	Luwingu	7	Northern	441	876	499,270
418	Menga Basic School and Clinic	Luwingu	8	Northern	441	876	499,270
419	Chakungubala Basic School	Luwingu	9	Northern	441	876	499,270
420	Lwenge Basic School	Luwingu	10	Northern	441	876	499,270
421	Laurent Chita Basic School and Clinic	Luwingu	11	Northern	441	876	499,270
422	Mufili Basic School	Luwingu	12	Northern	441	876	499,270
423	Makolongo Basic School	Luwingu	13	Northern	441	876	499,270
424	Lwena Basic School and Clinic	Luwingu	14	Northern	441	876	499,270
425	Tungati Basic School and Clinic	Luwingu	15	Northern	441	876	499,270
426	Saili Basic School	Luwingu	16	Northern	441	876	499,270
427	Chikumanino Market	Luwingu	17	Northern	441	876	499,270
428	Isandulula Peri-urban Community	Luwingu	18	Northern	441	876	499,270
429	Chief Tungati s Palace and School	Luwingu	19	Northern	441	876	499,270
430	Kapisha School	Luwingu	20	Northern	441	876	499,270
431	Lupili Market	Luwingu	21	Northern	441	876	499,270
432	Nsombo	Luwingu	22	Northern	441	876	499,270
433	Chiwala	Mporokoso	4	Northern	441	876	499,270
434	Samende	Kabompo	10	North-Western	441	876	499,270
435	Kalumbu	Kalabo	24	Western	441	876	499,270
436	LULANUNYI	Kalabo	27	Western	441	876	499,270
437	Kapili	Kaoma	41	Western	441	876	499,270
438	Kanglonga	Ndola	1	Copperbelt	400	795	496,733
439	Mwembeshi_ mano	Kafue	8	Lusaka	400	795	494,497
440	Chewe	Mporokoso	17	Northern	400	795	491,867
441	Z Chanda	Mporokoso	18	Northern	400	795	491,867
442	Namakwi	Kasama	8	Northern	430	854	491,428
443	Chiawa Central	Kafue	4	Lusaka	425	845	488,291
444	Kafweku	Mwinilunga	15	North-Western	435	864	484,388
445	Miponda	Samfa	4	Luapula	431	856	483,959
446	Nyakaseya	Mwinilunga	3	North-Western	400	795	482,400
447	Kopa	Mpika	10	Northern	410	815	478,208
448	Shitwa	Kaoma	5	Western	423	841	477,944
449	Shimukuni	Chibombo	1	Central	400	795	477,768
450	Ngwezi	Mazabuka	1	Southern	410	815	476,507
451	Kambwali	Nchelenge	20	Luapula	420	835	475,457
452	Loazamba	Sesheke	21	Western	428	850	474,491
453	Matala	Mumbwa	18	Central	420	835	474,319
454	Kalabwe	Mporokoso	10	Northern	425	845	471,157
455	Nyengo	Kalabo	25	Western	425	845	469,787
456	Mukuma	Kawambwa	5	Luapula	402	799	469,068
457	Nalikwanda	Mongu	19	Western	424	843	468,852
458	Mwabu	Chienge	4	Luapula	408	811	468,579
459	Mukunta	Chienge	8	Luapula	400	795	466,175
460	Sitoya	Mongu	9	Western	420	835	465,115
461	Chikomem	Lundazi	3	Eastern	402	799	464,791
462	Mushima	Mufumbwe	5	North-Western	400	795	462,739
463	Mpidi	Zambezi	3	North-Western	392	779	462,282
464	Waya	Chibombo	4	Central	400	795	460,856
465	Bwina	Sesheke	9	Western	412	819	460,758
466	Kashikishi	Nchelenge	19	Luapula	380	755	460,646
467	Lufubu	Kawambwa	12	Luapula	400	795	459,639
468	Nshinda	Nchelenge	11	Luapula	400	795	458,771
469	Mushiwala	Kaoma	10	Western	409	813	458,512
470	Lyamunale	Kaoma	18	Western	410	815	458,481
471	Mbanga	Lukulu	9	Western	400	795	456,110
472	Mbalango Mine Farm Block	Lufwanyama	3	Copperbelt	400	795	456,023
473	Mitete	Lukulu	4	Western	392	779	454,254
474	Mumpolokoso	Mwense	5	Luapula	400	795	454,131
475	Kafulwe	Chienge	13	Luapula	395	785	453,372
476	Kanongesha	Mwinilunga	7	North-Western	384	763	453,001
477	Mukumbi	Solwezi	12	North-Western	400	795	451,040
478	Tumva	Solwezi	18	North-Western	400	795	450,185
479	Mwange	Zambezi	13	North-Western	402	799	448,295
480	Kakeki	Zambezi	8	North-Western	400	795	446,426
481	Mombo	Mongu	39	Western	400	795	446,426
482	Mununshi	Mwense	12	Luapula	383	761	444,859
483	Kama	Mongu	18	Western	398	791	444,558
484	KALUWA	Kalabo	28	Western	396	787	442,689
485	Kashiba	Mwense	19	Luapula	378	751	441,089
486	Nkeyama	Kaoma	1	Western	351	698	440,575
487	Chibale	Chama	7	Eastern	389	773	436,148
488	Ikwiichi	Mongu	21	Western	386	767	433,345
489	Mangango	Kaoma	4	Western	336	668	432,057
490	Chitokoloki	Zambezi	1	North-Western	350	696	431,271
491	Kimsala	Solwezi	19	North-Western	380	755	431,154
492	Munwa Basic School	Kabwe	8	Central	380	755	430,062
493	Mwandi	Sesheke	4	Western	326	648	425,519
494	Nandombe	Mongu	27	Western	376	747	424,001
495	Kaumba	Monze	26	Southern	360	715	422,323
496	Ntambo Agricultural Camp	Monze	24	Southern	360	715	420,699
497	Samuteba	Mwinilunga	12	North-Western	361	717	419,984
498	Chiwoma	Mwinilunga	14	North-Western	361	717	418,075
499	Kapoche	Luangwa	11	Lusaka	364	723	414,128
500	Loona	Mongu	11	Western	364	723	412,788

Table 5-11 Temporary Electrification Priority of RGCs Based on Demand Criteria (6/13)

Ranking	RGC	District	Priority	Province	# of HHs (2006)	# of HHs (2030)	Daily Max Load
501	Chinkuli	Chongwe	6	Lusaka	361	717	411,325
502	Kenani	Nchelenge	15	Luapula	354	704	408,658
503	Litawa	Mongu	33	Western	359	713	408,116
504	Chipili	Mwense	22	Luapula	350	696	406,717
505	Nkumbi	Mkushi	13	Central	328	652	405,008
506	Mwalilia	Luangwa	7	Lusaka	352	700	403,382
507	Katondwe	Luangwa	3	Lusaka	328	652	400,875
508	Mphomwa	Mambwe	2	Eastern	350	696	392,921
509	Chikowa	Mambwe	11	Eastern	350	696	391,226
510	Bwalya Mponda	Samfa	8	Luapula	335	666	390,649
511	Munkonge	Kasama	7	Northern	339	674	389,643
512	Mwamba	Kasama	5	Northern	345	686	389,542
513	Sunkutu	Mporokoso	8	Northern	350	696	385,173
514	Nangili	Mongu	35	Western	350	696	385,173
515	Ngangu	Mongu	25	Western	349	694	384,239
516	Hoya	Lundazi	18	Eastern	337	670	383,556
517	St. Mary's	Lufwanyama	8	Copperbelt	330	656	381,475
518	Lulambo	Mongu	32	Western	344	684	379,567
519	Kambilombilo	Lufwanyama	2	Copperbelt	330	656	379,524
520	Kasomalunga	Samfa	9	Luapula	315	626	377,867
521	Mukutuma	Lufwanyama	7	Copperbelt	330	656	377,132
522	Fungulwe	Lufwanyama	9	Copperbelt	330	656	375,231
523	Milopa_	Lufwanyama	15	Copperbelt	330	656	375,139
524	Kafubu Depot	Kalulushi	4	Copperbelt	300	596	374,770
525	Nkana	Lufwanyama	40	Copperbelt	300	596	373,009
526	Sambula	Chienge	11	Luapula	320	636	370,925
527	Lumwana	Mwinilunga	5	North-Western	310	616	370,693
528	Shapopa	Namwala	14	Southern	333	662	369,631
529	Maposa	Ndola	5	Copperbelt	333	662	369,288
530	Namayula	Lukulu	17	Western	323	642	368,645
531	Mulobezi	Sesheke	2	Western	307	610	367,642
532	Kamifungo	Masaiti	6	Copperbelt	326	648	365,180
533	Katoba	Chongwe	5	Lusaka	325	646	364,363
534	Chondwe	Masaiti	10	Copperbelt	324	644	364,295
535	Mangwere	Chama	4	Eastern	327	650	363,682
536	Mateko	Solwezi	9	North-Western	320	636	360,900
537	Chitope	Luangwa	2	Lusaka	313	622	359,499
538	Kangwena	Solwezi	17	North-Western	320	636	359,464
539	Kapiji	Solwezi	3	North-Western	320	636	358,194
540	Luangwa Bridge	Chongwe	11	Lusaka	317	630	357,135
541	Kanyenshya Resettlement Scheme	Mkushi	20	Central	300	596	355,572
542	Nyakulena	Zambezi	2	North-Western	300	596	355,014
543	Chama	Kawambwa	1	Luapula	306	608	354,086
544	Mapunga	Solwezi	4	North-Western	300	596	353,470
545	Kameme	Kalulushi	1	Copperbelt	300	596	353,258
546	Luminu	Mwense	3	Luapula	300	596	353,130
547	Madzimoyo Sec. School	Chipata	4	Eastern	312	620	352,346
548	Kapichila	Lundazi	10	Eastern	298	592	351,880
549	Ipongo	Chibombo	5	Central	300	596	351,402
550	Lungo	Kitwe	2	Copperbelt	300	596	350,986
551	Mphomwa Tse-tse	Mambwe	1	Eastern	300	596	350,636
552	Kakoma	Mwinilunga	17	North-Western	301	598	349,711
553	Mabinga	Chama	3	Eastern	311	618	348,732
554	Kambila	Lufwanyama	25	Copperbelt	300	596	348,374
555	Munyama	Siavonga	4	Southern	300	596	347,903
556	Tomu	Mwinilunga	13	North-Western	299	594	345,609
557	Shantumbu	Kafue	2	Lusaka	300	596	343,880
558	Musaka	Solwezi	13	North-Western	300	596	341,571
559	Sanda	Solwezi	7	North-Western	300	596	340,776
560	Nalubanda	Mumbwa	9	Central	300	596	339,793
561	Chiparamba	Chipata	1	Eastern	300	596	339,793
562	Council Farm	Kitwe	5	Copperbelt	300	596	338,453
563	Kapara	Chipata	3	Eastern	300	596	338,453
564	Lwatembo	Zambezi	7	North-Western	300	596	338,453
565	Liyovu	Zambezi	16	North-Western	300	596	338,453
566	Kashona	Zambezi	20	North-Western	300	596	338,453
567	Nshinso	Mkushi	4	Central	274	545	333,277
568	Chibondo	Mwense	6	Luapula	286	568	331,431
569	Kikonge	Mufumbwe	12	North-Western	280	557	330,510
570	Jimbe	Mwinilunga	9	North-Western	281	559	329,200
571	Mujima	Solwezi	5	North-Western	280	557	327,625
572	Nakanjoli	Mumbwa	21	Central	280	557	327,471
573	Chiombo	Kasama	6	Northern	270	537	327,076
574	Bweengwa	Monze	17	Southern	275	547	326,866
575	Ndunga	Kabompo	11	North-Western	286	568	325,371
576	Kibanza	Solwezi	20	North-Western	280	557	325,361
577	Tapo	Mongu	24	Western	285	566	324,437
578	Musele	Solwezi	14	North-Western	280	557	323,648
579	Shilenda	Solwezi	10	North-Western	280	557	322,555
580	Ndanda	Mongu	6	Western	280	557	320,232
581	Kaputa	Nchelenge	6	Luapula	277	551	319,797
582	Katuntulu Com. School	Kabwe	5	Central	265	527	318,227
583	Kabuta Central	Nchelenge	18	Luapula	245	487	317,875
584	Ushaa	Mongu	7	Western	277	551	317,429
585	Lusu	Sesheke	8	Western	274	545	316,308
586	Mugula mano	Kafue	3	Lusaka	265	527	315,466
587	Lalafuta	Mufumbwe	16	North-Western	266	529	313,793
588	Kapongo	Kafue	7	Lusaka	270	537	313,599
589	Lumimba	Lundazi	12	Eastern	264	525	313,187
590	Kaunga	Luangwa	5	Lusaka	268	533	312,382
591	Kayuni	Monze	3	Southern	264	525	311,692
592	Chinyunyu	Chongwe	1	Lusaka	247	491	309,207
593	Masansa	Mkushi	12	Central	218	433	309,065
594	Namilaugi	Kaoma	6	Western	260	517	304,420
595	Koni Bunda Community	Kabwe	9	Central	250	497	297,011
596	Simaubi	Choma	10	Southern	250	497	295,863
597	Nselauke	Kasempa	1	North-Western	238	473	295,305
598	Munsakamba	Mkushi	7	Central	246	489	294,881
599	Chapula	Lufwanyama	41	Copperbelt	250	497	293,937
600	Kansoka	Lufwanyama	10	Copperbelt	250	497	293,555

Table 5-11 Temporary Electrification Priority of RGCs Based on Demand Criteria (7/13)

Ranking	RGC	District	Priority	Province	# of HHs (2006)	# of HHs (2030)	Daily Max Load
601	Chisuwo Agric Camp	Monze	19	Southern	250	497	292,062
602	Matushi	Mufumbwe	1	North-Western	250	497	291,817
603	Kafulamase Basic School	Kabwe	4	Central	260	517	291,233
604	Mumena	Solwezi	1	North-Western	248	493	290,622
605	Keemba	Monze	13	Southern	250	497	290,582
606	Sitwe	Chama	11	Eastern	262	521	288,413
607	Lweeta Agric Camp	Monze	20	Southern	250	497	288,390
608	Shombe	Lufwanyama	11	Copperbelt	250	497	287,930
609	Mujika	Monze	25	Southern	250	497	287,787
610	Kamalamba	Solwezi	8	North-Western	260	517	287,527
611	Kamiliambo	Mumbwa	13	Central	250	497	287,388
612	Siwa	Mongu	15	Western	258	513	284,675
613	Chikanda	Mumbwa	22	Central	250	497	284,438
614	Chifunda	Chama	6	Eastern	244	485	284,373
615	Chilongo (Mtepuke)	Nchelenge	1	Luapula	251	499	283,154
616	Saw-Mills	Lufwanyama	6	Copperbelt	250	497	282,974
617	Namitone	Mongu	17	Western	256	509	282,806
618	Kasomo	Chinsali	23	Northern	246	489	282,026
619	Chikola	Solwezi	16	North-Western	250	497	281,644
620	Kamphasa	Mambwe	10	Eastern	250	497	281,534
621	Nyamanongo	Chongwe	10	Lusaka	253	503	281,343
622	Mulonga	Solwezi	6	North-Western	250	497	280,208
623	Lundu	Chama	8	Eastern	253	503	280,003
624	Chaanga	Siavonga	6	Southern	250	497	279,866
625	Longe	Kaoma	25	Western	244	485	279,860
626	Mpale_Tuyu	Mkushi	9	Central	232	461	279,842
627	Kashinakazhi	Kabompo	1	North-Western	250	497	279,815
628	Konikalila	Samfa	11	Luapula	246	489	279,449
629	Mukulushi	Chibombo	3	Central	250	497	279,225
630	Lukulu North	Kasama	2	Northern	250	497	278,913
631	Chibwe	Kawambwa	14	Luapula	240	477	278,386
632	Kaminzeke	Mufumbwe	4	North-Western	240	477	277,841
633	Mphuka	Luangwa	6	Lusaka	249	495	277,249
634	Chamanza Resettlement	Kalulushi	9	Copperbelt	250	497	277,200
635	Chikowa_	Mambwe	15	Eastern	250	497	277,200
636	Kambobe	Mporokoso	6	Northern	250	497	277,200
637	Ndondo	Mongu	31	Western	250	497	277,200
638	Kafironda	Mufulira	5	Copperbelt	221	439	277,002
639	Mulonga	Mwense	16	Luapula	234	465	276,757
640	Naluama	Mazabuka	2	Southern	226	449	273,738
641	Lubuka	Kaoma	24	Western	236	469	272,024
642	Sianyoolo	Siavonga	3	Southern	230	457	267,303
643	Kasalamakanga	Mkushi	15	Central	219	435	266,801
644	Mwanambuyu	Kaoma	22	Western	233	463	265,741
645	Mulwa	Kaoma	38	Western	233	463	264,648
646	Mbanyutu	Kaoma	11	Western	230	457	264,263
647	Musa	Kasama	3	Northern	230	457	263,298
648	U_Lunsemfwa	Mkushi	8	Central	215	427	262,379
649	Kampampi (Chipakila)	Nchelenge	2	Luapula	226	449	262,355
650	Nsamba	Samfa	10	Luapula	223	443	262,259
651	Nalutanga	Monze	18	Southern	225	447	261,478
652	Chinyaku Palace	Chipata	9	Eastern	230	457	261,192
653	Chiyota	Chongwe	7	Lusaka	231	459	260,786
654	Miluji	Mufumbwe	10	North-Western	220	437	259,943
655	Lui	Kaoma	13	Western	215	427	259,437
656	Mwito	Lukulu	5	Western	214	425	258,845
657	Kakulunda	Lukulu	8	Western	227	451	258,827
658	Muyondoti	Lukulu	13	Western	227	451	258,827
659	Mukangala	Mwinilunga	19	North-Western	225	447	257,598
660	Kalwelwe Rail Station	Kabwe	3	Central	220	437	257,280
661	Lwakela	Mwinilunga	18	North-Western	216	429	256,943
662	Manga	Chama	5	Eastern	227	451	255,709
663	Chisengisengi	Mwinilunga	6	North-Western	220	437	255,585
664	Chitimbwa RHC	Mpulungu	2	Northern	226	449	254,774
665	Nabwalya	Mpika	13	Northern	215	427	254,389
666	Mukonshi	Mwense	7	Luapula	216	429	254,251
667	Kamapanda	Mwinilunga	16	North-Western	211	420	254,174
668	Mtambali	Lundazi	17	Eastern	216	429	253,788
669	Kanchomba	Choma	1	Southern	200	398	253,460
670	Mapamba	Chama	12	Eastern	223	443	253,342
671	Kampenba	Mwinilunga	10	North-Western	220	437	253,269
672	Kanyama	Mwinilunga	4	North-Western	210	418	252,430
673	Musonweji	Mufumbwe	15	North-Western	212	422	250,471
674	Musende	Mpulungu	3	Northern	220	437	249,168
675	Manyinga	Kabompo	15	North-Western	220	437	249,168
676	Nalusanga	Mumbwa	17	Central	200	398	248,999
677	Lubansa	Chiliabombwe	5	Copperbelt	180	358	248,801
678	Chamuka	Chibombo	17	Central	200	398	248,121
679	Njonjolo	Kaoma	16	Western	214	425	247,579
680	Mpima Dairy Scheme Shed	Kabwe	1	Central	210	418	247,513
681	Shabo (Kapambwe	Nchelenge	16	Luapula	212	422	247,185
682	Mingomba	Chiliabombwe	1	Copperbelt	210	418	246,422
683	Mwalumina	Chongwe	9	Lusaka	217	431	246,365
684	Chiyobola Agricultural Camp	Monze	21	Southern	200	398	244,503
685	Lwabwe	Kasama	4	Northern	210	418	243,699
686	Lusinina	Sesheke	12	Western	211	420	243,593
687	Sikusi	Mongu	8	Western	214	425	243,561
688	Malali	Mkushi	14	Central	200	398	243,274
689	Chipapa VC	Kafue	1	Lusaka	197	392	243,265
690	Kapupulu	Luanshya	3	Copperbelt	209	416	243,005
691	Kayambi	Mungwi	14	Northern	200	398	241,760
692	Munyama B. School	Kabwe	2	Central	200	398	241,644
693	Chisha	Mpulungu	11	Northern	210	418	241,631
694	Mubamba	Nchelenge	9	Luapula	201	400	240,844
695	Lukau	Lukulu	10	Western	208	414	240,790
696	Haatontola	Monze	28	Southern	200	398	240,661
697	Naimbu	Lukulu	11	Western	202	402	240,209
698	Siachele	Mumbwa	6	Central	200	398	240,151
699	Kachenge	Choma	12	Southern	200	398	239,911
700	Kashima W	Mufumbwe	2	North-Western	200	398	239,854

Table 5-11 Temporary Electrification Priority of RGCs Based on Demand Criteria (8/13)

Ranking	RGC	District	Priority	Province	# of HHs (2006)	# of HHs (2030)	Daily Max Load
701	Kapuku Fish Camp	Chibombo	2	Central	200	398	239,821
702	Manyonyo	Mazabuka	5	Southern	200	398	239,680
703	Chunga	Chinsali	14	Northern	200	398	239,635
704	Chizuzu	Zambezi	4	North-Western	200	398	239,525
705	Sumi	Senanga	19	Western	200	398	238,555
706	Manuele	Luangwa	9	Lusaka	204	406	237,991
707	Singani	Choma	5	Southern	200	398	237,259
708	Chisengu	Mambwe	3	Eastern	200	398	237,247
709	Chinonwe	Lukulu	15	Western	200	398	237,247
710	Namoomba	Siavonga	1	Southern	200	398	237,033
711	Mutipula	Mwense	4	Luapula	200	398	236,698
712	Kalilele	Solwezi	2	North-Western	200	398	236,562
713	Namateba Agricultural Camp	Monze	23	Southern	200	398	235,978
714	Malengo	Siavonga	8	Southern	200	398	235,710
715	Salujinga	Mwinilunga	11	North-Western	201	400	235,640
716	Chisakila	Kafue	12	Lusaka	200	398	234,938
717	Dongwe	Lukulu	2	Western	200	398	234,687
718	Chovwe	Solwezi	15	North-Western	200	398	234,363
719	Mukulaikwa	Mumbwa	4	Central	200	398	233,380
720	Mumbezi	Solwezi	11	North-Western	200	398	233,273
721	Nwanachmgurela	Mazabuka	3	Southern	180	358	233,188
722	Kenje	Chipata	10	Eastern	199	396	232,693
723	Naluvwi	Mumbwa	10	Central	200	398	232,287
724	Makolongo	Mkushi	16	Central	187	372	232,065
725	Luela	Kalulushi	5	Copperbelt	200	398	231,632
726	Kakaro	Luangwa	10	Lusaka	198	394	231,401
727	Kalimeta	Katete	11	Eastern	200	398	230,947
728	Katamba	Chilubi	3	Northern	200	398	230,947
729	Iyendwe	Mpulungu	7	Northern	200	398	230,947
730	Katontu	Zambezi	9	North-Western	200	398	230,947
731	Kmgubudu	Chipata	2	Eastern	198	394	230,418
732	Mutima	Mwense	9	Luapula	190	378	229,869
733	Khulamayen	Lundazi	20	Eastern	187	372	229,729
734	Kakwacha	Lukulu	14	Western	194	386	229,675
735	Kawama	Luanshya	4	Copperbelt	182	362	228,357
736	Naliele	Kaoma	14	Western	192	382	227,490
737	Lishiko	Kafue	5	Lusaka	190	378	226,622
738	Watopa	Lukulu	3	Western	183	364	225,747
739	Chungu Agric Camp	Monze	14	Southern	190	378	225,309
740	Mwata	Lundazi	11	Eastern	187	372	224,814
741	Nambwa	Mumbwa	20	Central	180	358	224,412
742	Kasupe	Kafue	13	Lusaka	180	358	223,703
743	Kalengwa	Mufumbwe	6	North-Western	180	358	222,944
744	Kazembe	Lundazi	8	Eastern	182	362	222,702
745	Lupui	Lukulu	6	Western	186	370	221,966
746	Kabosha	Nchelenge	10	Luapula	190	378	221,603
747	Mangonza	Choma	11	Southern	180	358	221,520
748	Munyambala	Mufumbwe	9	North-Western	178	354	220,434
749	Maguya	Chipata	6	Eastern	185	368	219,611
750	Neganega	Mazabuka	4	Southern	173	344	218,307
751	Lishuwa	Lukulu	12	Western	179	356	217,716
752	Kalundu	Mwense	2	Luapula	179	356	217,094
753	Kawaya	Lukulu	18	Western	181	360	215,561
754	Mumila	Mpulungu	8	Northern	180	358	212,259
755	Kafubu	Luanshya	1	Copperbelt	146	290	203,050
756	Shukwe	Mufumbwe	7	North-Western	170	338	199,771
757	Milopa	Lufwanyama	5	Copperbelt	160	318	196,375
758	Mbabala	Samfa	12	Luapula	173	344	196,362
759	Nkole	Kapiri Mposhi	2	Central	169	336	196,236
760	Kansoka__	Lufwanyama	39	Copperbelt	160	318	195,180
761	Kantende	Lufwanyama	26	Copperbelt	160	318	194,000
762	Kabapupu	Mufumbwe	11	North-Western	168	334	193,439
763	Waya	Kapiri Mposhi	8	Central	159	316	192,982
764	Mafungautsi	Kafue	15	Lusaka	160	318	192,811
765	Chikupili	Mkushi	5	Central	149	296	192,544
766	Upper Kaleya	Mazabuka	6	Southern	158	314	191,921
767	Chipepo	Gwembe	5	Southern	159	316	191,858
768	Chiriwe	Luangwa	8	Lusaka	169	336	191,005
769	Likapai	Lukulu	16	Western	169	336	190,972
770	Mamvule	Mumbwa	23	Central	160	318	190,724
771	Kapilamikwa	Lufwanyama	19	Copperbelt	160	318	187,865
772	Kansoka_	Lufwanyama	16	Copperbelt	160	318	187,522
773	Mazaba	Sesheke	19	Western	167	332	187,480
774	Funda	Lufwanyama	32	Copperbelt	160	318	187,180
775	Phikamalaza	Lundazi	9	Eastern	159	316	186,977
776	Milulu Mitambo	Lufwanyama	14	Copperbelt	160	318	186,694
777	Tukunka	Kafue	14	Lusaka	160	318	186,566
778	Kamabuta	Mufumbwe	3	North-Western	160	318	185,556
779	Maggobo	Mazabuka	8	Southern	150	298	185,181
780	Moyo	Choma	3	Southern	150	298	183,456
781	Milulu Kabamba	Lufwanyama	30	Copperbelt	160	318	182,548
782	ZASP	Lundazi	16	Eastern	159	316	181,395
783	Malende	Monze	4	Southern	156	310	180,732
784	Katuta	Mwense	1	Luapula	155	308	180,633
785	Kalundu	Namwala	10	Southern	160	318	180,582
786	Silumbu	Sesheke	20	Western	158	314	180,163
787	Minsenga	Kalulushi	11	Copperbelt	145	288	179,857
788	Nchakwa	Lufwanyama	23	Copperbelt	160	318	179,554
789	Nteme	Monze	12	Southern	150	298	179,001
790	Lukwesa	Nchelenge	12	Luapula	150	298	178,184
791	Lengwe	Kawambwa	7	Luapula	150	298	177,648
792	Chibuluma	Mumbwa	16	Central	150	298	177,448
793	Lipumpu	Sesheke	5	Western	148	294	176,774
794	Kasapa	Chiliabombwe	2	Copperbelt	150	298	176,574
795	Kasompa	Sesheke	18	Western	156	310	176,516
796	Mulumbu	Milenge	3	Luapula	157	312	175,767
797	Siambabala	Gwembe	11	Southern	153	304	175,736
798	Kangalati_	Lufwanyama	34	Copperbelt	150	298	175,512
799	Mbaya Musuma	Mazabuka	7	Southern	138	275	173,338
800	Malundu	Monze	16	Southern	135	269	171,350

Table 5-11 Temporary Electrification Priority of RGCs Based on Demand Criteria (9/13)

Ranking	RGC	District	Priority	Province	# of HHs (2006)	# of HHs (2030)	Daily Max Load
801	Myamdafuka	Mufumbwe	14	North-Western	150	298	171,252
802	Maguya_	Chipata	7	Eastern	152	302	171,095
803	Chisau	Mungwi	17	Northern	150	298	170,567
804	Chitina	Mkushi	19	Central	135	269	170,269
805	Kalombe	Mkushi	17	Central	139	277	170,074
806	Mulangwa	Kafue	11	Lusaka	149	296	169,975
807	Manyemunyemu	Kazungula	10	Southern	119	237	169,759
808	Tanganyika	Mpulungu	5	Northern	150	298	169,227
809	Posa, Muzabuwera, Mupata (Itimbwe)	Mpulungu	9	Northern	150	298	169,227
810	Vyamba	Mpulungu	10	Northern	150	298	169,227
811	Lukunyi	Zambezi	10	North-Western	150	298	169,227
812	Chitimukulu	Mungwi	10	Northern	140	279	169,197
813	Mushukula	Sesheke	15	Western	145	288	168,358
814	Mambova	Kazungula	1	Southern	92	183	168,124
815	Chikakala	Mpika	20	Northern	140	279	168,085
816	Bulbe	Lundazi	14	Eastern	143	284	167,601
817	Chipembe	Nyimba	1	Eastern	128	255	167,510
818	Musofu	Mkushi	3	Central	123	245	167,450
819	Mwalede	Sinazongwe	15	Southern	140	279	166,948
820	Ketani	Chinsali	9	Northern	138	275	166,702
821	Kashima E	Mufumbwe	8	North-Western	136	271	164,238
822	Simango	Kazungula	11	Southern	130	259	163,326
823	Lufila	Mpika	19	Northern	130	259	163,016
824	Muzuri (Kamuzya East)	Monze	1	Southern	138	275	162,529
825	Lumpuma	Lufwanyama	4	Copperbelt	127	253	162,251
826	Luashimba	Kapiri Mposhi	7	Central	120	239	162,234
827	Kazungula	Monze	32	Southern	138	275	162,187
828	Bankaila	Monze	15	Southern	130	259	161,438
829	Chilimina	Chiliabombwe	7	Copperbelt	135	269	161,162
830	Kalinkhu	Chama	1	Eastern	138	275	160,880
831	Nkulungwe	Chinsali	18	Northern	127	253	160,466
832	Mukamunga	Choma	2	Southern	135	269	160,310
833	Imusho	Sesheke	13	Western	136	271	160,073
834	Lumwana	Lufwanyama	24	Copperbelt	130	259	159,957
835	Chilombo	Chinsali	13	Northern	133	265	159,191
836	Chitimba	Chinsali	20	Northern	133	265	159,081
837	Makasa	Mungwi	1	Northern	133	265	159,002
838	Kandende	Kaoma	36	Western	133	265	157,548
839	Chiteve	Kabompo	12	North-Western	137	273	157,546
840	Musungu	Kawambwa	20	Luapula	115	229	157,505
841	Kavalamanja	Luangwa	12	Lusaka	132	263	156,507
842	Nchelenge boma	Nchelenge	17	Luapula	97	193	156,201
843	Chiyengele	Kabompo	4	North-Western	93	185	156,045
844	Chimba	Mungwi	6	Northern	135	269	155,678
845	Siamejele	Sinazongwe	19	Southern	131	261	154,249
846	Sanjongo	Chavuma	2	North-Western	132	263	154,215
847	Shimwalule	Chinsali	27	Northern	125	249	153,572
848	Kabila	Mwense	10	Luapula	129	257	153,422
849	Kabele	Kasempa	12	North-Western	128	255	153,185
850	Mumba	Mungwi	8	Northern	128	255	153,069
851	Kanselele	Chama	10	Eastern	132	263	152,874
852	Hangoma	Gwembe	4	Southern	132	263	152,874
853	Mufwaya	Kawambwa	10	Luapula	120	239	152,757
854	Hufwa	Monze	8	Southern	130	259	152,688
855	Dengwe	Kasempa	5	North-Western	129	257	152,097
856	Mimpongo	Kaoma	33	Western	129	257	152,097
857	Luangwa Sec	Luangwa	4	Lusaka	127	253	152,092
858	Nyango	Kaoma	8	Western	126	251	151,693
859	Kasongwa sub boma	Mansa	1	Luapula	98	195	150,908
860	Kanyangala	Kafue	10	Lusaka	125	249	150,668
861	Masuku	Choma	7	Southern	120	239	150,660
862	Nyawa Central	Kazungula	3	Southern	90	179	150,526
863	Manungu A	Monze	9	Southern	103	205	150,477
864	Muyembe	Kawambwa	19	Luapula	120	239	150,437
865	Fitobaula	Chiliabombwe	4	Copperbelt	120	239	150,173
866	Mukolo	Kabompo	3	North-Western	100	199	150,019
867	Kantenda	Kasempa	4	North-Western	122	243	149,979
868	Ndasa	Mungwi	9	Northern	128	255	149,137
869	Mandia	Kazungula	12	Southern	120	239	149,067
870	Shemu	Nakonde	5	Northern	114	227	148,770
871	Kakhoma	Chavuma	6	North-Western	120	239	148,751
872	Siampande	Gwembe	10	Southern	121	241	148,611
873	Katimba	Monze	30	Southern	120	239	147,443
874	Luili	Mumbwa	19	Central	110	219	147,420
875	Chisangwa	Kalulushi	7	Copperbelt	120	239	147,277
876	Simeweendengwe	Monze	10	Southern	120	239	147,277
877	Lwimba	Chongwe	3	Lusaka	110	219	146,030
878	Hakasenke	Monze	6	Southern	120	239	145,808
879	Mulakupikwa	Chinsali	3	Northern	105	209	145,633
880	Mukandamina	Kaoma	34	Western	122	243	145,556
881	Senamba	Sesheke	17	Western	121	241	144,621
882	Chiluli	Kaoma	29	Western	120	239	144,372
883	Misaka	Kitwe	4	Copperbelt	120	239	141,662
884	Chifulo	Mungwi	12	Northern	120	239	141,662
885	Kakoto	Zambezi	17	North-Western	120	239	141,662
886	Kanyembo	Nchelenge	7	Luapula	100	199	141,162
887	Shivuma	Kasempa	14	North-Western	111	221	140,702
888	Kahokoto	Kaoma	37	Western	116	231	140,635
889	Chikanda	Chinsali	4	Northern	115	229	140,296
890	Mpungu	Kasempa	7	North-Western	110	219	139,768
891	Malyango	Sinazongwe	7	Southern	110	219	139,625
892	Mwatishi Farm block 2	Nchelenge	3	Luapula	112	223	139,102
893	Mayumbelo	Livingstone	9	Southern	117	233	138,858
894	Manungu B	Monze	5	Southern	105	209	138,611
895	Hamusankwa	Monze	11	Southern	108	215	137,932
896	Kalobolelwa	Sesheke	6	Western	108	215	137,842
897	Nguba	Kazungula	7	Southern	91	181	136,715
898	Katungulu	Kawambwa	11	Luapula	110	219	136,633
899	Napenzi	Livingstone	4	Southern	113	225	136,461
900	Sianqwaze	Gwembe	7	Southern	106	211	136,207

Table 5-11 Temporary Electrification Priority of RGCs Based on Demand Criteria (10/13)

Ranking	RGC	District	Priority	Province	# of HHs (2006)	# of HHs (2030)	Daily Max Load
901	Milambo	Milenge	5	Luapula	113	225	135,121
902	Kalela	Chinsali	16	Northern	101	201	135,078
903	Fibanga	Mkushi	18	Central	105	209	135,012
904	Kabangala	Chibombo	8	Central	100	199	134,978
905	Mtilizi Scheme	Nyimba	3	Eastern	108	215	134,459
906	Mwanya	Lundazi	7	Eastern	104	207	134,303
907	Hamapande	Monze	7	Southern	112	223	134,186
908	Chibote	Kawambwa	4	Luapula	90	179	132,179
909	Zemba	Chadiza	2	Eastern	90	179	132,063
910	Chungulo	Chinsali	24	Northern	97	193	131,341
911	Kalombe	Kasempa	6	North-Western	106	211	131,246
912	Mukamba	Kawambwa	16	Luapula	100	199	131,240
913	Chimbwese	Chinsali	12	Northern	103	205	131,049
914	Mulilo	Chama	9	Eastern	108	215	130,449
915	Lima	Lufwanyama	35	Copperbelt	100	199	129,900
916	Chilanga	Chinsali	10	Northern	97	193	129,484
917	Kundamfumu	Mansa	6	Luapula	98	195	128,885
918	Chimoto	Lufwanyama	22	Copperbelt	100	199	128,291
919	Kavumbo	Mbala	3	Northern	105	209	127,645
920	Mwachilele	Chongwe	8	Lusaka	103	205	127,117
921	Kamakuku	Kasempa	10	North-Western	95	189	126,975
922	Kakiakasa	Mufumbwe	13	North-Western	100	199	126,667
923	Lukoshi	Kalulushi	6	Copperbelt	100	199	126,310
924	Sinakaimbi	Sinazongwe	1	Southern	90	179	126,229
925	Kalombo	Chavuma	5	North-Western	92	183	126,118
926	Chombela	Chibombo	9	Central	100	199	125,964
927	Lingundu	Chavuma	12	North-Western	95	189	125,718
928	Sikoongo	Siavonga	10	Southern	100	199	125,297
929	Chamfubu	Mungwi	5	Northern	102	203	124,842
930	Namilongwe	Monze	33	Southern	89	177	124,650
931	Chilobwe	Kitwe	3	Copperbelt	100	199	124,066
932	Shikabeta	Chongwe	12	Lusaka	97	193	123,910
933	Kaputo	Nchelenge	5	Luapula	101	201	123,908
934	Muuka	Sinazongwe	12	Southern	94	187	123,732
935	Lima Com. School	Chipata	12	Eastern	100	199	122,973
936	Ishima	Zambezi	6	North-Western	100	199	122,973
937	Kayenge	Zambezi	11	North-Western	100	199	122,973
938	Sikongo	Kalabo	1	Western	98	195	122,445
939	Vizimumba Central	Nyimba	2	Eastern	90	179	122,339
940	Fumbwe	Lufwanyama	28	Copperbelt	90	179	122,050
941	Chama	Nchelenge	8	Luapula	97	193	121,948
942	Chaposwa	Gwembe	12	Southern	97	193	121,153
943	Kalweu Kasakalabwe	Lufwanyama	31	Copperbelt	90	179	120,213
944	Mboroma	Mkushi	10	Central	88	175	119,833
945	Munyati	Sinazongwe	5	Southern	90	179	119,697
946	Kamisamba	Chavuma	7	North-Western	90	179	119,632
947	M_Mfino	Mungwi	13	Northern	96	191	119,236
948	Manyati	Choma	9	Southern	91	181	117,972
949	Luson'a	Kabompo	8	North-Western	63	126	117,890
950	C_Weyaya	Mungwi	18	Northern	92	183	117,878
951	Nchute	Chongwe	4	Lusaka	93	185	117,773
952	Kalisha	Kalulushi	10	Copperbelt	90	179	117,647
953	Kamano	Chibombo	18	Central	90	179	117,380
954	Hofmeyre	Nyimba	7	Eastern	90	179	117,257
955	Sokontwe	Milenge	4	Luapula	91	181	116,530
956	Chinwandumba	Chavuma	4	North-Western	89	177	116,434
957	Mulala	Livingstone	5	Southern	93	185	116,433
958	Kanyafimbolo	Lufwanyama	37	Copperbelt	90	179	115,938
959	Nsampa	Mungwi	16	Northern	92	183	115,498
960	Chimula	Mbala	1	Northern	90	179	113,629
961	Kaka	Mbala	12	Northern	90	179	113,629
962	Siambelele	Kazungula	13	Southern	72	143	110,842
963	Kalaba	Mansa	8	Luapula	86	171	109,295
964	Mweemba	Sinazongwe	3	Southern	80	159	109,237
965	Chipepo	Kapiri Mposhi	1	Central	85	169	109,170
966	Siacheka	Gwembe	6	Southern	79	157	108,998
967	Ngwezi Mataki	Kazungula	5	Southern	78	155	105,635
968	Ntoposhi	Mansa	7	Luapula	87	173	104,602
969	Lifwambula	Chibombo	12	Central	85	169	104,545
970	Nangoma	Senanga	20	Western	80	159	103,650
971	Nachanowe	Choma	8	Southern	86	171	103,390
972	Kabanda	Chinsali	11	Northern	80	159	101,194
973	Lombelombe	Kaoma	2	Western	86	171	100,304
974	Kanogo	Kasempa	11	North-Western	84	167	100,130
975	Kalulu	Mungwi	15	Northern	82	163	98,792
976	Nzala	Gwembe	13	Southern	86	171	98,541
977	Chingombe	Mkushi	11	Central	78	155	98,516
978	Mwalala	Chinsali	17	Northern	80	159	97,507
979	Lunga	Kasempa	3	North-Western	66	132	97,141
980	Kankunko_	Lufwanyama	33	Copperbelt	85	169	96,951
981	Lukolwe	Chavuma	3	North-Western	80	159	96,911
982	Kangalati	Lufwanyama	18	Copperbelt	85	169	96,907
983	Chikabuke	Lufwanyama	17	Copperbelt	85	169	96,733
984	Chantete	Lufwanyama	20	Copperbelt	85	169	95,968
985	Kafwambila	Sinazongwe	6	Southern	80	159	94,471
986	Kanenga	Chiliabombwe	6	Copperbelt	80	159	94,427
987	Peleti	Mungwi	2	Northern	85	169	93,957
988	Gamela	Choma	4	Southern	80	159	92,648
989	Kambuya	Chavuma	8	North-Western	72	143	92,385
990	Chiyabi	Sinazongwe	4	Southern	80	159	92,318
991	Sinamalima	Sinazongwe	11	Southern	80	159	92,234
992	Siansalama	Sinazongwe	20	Southern	78	155	92,158
993	Chabulabwambe	Gwembe	8	Southern	82	163	92,137
994	Kayosha	Chibombo	10	Central	80	159	92,061
995	St-Pauls	Mbala	8	Northern	80	159	91,900
996	Michinka	Kalulushi	3	Copperbelt	80	159	91,311
997	Mulumbi	Milenge	6	Luapula	82	163	91,154
998	Siadazya	Livingstone	3	Southern	79	157	90,784
999	Namafulu	Sinazongwe	2	Southern	75	149	90,383
1000	Chowa	Chibombo	15	Central	68	136	90,288

Table 5-11 Temporary Electrification Priority of RGCs Based on Demand Criteria (11/13)

Ranking	RGC	District	Priority	Province	# of HHs (2006)	# of HHs (2030)	Daily Max Load
1001	Mandalo	Chavuma	9	North-Western	78	155	90,127
1002	Banamwaze	Itezhi-tezhi	5	Southern	79	157	89,691
1003	Kawimbe	Mbala	2	Northern	80	159	89,285
1004	Mpande	Mbala	4	Northern	80	159	89,285
1005	Mwiluzi	Mbala	6	Northern	80	159	89,285
1006	Senka	Mbala	15	Northern	80	159	89,285
1007	Mwamba	Mbala	16	Northern	80	159	89,285
1008	Zimba Hills Settlements	Kazungula	2	Southern	72	143	89,215
1009	Lubofu	Kasempa	13	North-Western	74	147	88,820
1010	Nashinga	Chinsali	5	Northern	70	140	88,630
1011	Fiwila	Mkushi	6	Central	48	96	88,139
1012	Vubwi	Chadiza	3	Eastern	60	120	88,134
1013	Kamakechi	Kasempa	2	North-Western	74	147	87,652
1014	Liumba	Kalabo	3	Western	78	155	87,416
1015	Nyamaluma	Mambwe	6	Eastern	75	149	86,922
1016	Shiwan'gandu area	Chinsali	1	Northern	60	120	85,651
1017	Ibbwemunyama	Siavonga	2	Southern	70	140	84,167
1018	Momboshi	Chibombo	19	Central	55	110	82,923
1019	Musolo	Milenge	9	Luapula	73	145	82,744
1020	Muchinga	Mwense	11	Luapula	70	140	82,434
1021	Ma Hundred	Livingstone	6	Southern	71	142	81,343
1022	Siabwengo	Gwembe	1	Southern	68	136	79,865
1023	Nyangwali	Kabompo	5	North-Western	65	130	79,818
1024	Mukwikile	Chinsali	8	Northern	56	112	79,805
1025	Chinyongola	Chibombo	20	Central	62	124	79,743
1026	Silwili	Monze	2	Southern	65	130	79,728
1027	Namakaka_	Namwala	12	Southern	50	100	78,889
1028	Lameck	Chinsali	19	Northern	60	120	78,303
1029	Sakurita	Livingstone	18	Southern	66	132	78,238
1030	Kanengo	Kawambwa	3	Luapula	60	120	78,186
1031	Mchimadzi Scheme	Nyimba	4	Eastern	62	124	77,901
1032	Mbesuma area	Chinsali	2	Northern	55	110	77,563
1033	Chimphanje	Nyimba	8	Eastern	66	132	77,356
1034	Nangombe	Sinazongwe	13	Southern	64	128	77,111
1035	Mibenge	Mansa	5	Luapula	54	108	76,530
1036	Chisengi	Kabompo	6	North-Western	60	120	76,453
1037	Musanya	Chinsali	6	Northern	50	100	76,254
1038	Taferansoni	Chadiza	5	Eastern	55	110	76,106
1039	Natebe	Livingstone	2	Southern	62	124	76,051
1040	Nyathanda	Chavuma	13	North-Western	65	130	75,736
1041	Gwena	Siavonga	9	Southern	60	120	75,463
1042	Chipete	Mansa	9	Luapula	56	112	75,405
1043	Mbila	Itezhi-tezhi	3	Southern	63	126	75,208
1044	Simuloongo	Gwembe	3	Southern	57	114	74,969
1045	Kalyongo	Mansa	17	Luapula	60	120	74,868
1046	Sikalinda Resettlement	Monze	31	Southern	60	120	74,770
1047	Chiwaula	Chadiza	4	Eastern	30	60	74,503
1048	Chimbola	Mungwi	7	Northern	62	124	74,241
1049	Chichele	Ndola	6	Copperbelt	63	126	73,868
1050	Mulinga	Kalabo	21	Western	63	126	73,868
1051	Muswishi	Chibombo	14	Central	45	90	73,682
1052	Kapolyo	Mungwi	11	Northern	61	122	73,339
1053	Mushingashi	Lufwanyama	21	Copperbelt	60	120	72,778
1054	Kampemba	Chinsali	28	Northern	60	120	72,404
1055	Kabombo	Kalulushi	8	Copperbelt	60	120	71,750
1056	Nyalugwe	Nyimba	14	Eastern	56	112	70,884
1057	Chimbele	Chinsali	7	Northern	50	100	70,356
1058	Chinkonkwelo	Kabompo	9	North-Western	46	92	70,143
1059	Siameja	Sinazongwe	14	Southern	48	96	69,849
1060	Mlolo	Chadiza	1	Eastern	50	100	69,735
1061	Kankwanda	Kaoma	32	Western	48	96	69,723
1062	Siatwiinda	Sinazongwe	8	Southern	57	114	69,601
1063	Lueti	Kalabo	9	Western	57	114	69,601
1064	Mundoza	Gwembe	9	Southern	56	112	69,293
1065	Rosa	Mungwi	4	Northern	56	112	68,667
1066	Musonko	Chinsali	26	Northern	45	90	68,219
1067	Nkenga	Kaoma	12	Western	43	86	68,155
1068	Mutiti	Mansa	10	Luapula	46	92	67,444
1069	Maako	Kasempa	8	North-Western	50	100	67,392
1070	Kalongwa	Kasempa	15	North-Western	49	98	67,234
1071	Mansa Ressetlement Scheme	Mansa	2	Luapula	51	102	66,748
1072	Chinemu	Lufwanyama	13	Copperbelt	45	90	66,452
1073	Chambi	Chavuma	10	North-Western	52	104	65,957
1074	Ngweze	Sesheke	14	Western	52	104	65,957
1075	Ndoba	Mansa	11	Luapula	36	72	65,907
1076	Lukena	Kaoma	15	Western	49	98	65,897
1077	Makunku	Itezhi-tezhi	7	Southern	53	106	65,864
1078	Namusenga	Namwala	15	Southern	50	100	65,712
1079	Miyombe	Kasempa	9	North-Western	46	92	65,546
1080	Kasiya	Livingstone	1	Southern	50	100	64,496
1081	Chalubilo	Nyimba	11	Eastern	38	76	64,386
1082	No.57 (Lubanda)	Itezhi-tezhi	1	Southern	50	100	64,153
1083	Chikonkomene	Chibombo	13	Central	36	72	63,649
1084	Namasheshe	Kaoma	30	Western	42	84	63,495
1085	Mwerya	Sinazongwe	9	Southern	49	98	63,219
1086	Masongo	Chinsali	29	Northern	50	100	63,060
1087	Sekute	Kazungula	6	Southern	42	84	62,633
1088	Sulwegonde	Sinazongwe	18	Southern	45	90	61,790
1089	Namando	Kaoma	21	Western	46	92	61,315
1090	Kandole	Lufwanyama	36	Copperbelt	45	90	61,040
1091	Ndake	Nyimba	5	Eastern	42	84	60,863
1092	Chintu	Milenge	7	Luapula	49	98	60,786
1093	Kalale	Kaoma	17	Western	44	88	60,448
1094	Mano	Mansa	4	Luapula	44	88	60,207
1095	Wilison	Nyimba	10	Eastern	44	88	60,115
1096	kalasa kando	Mansa	16	Luapula	45	90	59,759
1097	Kabangama	Chinsali	25	Northern	34	68	58,980
1098	Syangwemu	Siavonga	7	Southern	40	80	58,820
1099	Kabunda	Mansa	13	Luapula	41	82	58,440
1100	Mukelangombe	Chavuma	11	North-Western	45	90	58,388

Table 5-11 Temporary Electrification Priority of RGCs Based on Demand Criteria (12/13)

Ranking	RGC	District	Priority	Province	# of HHs (2006)	# of HHs (2030)	Daily Max Load
1101	Namatindi	Kalabo	5	Western	45	90	58,388
1102	Chivombo	Chavuma	1	North-Western	40	80	58,146
1103	Mutenda	Lufwanyama	43	Copperbelt	45	90	58,076
1104	Muchinshi	Lufwanyama	44	Copperbelt	45	90	58,076
1105	Inonge	Livingstone	7	Southern	41	82	58,074
1106	Bukanda	Mansa	15	Luapula	42	84	58,049
1107	Chipe	Milenge	2	Luapula	41	82	57,243
1108	Muliro	Nyimba	16	Eastern	40	80	57,238
1109	Mulila Nsolo	Kafue	16	Lusaka	45	90	57,048
1110	Nakayembe	Kaoma	19	Western	41	82	56,429
1111	Kalongo Mwape	Nyimba	15	Eastern	41	82	56,344
1112	Namaloba	Kaoma	20	Western	40	80	56,052
1113	mbaso	Mansa	19	Luapula	38	76	55,825
1114	Malimba	Kazungula	8	Southern	21	42	55,790
1115	Lunyiwe Basic School	Kabompo	7	North-Western	36	72	55,779
1116	Mukunkiki	Kaoma	27	Western	41	82	55,679
1117	Loke West	Kalabo	10	Western	42	84	55,585
1118	Mudonki	Gwembe	2	Southern	42	84	55,571
1119	Dibbwi	Siavonga	5	Southern	40	80	55,042
1120	Chambula	Nyimba	9	Eastern	42	84	54,588
1121	Manje	Chadiza	6	Eastern	36	72	54,420
1122	Kafunda	Kaoma	31	Western	29	58	53,766
1123	Kalamba	Kawambwa	6	Luapula	40	80	53,747
1124	Muyumbana	Kalabo	7	Western	40	80	53,716
1125	Majeledi	Livingstone	16	Southern	41	82	53,311
1126	Sihole	Kalabo	2	Western	41	82	53,311
1127	Kasoma Iwela	Mansa	3	Luapula	35	70	52,548
1128	Uningi	Mbala	9	Northern	40	80	52,376
1129	Kaluluzi	Mbala	11	Northern	40	80	52,376
1130	Matanga	Mbala	13	Northern	40	80	52,376
1131	Katapazi	Kazungula	9	Southern	31	62	52,355
1132	Shishamba	Kaoma	23	Western	36	72	52,314
1133	chisunka	Mansa	18	Luapula	35	70	51,508
1134	Lukola	Mansa	21	Luapula	34	68	51,104
1135	Mikula	Mansa	22	Luapula	35	70	51,010
1136	mwanachama	Mansa	20	Luapula	32	64	50,671
1137	Kalingindi	Nyimba	13	Eastern	36	72	50,605
1138	Kapanda	Mansa	14	Luapula	35	70	49,730
1139	Mulira	Nyimba	6	Eastern	34	68	49,679
1140	Afumba	Kaoma	28	Western	32	64	49,669
1141	Lwanya	Chinsali	21	Northern	30	60	49,288
1142	Mutwewankoko	Mansa	12	Luapula	34	68	49,138
1143	Kotinteden	Masaiti	7	Copperbelt	25	50	48,818
1144	Dengera	Sinazongwe	16	Southern	30	60	48,647
1145	Mulundumano	Kalabo	16	Western	36	72	48,639
1146	Muchenje	Chibombo	6	Central	26	52	48,542
1147	Chibuluma Mine Area	Lufwanyama	45	Copperbelt	35	70	47,704
1148	Kabimba	Choma	6	Southern	30	60	47,024
1149	Luchena	Itezhi-tezhi	2	Southern	30	60	46,448
1150	Kachohola	Nyimba	12	Eastern	32	64	46,241
1151	Nyambi 2	Kaoma	26	Western	29	58	46,116
1152	Chilele	Sinazongwe	10	Southern	21	42	45,495
1153	Kapopo	Chibombo	11	Central	30	60	45,058
1154	Sinde	Livingstone	14	Southern	32	64	44,901
1155	Ngoma	Sinazongwe	17	Southern	23	46	44,072
1156	Konja	Chinsali	15	Northern	20	40	44,042
1157	Kapimbe	Lufwanyama	29	Copperbelt	25	50	43,335
1158	Luela	Lufwanyama	27	Copperbelt	25	50	43,332
1159	Sumbi	Mbala	5	Northern	30	60	43,032
1160	Kalukanya	Mbala	7	Northern	30	60	43,032
1161	Chalele	Mbala	10	Northern	30	60	43,032
1162	Chisanzu	Mbala	14	Northern	30	60	43,032
1163	Kasaba Bay	Mpulungu	1	Northern	30	60	43,032
1164	Lutwi	Kalabo	12	Western	30	60	43,032
1165	Ngabwe	Kapiri Mposhi	11	Central	25	50	42,100
1166	Chikwasha	Nyimba	17	Eastern	29	58	42,098
1167	Kananga	Livingstone	20	Southern	29	58	42,098
1168	Kasosolo	Chibombo	16	Central	20	40	42,056
1169	Malekani	Chinsali	22	Northern	25	50	41,666
1170	Mahelituna	Livingstone	11	Southern	27	54	41,257
1171	Nguvu	Chavuma	14	North-Western	25	50	38,360
1172	Muwezwa	Itezhi-tezhi	6	Southern	24	48	37,426
1173	Sichilore	Livingstone	13	Southern	24	48	37,426
1174	Chipeso	Chibombo	7	Central	16	32	35,754
1175	Fidashi	Masaiti	15	Copperbelt	20	40	35,714
1176	Namatoya	Shangombo	12	Western	18	36	34,878
1177	Simwizi	Livingstone	17	Southern	21	42	34,623
1178	Chilizya	Livingstone	12	Southern	19	38	34,094
1179	Kuuli	Kalabo	4	Western	20	40	33,688
1180	Mishuwundu	Kalabo	17	Western	20	40	33,688
1181	Palace	Shangombo	3	Western	20	40	33,688
1182	Mubalu	Livingstone	15	Southern	19	38	32,754
1183	Sishekanu	Kalabo	18	Western	18	36	32,505
1184	Winda	Kaoma	35	Western	16	32	31,976
1185	Liuwa	Kalabo	14	Western	18	36	31,819
1186	Matete	Masaiti	14	Copperbelt	15	30	31,042
1187	Katubia	Livingstone	10	Southern	17	34	30,885
1188	Kalenga	Kalabo	6	Western	15	30	30,356
1189	Liumena	Kalabo	11	Western	15	30	30,356
1190	Salati	Masaiti	11	Copperbelt	15	30	29,999
1191	Mbilisao	Nyimba	18	Eastern	15	30	29,016
1192	Munde	Kalabo	15	Western	15	30	29,016
1193	Malasha	Kalabo	19	Western	15	30	29,016
1194	Smachuma	Livingstone	8	Southern	14	28	28,424
1195	Zangala	Livingstone	19	Southern	13	26	27,147
1196	Salunda	Kalabo	8	Western	13	26	27,147
1197	Mwandi	Kalabo	13	Western	13	26	27,147
1198	Mikata	Mpongwe	1	Copperbelt	11	22	26,619
1199	Chipundu	Milenge	8	Luapula	8	16	22,475
1200	Chibuli	Mpongwe	7	Copperbelt	6	12	21,947

Table 5-11 Temporary Electrification Priority of RGCs Based on Demand Criteria (13/13)

Ranking	RGC	District	Priority	Province	# of HHs (2006)	# of HHs (2030)	Daily Max Load
1201	Munsongwe	Mpongwe	11	Copperbelt	6	12	21,947
1202	Mbalala	Kalabo	20	Western	7	14	21,541
1203	Mushipushi	Mpongwe	15	Copperbelt	4	8	21,170
1204	Munkunpa	Mpongwe	3	Copperbelt	5	10	21,012
1205	Chinwa	Mpongwe	9	Copperbelt	5	10	21,012
1206	Chowa	Mpongwe	10	Copperbelt	5	10	21,012
1207	Luswishi	Mpongwe	16	Copperbelt	5	10	21,012
1208	Shingwa	Mpongwe	8	Copperbelt	6	12	20,606
1209	Chitabale	Mpongwe	13	Copperbelt	4	8	20,078
1210	Machiya	Mpongwe	5	Copperbelt	4	8	19,830
1211	Chisanga	Mpongwe	6	Copperbelt	3	6	19,143
1212	Ipumbu	Mpongwe	14	Copperbelt	3	6	19,143
1213	Kasamba	Mpongwe	2	Copperbelt	3	6	18,896
1214	Kapili	Mpongwe	18	Copperbelt	2	4	18,209
1215	Mushine	Mpongwe	17	Copperbelt	2	4	17,962
1216	Chisapa	Mpongwe	19	Copperbelt	3	6	17,803
1217	Musofu	Mpongwe	20	Copperbelt	3	6	17,803
				Total	537,617	1,068,233	612,302,427

Chapter 6

Transmission System Analysis

Chapter 6. Transmission System Analysis

6.1. Purpose of the System Analysis

The capacity of a power system to transmit electricity has limitations depending on the design of equipment and system condition. If the implementation of an electrification project, with the maximum power load at local level exceeds the system capacity of that area, then reinforcement of transmission system is inevitable and its cost should be added to the cost of the electrification project. This is why the analysis of the capacity of local network systems, i.e. the capacity of each substation, needs to be carried out for an electrification study.

In this section, the capacity of the transmission system and possible bottlenecks are studied.

6.2. Current Status of the Power Transmission System in Zambia

The main characteristics of ZESCO's power transmission system are as follows.

- ZESCO's transmission system has various voltage levels, namely 330kV, 220kV, 132kV, 88kV and 66kV. These voltage levels are stepped-down to 33kV and 11kV for distribution at substations.
- ZESCO's power system is interconnected to that of neighbouring countries as part of the Southern African Power Pool (SAPP). SAPP consists of power systems in southern African countries, namely Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Mozambique, Namibia, Republic of South Africa, Swaziland, Tanzania, Zambia and Zimbabwe, though actually some of these countries are not interconnected yet.
- The main 330kV transmission lines are running north to south in the middle of the country because the copper mines, the largest load centre, are located in the north and the main generation stations are located in the south. The electricity generation mostly comes from three hydro power plants located in southern area of Zambia, thus the main power flow is streaming from south to north.
- Copperbelt Energy Corporation (CEC) has some transmission lines, substations and generators to supply electricity to the copper mines. CEC's transmission system also has interconnection with DR Congo to wheel power export from DR Congo to Zimbabwe and South Africa.
- 66kV transmission lines are used for local supply. In North-Eastern and Western areas, the span of 66kV lines is in general very long.

Figure 6-1 illustrates the diagram of transmission system in Zambia as of 2006, most of which is owned and operated by ZESCO. The list of 330kV – 88kV transmission lines and that of 66kV line are shown in Table 6-1 and Table 6-2 respectively. According to the statistic data of ZESCO, total circuit length of 330kV transmission lines is 2,241km, total 220kV lines 348km, total 132kV lines 202km, total 88kV lines 754km and total 66kV lines 3,033km as at the end of March 2006. In addition, CEC also has transmission lines whose total length is 808km. Transmission system of ZESCO, as part of SAPP, has interconnection with DR Congo, Zimbabwe and Namibia in the south, and is also used for international power trade.

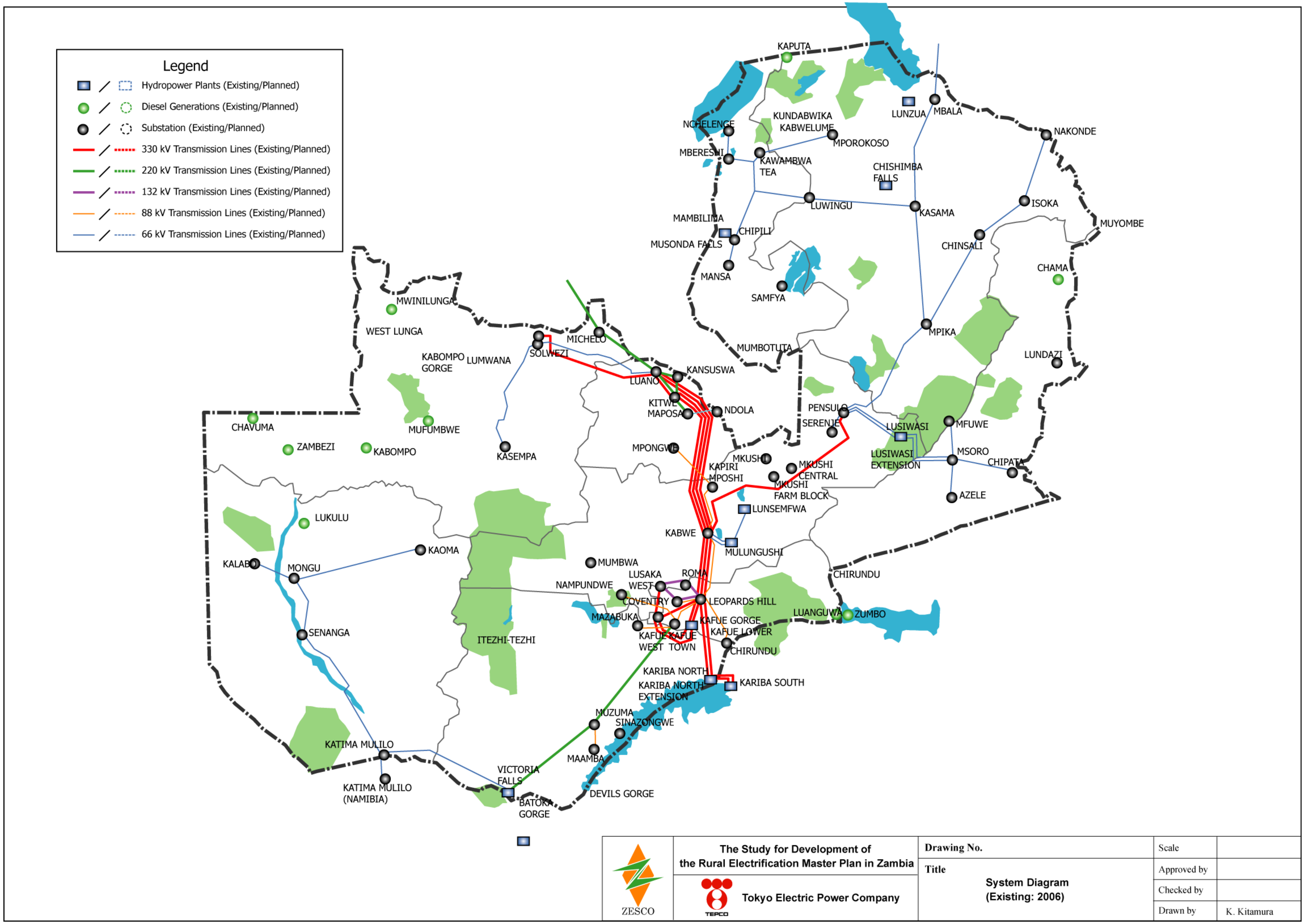


Figure 6-1 Transmission System Diagram of Zambia as of 2006

Table 6-1 Transmission Lines of ZESCO as of June 2006 (330kV – 88kV)

Voltage (kV)	Line (from – to)	Conductor	No. of Circuits	Route Length (km)
330	Kabwe – Pensulo	2xACSR381, Bison	1	300
	Kabwe – Luano	2xACSR381, Bison	2	252
	Kabwe – Kitwe	2xACSR381, Bison	2	212
	Kariba North – Leopards Hill	2xACSR381, Bison	2	123
	Leopards Hill – Kabwe	2xACSR381, Bison	3	97
	Kafue West – Lusaka West	2xACSR381, Bison	1	42
	Leopards Hill – Kafue West	2xACSR381, Bison	1	53
	Kafue Gorge – Leopards Hill	2xACSR381, Bison	2	47
	Kafue Gorge – Kafue West	2xACSR381, Bison	1	42
	Kitwe – Luano	2xACSR381, Bison	1	40
	Kafue Town – Kafue West	2xACSR381, Bison	1	3
	Kariba North – Zimbabwe Border	2xACSR381, Bison	2	1
220	Muzuma – Kafue Town	1xACSR381, Bison	1	189
	Victoria Falls – Muzuma	1xACSR381, Bison	1	159
132	Lusiwasi – Msoro	1xACSR158, Wolf	1	115
	Leopards Hill – Coventry	1xACSR100, Dog	1	29
	Lusaka West – Roma	1xACSR158, Wolf	1	20
	Roma – Leopards Hill	1xACSR158, Wolf	1	26
	Lusaka West – Coventry	1xACSR158, Wolf	1	11
88	Leopards Hill – Kafue Town	1xACSR158, Wolf	1	62
	Kapiri – Mpongwe	1xACSR158, Wolf	1	96
	Figtree – Kabwe	1xACSR158, Wolf	1	56
	Leopards Hill – Figtree	1xACSR158, Wolf	1	55
	Leopards Hill – Chirundu	1xACSR100, Dog	1	80
	Napundwe – Mumbwa	1xACSR100, Dog	1	90
	Kafue Town – Napundwe	1xACSR100, Dog	1	46
	Leopards Hill – Water Works	1xACSR100, Dog	1	22
	Kafue Town – Mazabuka	1xACSR100, Dog	1	40
	Muzuma – Maamba	1xACSR100, Dog	1	30
	Kabwe Step Down – Kapiri Mposhi	1xACSR100, Dog	1	98
	Leopards Hill – Mapepe	1xACSR158, Wolf	1	29
	Leopards Hill – Coventry	1xACSR100, Dog	1	28
	Kabwe Step Down – Kabwe Town	1xACSR100, Dog	1	24
	Kafue Town – Mapepe	1xACSR158, Wolf	1	33

Source: ZESCO Statistic Data 2005/06

Table 6-2 Transmission lines of ZESCO as of June 2006 (66kV)

Voltage (kV)	Line (from – to)	Conductor	No. of Circuits	Route Length (km)
66	Katima Mulilo – Senanga	1xACSR100, Dog	1	212
	Kasama – Mpika	1xACSR158, Wolf	1	211
	Luano – Solwezi	1xACSR131, Tiger	1	189
	Chinsali – Mpika	1xACSR158, Wolf	1	179
	Kasama – Mbala	1xACSR158, Wolf	1	161
	Kawambwa – Mporokoso	1xACSR158, Wolf	1	142
	Chabasitu tee – Luwingu	1xACSR158, Wolf	1	123
	Lusiwasi – Msoro	1xACSR158, Wolf	1	115
	Kazungula – Sesheke	1xACSR100, Dog	1	108
	Isoka – Nakonde	1xACSR158, Wolf	1	107
	Mongu – Senanga	1xACSR100, Dog	1	105
	Lubushi – Luwingu	1xACSR158, Wolf	1	100
	Chilonga – Mununga	1xACSR158, Wolf	1	100
	Lusiwasi – Pensulo	1xACSR158, Wolf	1	90
	Chinsali – Isoka	1xACSR158, Wolf	1	82
	Chipata – Msoro	1xACSR100, Dog	1	80
	Victoria Falls – Kazungula	1xACSR100, Dog	1	80
	Pensulo – Mununga	1xACSR158, Wolf	1	75
	Chambasitu Tee – Kawambwa	1xACSR158, Wolf	1	71
	Kasama – Lubushi	1xACSR158, Wolf	1	70
	Kalabo – Mongu	1xACSR100, Dog	1	66
	Msoro – Mfuwe	1xACSR100, Dog	1	65
	Msoro – Azele	1xACSR100, Dog	1	55
	Lusiwasi – Kaombe	1xACSR158, Wolf	1	50
	Pensulo – Serenje	1xACSR158, Wolf	1	43
	Musonda Falls – Chambasitu Tee	1xACSR158, Wolf	1	40
	Chishimba Falls – Kasama	1xACSR100, Dog	1	30
	Mpika – Chilonga	1xACSR158, Wolf	1	22
	Kanona – Kaombe	1xACSR158, Wolf	1	21
	Kanona – Chinese Rd	1xACSR158, Wolf	1	19
	Sesheke – Katima Mulilo	1xACSR100, Dog	1	8
	Pensulo – Chinese Rd	1xACSR158, Wolf	1	1
	Mongu – Kaoma	1xACSR158, Wolf	1	195

Source: ZESCO Statistics data 2005/06

Table 6-3 Transformers of ZESCO Substations as of 2006

Substation	Transformer Capacity [MVA]	Voltages [kV]
Leopards Hill	2 x125	330/132
	2 x 90	330/ 88
Kafue Town	1 x 60	330/ 88
	2 x 60	220/ 88
Kabwe	2 x 60	330/ 88
Kitwe	6 x120	330/220
	6 x 60	220/ 66
Luano	4 x120	330/220
Pensulo	2 x 60	330/ 66

Source: ZESCO Statistics Data 2005/06

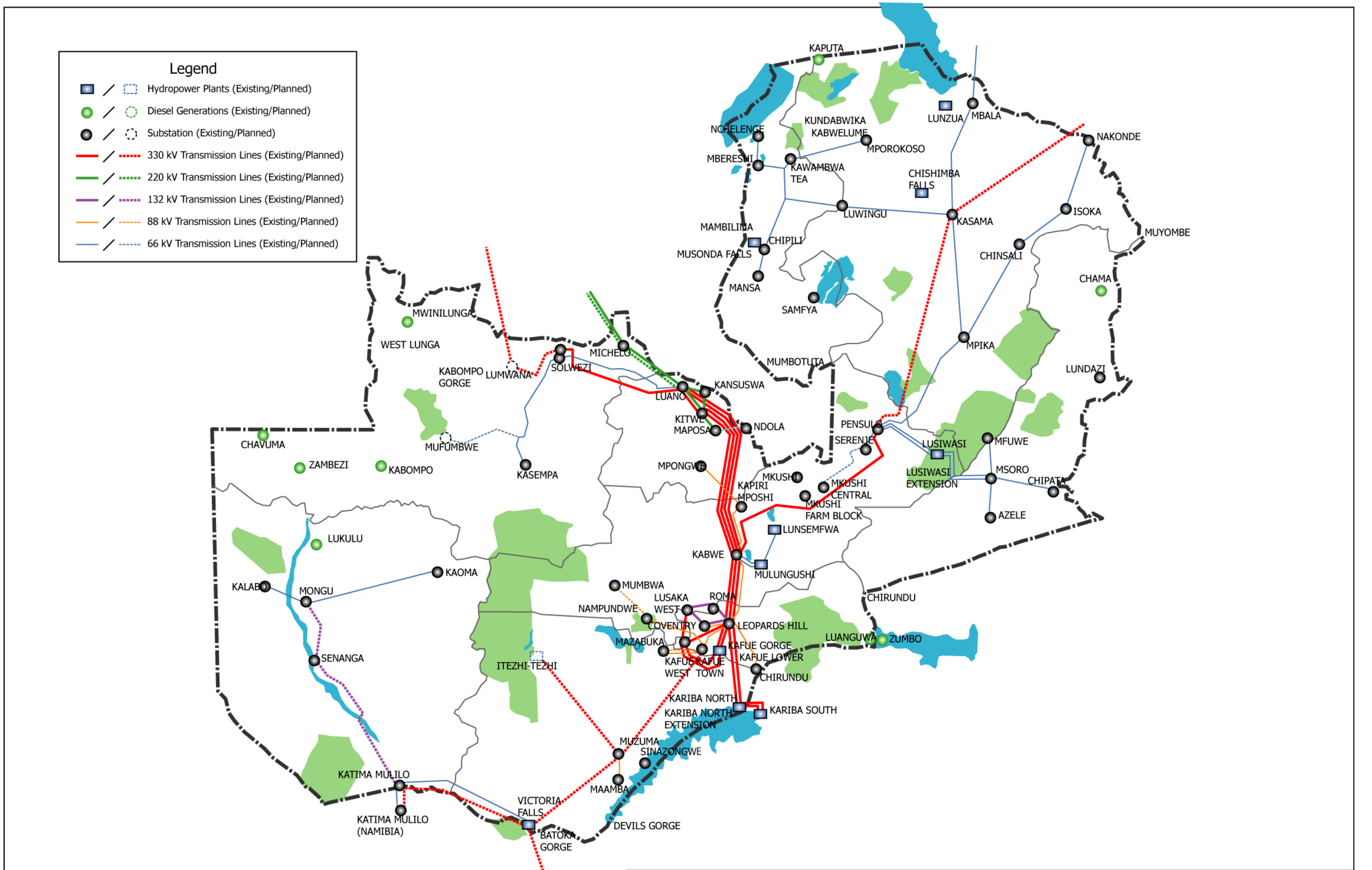
6.3. Reinforcement Plan of Transmission System in Zambia

Transmission System Development Plan, which was provided by the Transmission System Planning Department of ZESCO, is listed in Table 6-4 . Diagrams of projected transmission system in 2010, 2015, 2020 and 2030 respectively are shown in Figures from Figure 6-2 to Figure 6-5

Table 6-4 ZESCO's Existing Transmission Development Plan

Voltage	From-To	Commissioning year	No. of circuits	Notes
330	Kansanshi – Lumwana	2007	1	New installation
	Pensulo – Kasama	2009	2	New installation
	Kasama – (Tanzania)	2009	2	New installation
	Kafue Town – Muzuma	2010	1	Upgrade
	Muzuma – Victoria Falls	2010	1	Upgrade
	Victoria Falls – Katimamulilo	2010	1	Upgrade
	Katimamulilo – (Namibia)	2010	1	Upgrade
	Muzuma – Itezhi-Tezhi	2010	1	Upgrade
	Victoria Falls – (Zimbabwe)	2010	1	New installation
	Lumwana – (DR Congo)	2010	1	New installation
	Kabwe – Pensulo	2011	1	2nd circuit
	Pensulo – Lusiwasi	2020	1	New installation
	Lusiwasi – Msoro	2020	1	New installation
	Msoro – (Malawi)	2030	1	New installation
220	Victoria Falls – Katima Mulilo	2006	1	New installation
	Katima Mulilo – (Namibia)	2006	1	New installation
	Luano – Michelo	2008	1	2nd circuit
	Michelo – (DR Congo)	2008	1	2nd circuit
	Muzuma – Itezhi-Tezhi	2009	1	New installation
132	Katima Mulilo – Senanga	2008	1	Upgrade
	Senanga – Mongu	2008	1	Upgrade
	Leopards Hill – Chirundu	2030	1	New installation
66	Serenje – Mkushi	2007	1	New installation
	Kasempa – Mufumbwe	2008	1	New installation
	Mongu – Lukulu	2020	1	New installation
	Lukulu – Kabonpo	2020	1	New installation
	Lukulu – Zambezi	2020	1	New installation
	Zambezi – Chavuma	2020	1	New installation
	Lumwana - Mwinilunga	2030	1	New installation

Source: ZESCO



	The Study for Development of the Rural Electrification Master Plan in Zambia	Drawing No.		Scale	
ZESCO	Tokyo Electric Power Company	Title	System Diagram (Planned: 2010)	Approved by	
				Checked by	
				Drawn by	K. Kitamura

Figure 6-2 Transmission System Diagram of Zambia as of 2010

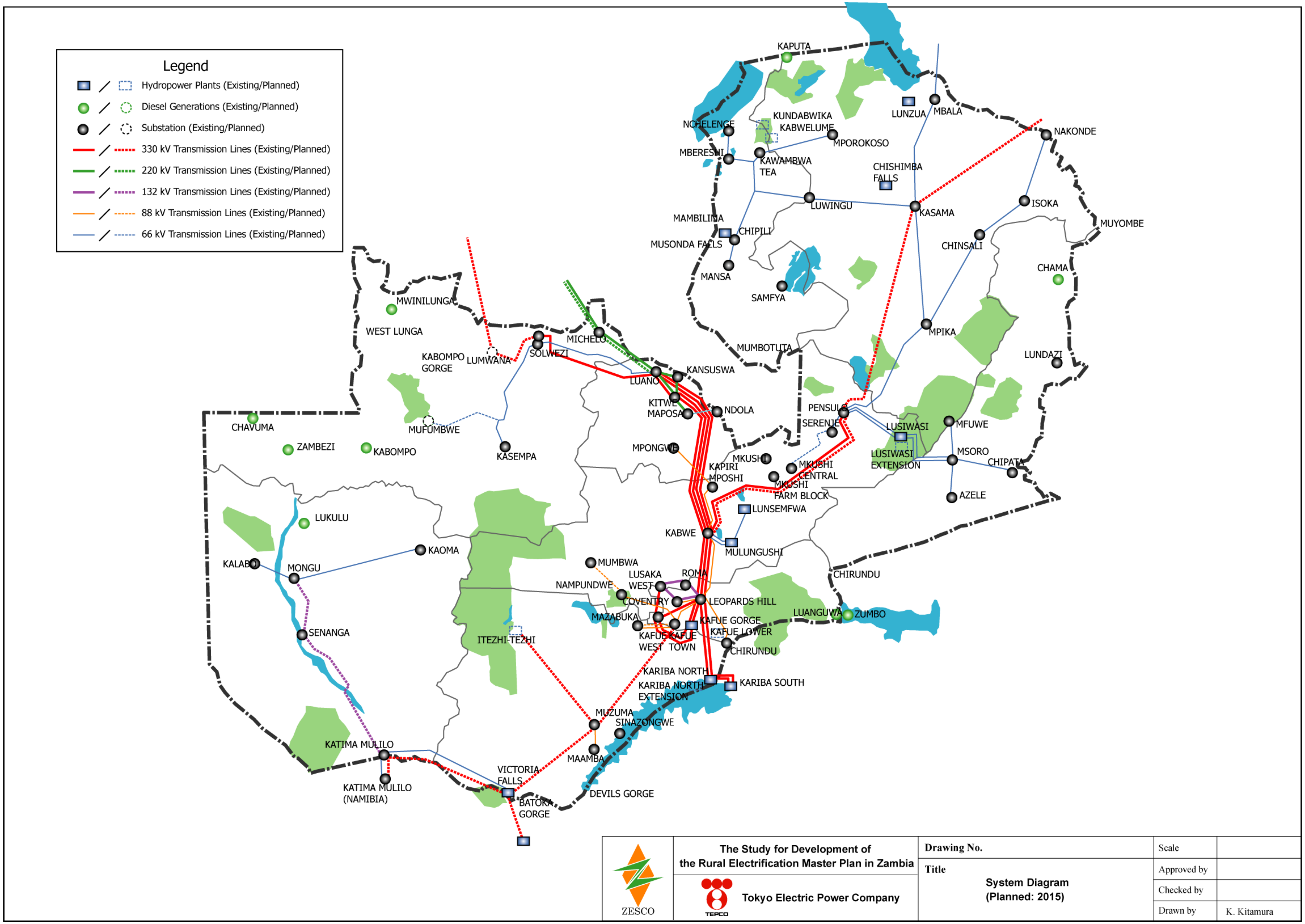


Figure 6-3 Transmission System Diagram of Zambia as of 2015

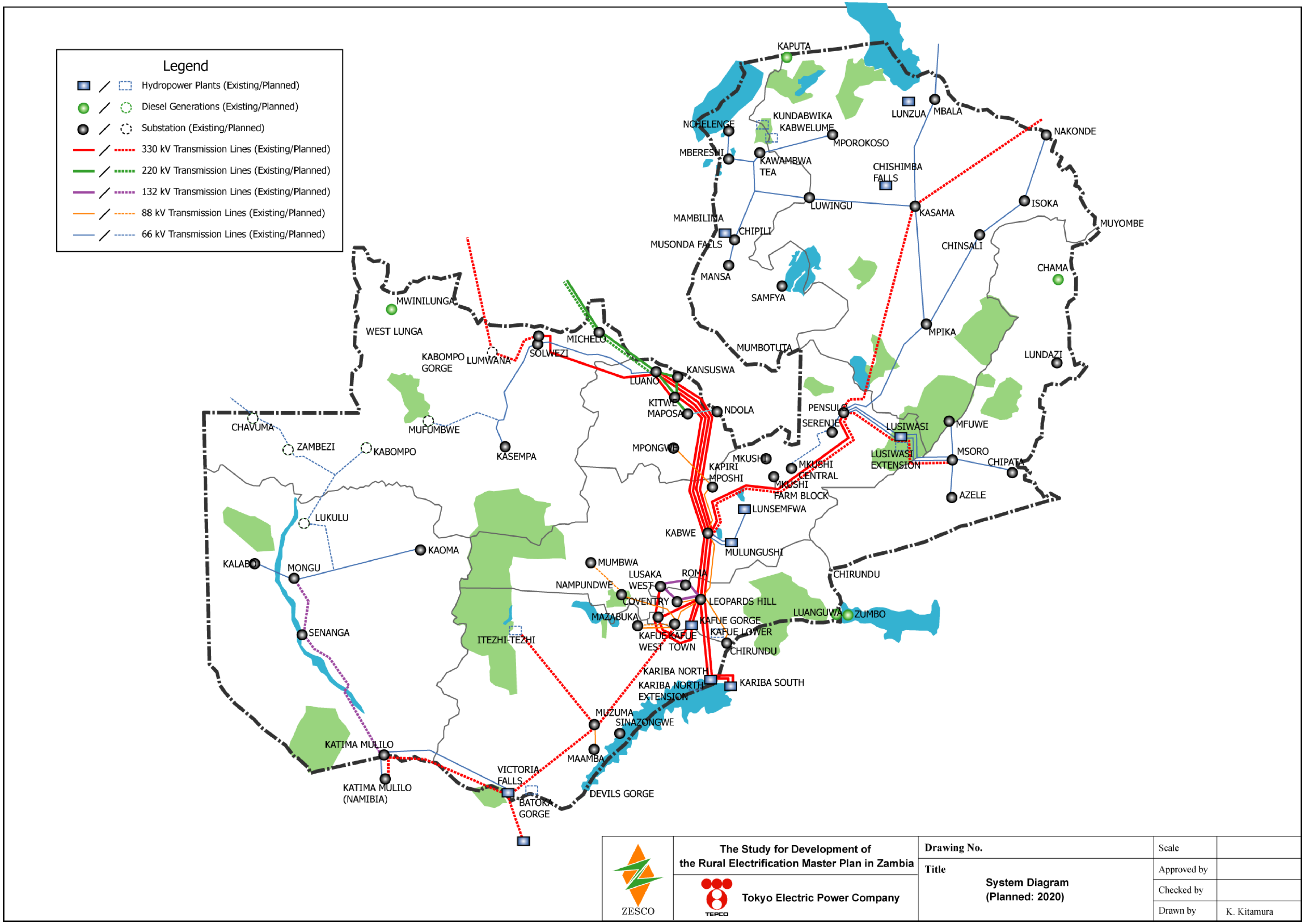


Figure 6-4 Transmission System Diagram of Zambia as of 2020

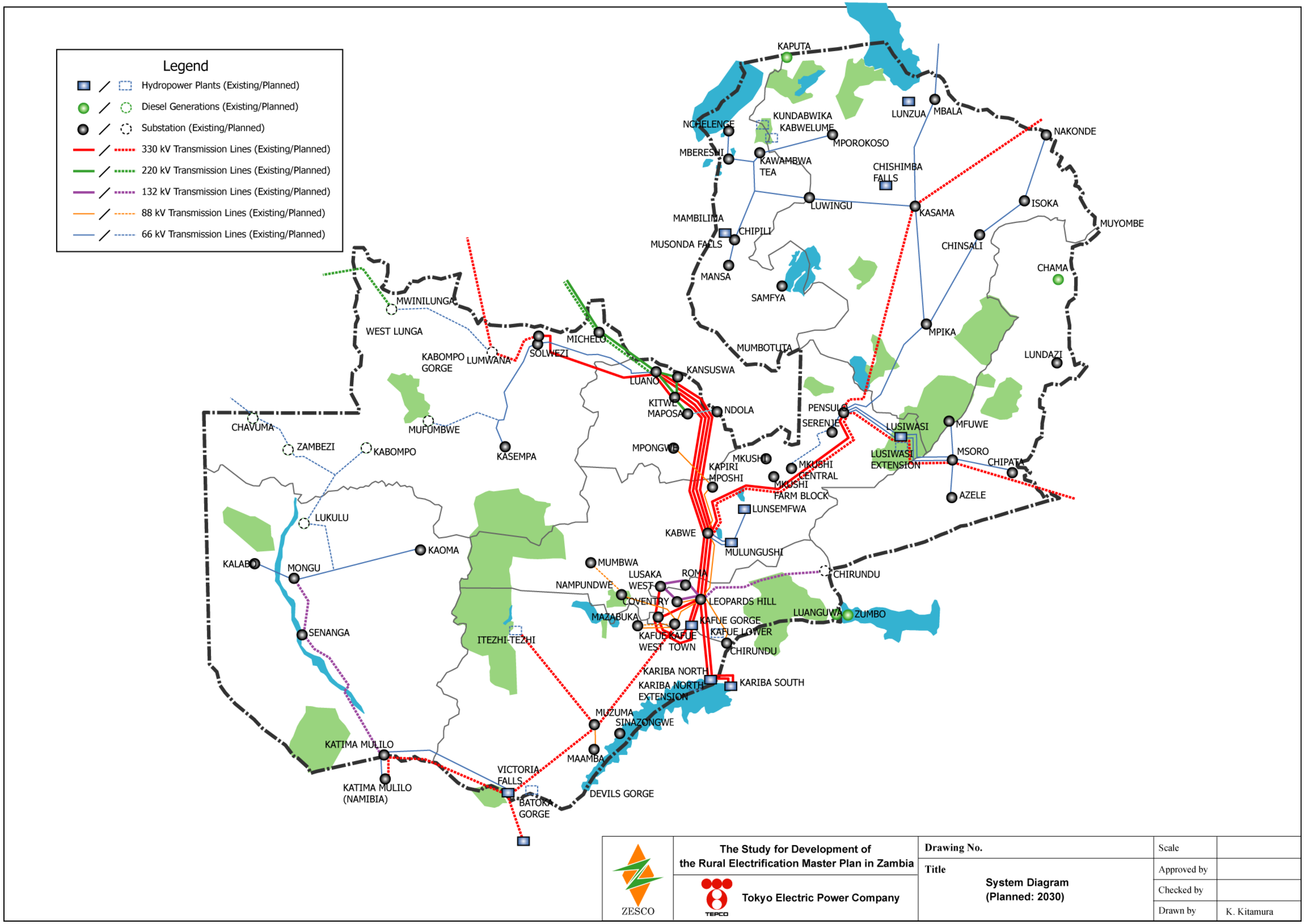


Figure 6-5 Transmission System Diagram of Zambia as of 2030

6.4. Analysis of the Capacity of Transmission System

There are two options of rural electrification, i.e. national grid extension and off-grid electrification, and regarding the first option, which is the topic of this section, it is necessary to take into account the effect of an electrification project on the capacity of power system such as substations and transmission lines. As already explained in Section 6.1. , if the maximum power load at local level is expected to exceed the facilities' capacity, reinforcement of the system should be considered as a part of the electrification project.

In this section, the capacity of the transmission system is analysed by using a simulation model. The main objective of this analysis is to identify the capacity of transmission system, especially regarding substations, which can be specified as follows, and the bottlenecks in the system, taking into account the demand growth and the system development plan.

- Remaining capacity of source substations that can be used for the local supply system from bulk power transmission system (blue coloured circle in image diagram)
- Remaining capacity of end substation that can be used for local supply system (red coloured circle in image diagram)

Figure 6-6 is the image diagram of remaining availability for electrification projects.

6.4.1. Assumptions of the Analysis

(1) Methodology

The methodology to grasp the system's capacity takes the following steps. First, the base scenario of the power system in the future is considered based on the business as usual (BAU) case power demand projection (that is, additional rural electrification projects are not considered) and the system reinforcement already planned by ZESCO. Then, the power flow and the voltage in the system are simulated repeatedly by gradually increasing the local load of a particular area. And finally each substation's remaining availability for electrification projects is determined at the level just below the point where the calculation cannot be converged due to the system's overload or voltage instability. When we find that some system reinforcement is necessary even in the base scenario but that no information regarding the reinforcement has been given by ZESCO, we assume that an appropriate reinforcement shall be done, which is included additionally in the base scenario. This simulation model also assumes that the installation of capacitors, which is necessary for keeping the system voltage stable to meet the demand growth, shall be done properly. Although it is said that 88kV is not standard voltage level in Zambia, 88kV existing and planning facilities are took into consideration in system analysis. And the necessary reinforcement in the base scenario of each simulation period is the same as existing one even 88kV system, which is the simplest method. The details should be considered in transmission system master plan.

(2) Simulation periods

Year 2010, 2015, 2020, and 2030

(3) Power demand

The simulation model uses the projection of annual peak demand that is supposed to be possibly the highest so that the tight supply-demand balance is assumed even without electrification projects. The peak demand up to 2013 is based on ZESCO's forecast. Peak demand beyond 2013, i.e. between 2014 and 2030, is projected by the Study Team, assuming that 3% p.a. growth rate for the last five years in ZESCO's projection (from 2008 to 2013) continues. The annual peak demand used for this analysis is summarized in Table 6-5 . Generation development plan, shown in Table 6-6, is also included in the base scenario.

Table 6-5 Projection of Peak Demand in Zambia

Year	2006	2010	2015	2020	2030
Peak demand [MW]	1,404	1,818	2,108	2,448	3,295
Average annual growth rate	–	6.7%	3.0%	3.0%	3.0%

Table 6-6 Generation Development Plan of ZESCO

Power Station	Unit No.	Capacity [MW]	Commissioning Year	Notes
Kafue Gorge	1,2	150 → 165	2007	Rehabilitation
Kafue Gorge	3,4	150 → 165	2006	Rehabilitation
Kafue Gorge	5,6	150 → 165	2008	Rehabilitation
Kariba North	1,2	150 → 180	2006	Rehabilitation
Kariba North	3,4	150 → 180	2009	Rehabilitation
Itezhi-Tezhi	1	120	2009	New installation
Kariba North	5	360	2009	Extension
Kafue Gorge Lower	1	750	2011	New installation
Kalungwishi	1	220	2015	New installation
Lusiwasi	1,2,3,4	3 → 15.5	2015	Rehabilitation
Musonda Falls	1	5 → 7.5	2015	Rehabilitation
Chishimba Falls	1	6 → 9.6	2015	Rehabilitation
Lunzua	1	0.75 → 4.4	2015	Rehabilitation

Source: ZESCO

(4) Power trade with neighbouring countries through interconnection line

The following Table 6-7 is the assumption of power export/import through interconnection lines. These numbers are provided to the Study Team by ZESCO.

Table 6-7 Trading Power of Interconnection Line with Neighboring Countries

Country	Voltage	Substation in Zambia	Commissioning Year	Target Power Flow
D.R.Congo	220	Michelo	Existing (reinforced in 2008)	200MW inflow
D.R.Congo	330	Lumwana	2010	500MW inflow
Tanzania	330	Kasama	2009	200MW outflow
Zimbabwe	330	Kariba north	Existing	200MW outflow
Zimbabwe	330	Victoria Falls	2010	100MW outflow
Namibia	330 (220)	Katima Mulilo	2010 (2006)	200MW outflow
Malawi	330	Msoro	2030	100MW outflow

(5) Power system analysis software

PSS/E is employed for the study, which is also the software that ZESCO uses for system planning and analysis.

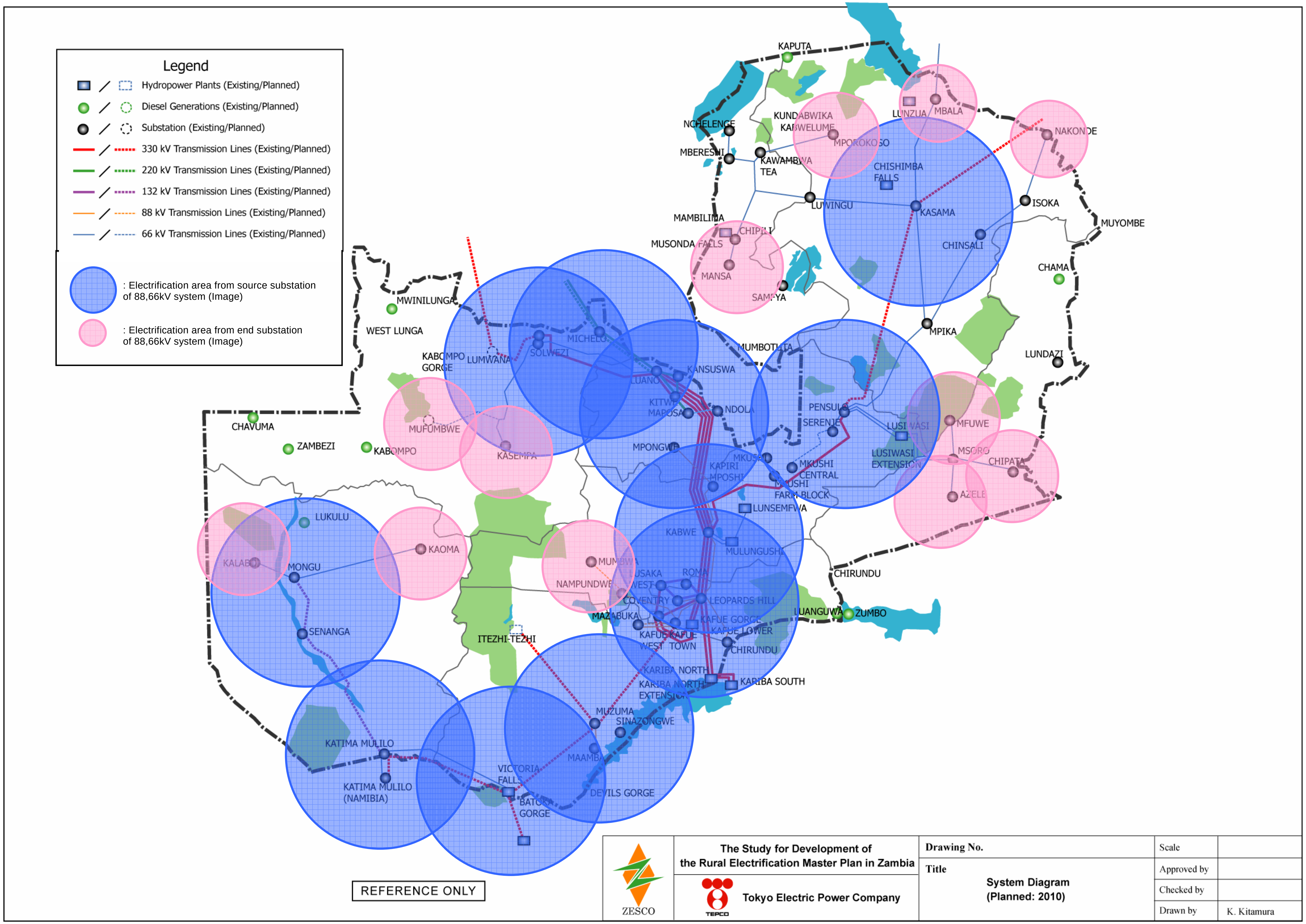


Figure 6-6 Image Diagram of Remaining Availability for Electrification Projects

6.4.2. Transmission System as of 2010

Transmission system diagram as of 2010 is shown in Figure 6-2 . The list of reinforcement of substations necessary to be done by 2010 is shown in Table 6-8 and that of transmission lines are shown in Table 6-9 These reinforcements are considered in the base scenario in addition to the reinforcement projects already planned by ZESCO (refer to Table 6-4 The demand growth and power development plan up to 2010 are considered as explained in “(1) Assumptions of the Analysis”. This simulation model assumes that the installation of capacitors is done properly to keep the system voltage stable.

Power flow diagram of the base scenario as of 2010 is shown in Figure 6-7 Table 6-10 shows the remaining availability that can be used for electrification projects, as well as the maximum capacity of each local substation in the base scenario, which is shown in Figure 6-8 as image diagram.

Table 6-8 Additional Necessary Reinforcement of Substations by 2010

Substation	Reinforcement (Objective)
Lusaka West	Install one more unit of 330/132kV Transformer (Overload prevention)
Michelo	Install one more unit of 220/66kV Transformer (Overload prevention)
Kabwe	Install one more unit of 88/66kV Transformer (Overload prevention)

Table 6-9 Additional Necessary Reinforcement of Transmission Lines by 2010

Transmission Line	Reinforcement (Objective)
132kV Leopards Hill – Coventry (Leopards Hill 132kV system)	Install one more circuit (Overload prevention)
132kV Leopards Hill – Roma (Leopards Hill 132kV system)	Install one more circuit (Overload prevention)
88kV Leopards Hill – Waterworks (Leopards Hill 88kV system)	Install one more circuit (Overload prevention)
66kV Maposa - Dolahill (Maposa 66kV system)	Install one more circuit (Overload prevention)
66kV Ndola - Dolahill (Maposa 66kV system)	Install one more circuit (Overload prevention)
66kV Pensulo - Serenje (Pensulo 66kV system)	Install one more circuit (Overload prevention)

Table 6-10 Maximum Transmitting Capacity of each Substation as of 2010

Substation	Peak Demand [MW]	Remaining Availability [MW]	Maximum Capacity [MW]	Bottlenecks
System source substations of 88kV and 66kV				
Kasama 66kV	16	65	81	Overload (Kasama 330/66kV Tr)
Pensulo 66kV	58	60	118	Overload (Pensulo 330/66kV Tr)
Michelo 66kV	96	60	156	Overload (Michelo 220/66kV Tr)
Luano 66kV	245	40	285	Overload (66kV Michelo–Bancroft Line)
Kansuswa 66kV	177	45	222	Overload (Kansuswa 330/66kV Tr)
Kitwe 66kV	229	25	254	Overload (Kitwe 220/66kV Tr)
Maposa 66kV	248	50	298	Overload (Maposa 330/66kV Tr)
Kabwe 66kV	17	8	25	Overload (Kabwe 88/66kV Tr)
Kabwe 88kV	64	35	99	Overload (Kabwe 330/88kV Tr)
Leopards Hill 88kV	141	40	181	Overload (Leopards Hill 330/88kV Tr)
Kafue Town 88kV	72	45	117	Overload (Kafue Town 330/88kV Tr)
Muzuma 88kV	16	40	56	Overload (Muzuma 330/88kV Tr)
Victoria Falls 33kV	0	75	75	Overload (330kV Muzuma–Victoria Falls Line)
Victoria Falls 66kV	9	2	11	Overload (Victoria Falls 33/66kV Tr)
Katimamulilo 66kV	1	50 *	51	Overload (Katimamulilo 330/66kV Tr)
Mongu 66kV	6	40 *	46	Overload (Mongu 132/66kV Tr)
System end substations of 88kV and 66kV				
Mbala 66kV	5	20	25	Overload (66kV Kasama-Mbala Line)
Mporokoso 66kV	1	5	6	Voltage instability
Mansa 66kV	4	5	9	Voltage instability
Nakonde 66kV	1	5	6	Voltage instability
Mfuwe 66kV	1	15	16	Voltage instability
Chipata 66kV	8	10	18	Voltage instability
Azele 66kV	2	15	17	Voltage instability
Mufumbwe 66kV	3	2	5	Voltage instability
Kasempa 66kV	4	1	5	Voltage instability
Mumbwa 88kV	0	25	25	Overload (88kV Nampundwe–Mumbwa Line)
Kaoma 66kV	3	10	13	Voltage instability
Kalabo 66kV	1	25 *	26	Overload (66kV Mongu–Kalabo Line)

Note: * These are calculated based on the assumption that Victoria Falls 33/66kV transformers, which are to be overloaded as a result of loop power flow balancing when the system load at 66kV level becomes high, shall be isolated.

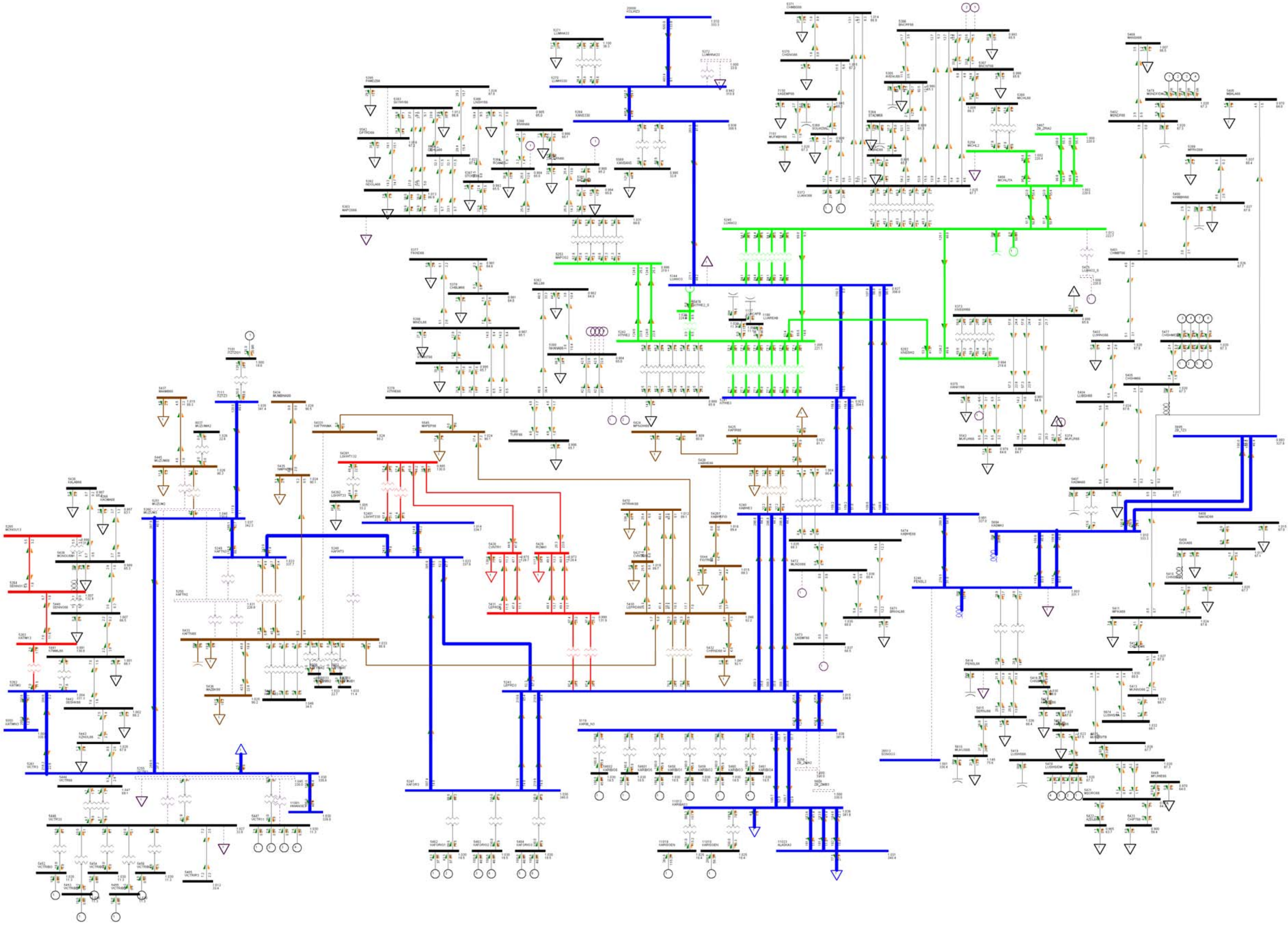


Figure 6-7 Power Flow Diagram of the Base Scenario as of 2010

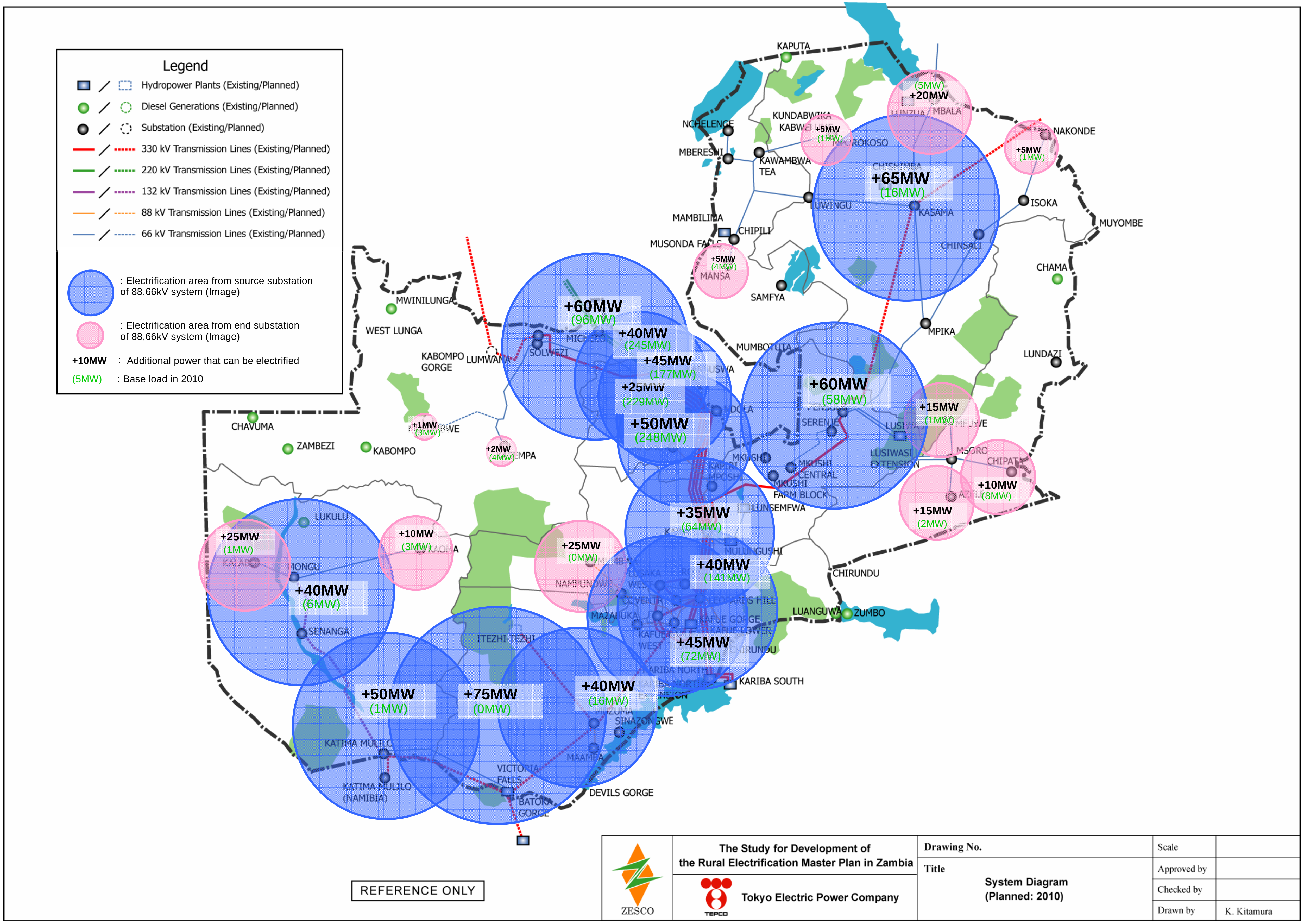


Figure 6-8 Image Diagram of Remaining Availability for Electrification Projects in 2010

6.4.3. Transmission System in 2015

Transmission system diagram in 2015 is shown in Figure 6-3 The list of reinforcement of substations necessary to be done by 2015 is shown in Table 6-11 and that of transmission lines are shown in Table 6-12 These reinforcements are considered in the base scenario in addition to the reinforcement projects already planned by ZESCO (refer to Table 6-4 The demand growth and power development plan up to 2015 are considered as explained in “(1) Assumptions of the Analysis”. This simulation model assumes that the installation of capacitors is done properly to keep the system voltage stable.

Power flow diagram of the base scenario as of 2015 is shown in Figure 6-9 Table 6-13 shows the remaining availability that can be used for electrification projects, as well as the maximum capacity of each local substation in the base scenario, which is shown in Figure 6-10 as image diagram.

Table 6-11 Additional Necessary Reinforcement of Substations by 2015

Substation	Reinforcement (Objective)
Kitwe	Install one more unit of 220/66kV Transformer (Overload prevention)
Kansanshi	Install one more unit of 330/33kV Transformer (Overload prevention)
Luano	Install each one more unit of 330/33 & 220/66kV Transformers (Overload prevention)
Maposa	Install one more unit of 220/66kV Transformer (Overload prevention)

Table 6-12 Additional Necessary Reinforcement of Transmission Lines by 2015

Transmission Line	Reinforcement (Objective)
66kV Maposa - Ndola (Maposa 66kV system)	Install one more circuit (Overload prevention)
66kV Stadium – Kabundi (Luano 66kV system)	Install one more circuit (Overload prevention)
66kV Michelo – Bancroft (Michelo 66kV system)	Install one more circuit (Overload prevention)

Table 6-13 Maximum Transmitting Capacity of each Substation in 2015

Substation	Peak Demand [MW]	Remaining Availability [MW]	Maximum Capacity [MW]	Bottlenecks
System source substations of 88kV and 66kV				
Kasama 66kV	16	60	76	Overload (Kasama 330/66kV Tr)
Pensulo 66kV	49	65	114	Overload (Pensulo 330/66kV Tr)
Michelo 66kV	109	30	139	Overload (Michelo 220/66kV Tr)
Luano 66kV	286	65	351	Overload (Luano 220/66kV Tr) [open BNCNT–BNCRF Line]
Kansuswa 66kV	206	35	241	Overload (Kansuswa 330/66kV Tr)
Kitwe 66kV	308	30	338	Overload (Kitwe 220/66kV Tr)
Maposa 66kV	414	60	474	Overload (Maposa 220/66kV Tr)
Kabwe 66kV	19	5	24	Overload (Kabwe 88/66kV Tr)
Kabwe 88kV	75	25	100	Overload (Kabwe 330/88kV Tr)
Leopards Hill 88kV	161	15	176	Overload (Leopards Hill 330/88kV Tr)
Kafue Town 88kV	85	30	115	Overload (Kafue Town 330/88kV Tr)
Muzuma 88kV	19	35	54	Overload (Muzuma 330/88kV Tr)
Victoria Falls 33kV	0	70	70	Overload (330kV Muzuma–Victoria Falls Line)
Victoria Falls 66kV	10	1	11	Overload (Victoria Falls 33/66kV Tr)
Katimamulilo 66kV	2	45 *	47	Overload (Katimamulilo 330/66kV Tr)
Mongu 66kV	7	35 *	42	Overload (Mongu 132/66kV Tr)
System end substations of 88kV and 66kV				
Mbala 66kV	5	15	20	Voltage instability
Mporokoso 66kV	1	5	6	Voltage instability
Mansa 66kV	4	5	9	Voltage instability
Nakonde 66kV	1	5	6	Voltage instability
Mfuwe 66kV	1	15	16	Voltage instability
Chipata 66kV	9	10	19	Voltage instability
Azele 66kV	2	15	17	Voltage instability
Mufumbwe 66kV	3	0	3	Voltage instability
Kasempa 66kV	5	0	5	Voltage instability
Mumbwa 88kV	0	20	20	Overload (Kafue Town 330/88kV Tr)
Kaoma 66kV	3	5	8	Voltage instability
Kalabo 66kV	1	20 *	21	Voltage instability

Note: * These are calculated based on the assumption that Victoria Falls 33/66kV transformers, which are to be overloaded as a result of loop power flow balancing when the system load at 66kV level becomes high, shall be isolated.

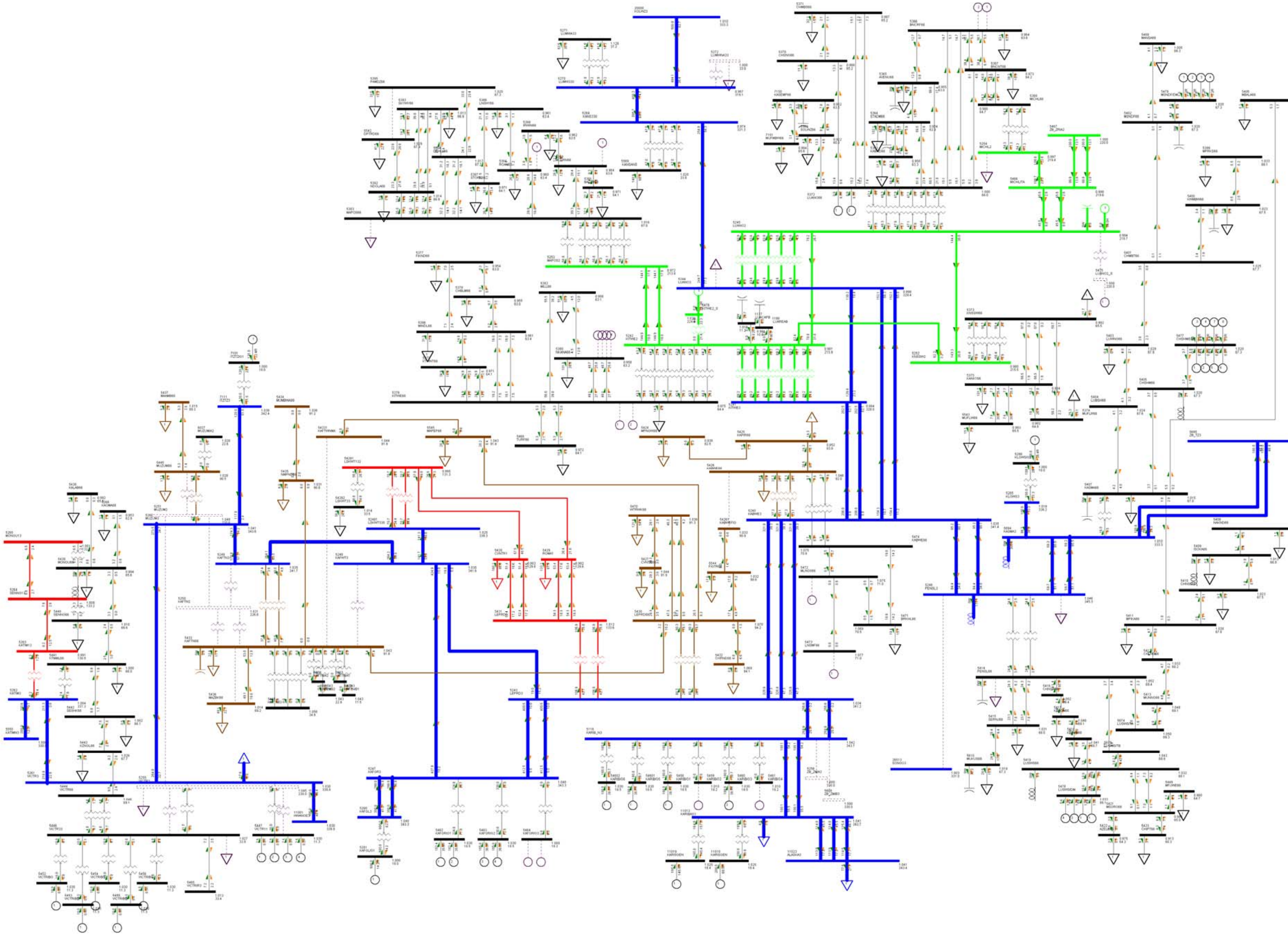


Figure 6-9 Power Flow Diagram of the Base Scenario in 2015

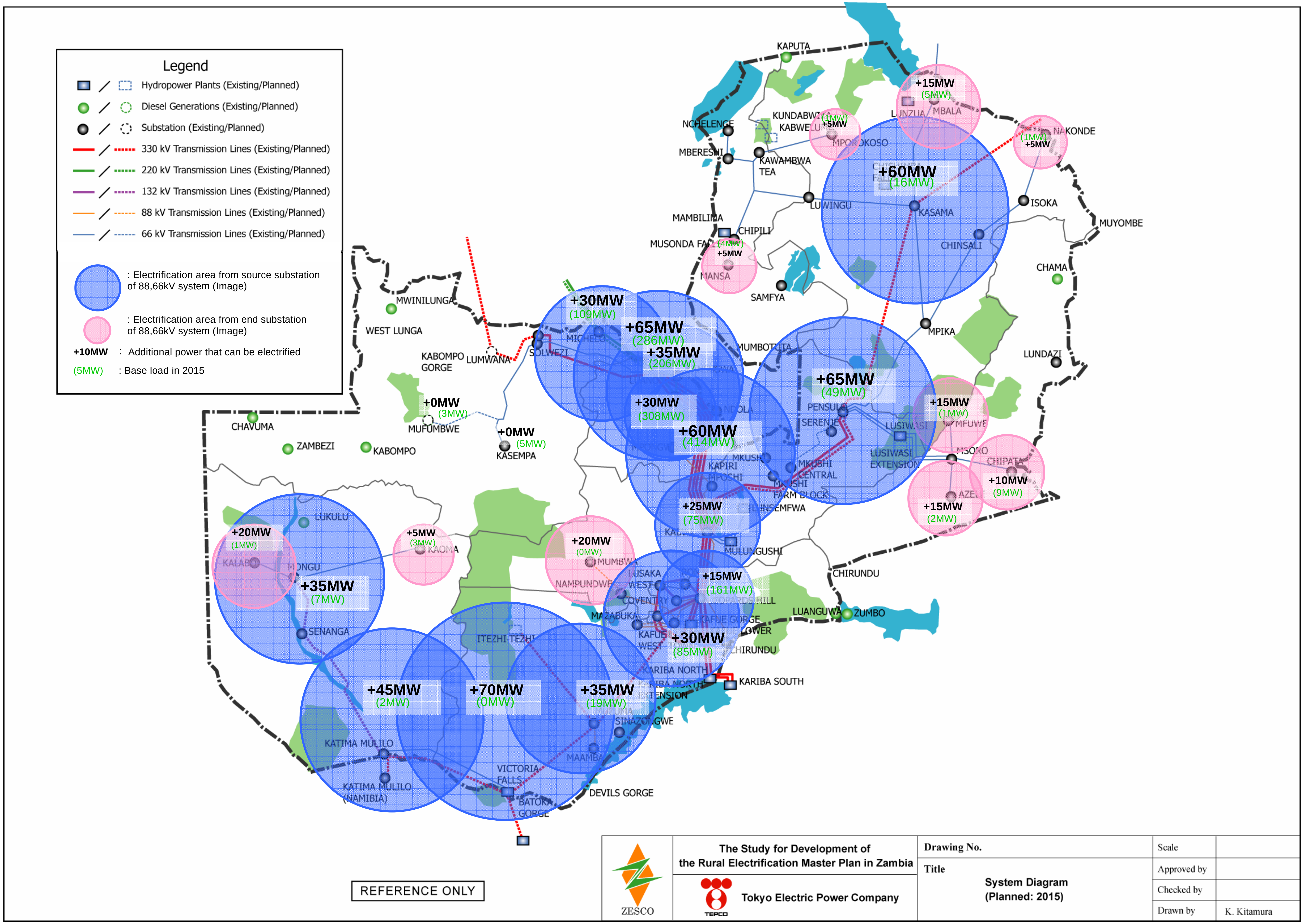


Figure 6-10 Image Diagram of Remaining Availability for Electrification Projects in 2015

6.4.4. Transmission system in 2020

Transmission system diagram in 2020 is shown in Figure 6-4 The list of reinforcement of substations necessary to be done by 2020 is shown in Table 6-14 and that of transmission lines are shown in Table 6-15 These reinforcements are considered in the base scenario in addition to the reinforcement projects already planned by ZESCO (refer to Table 6-4 The demand growth and power development plan up to 2020 are considered as explained in “(1) Assumptions of the Analysis”. This simulation model assumes that the installation of capacitors is done properly to keep the system voltage stable.

Power flow diagram of the base scenario as of 2020 is shown in Figure 6-11 Table 6-16 shows the remaining availability that can be used for electrification projects, as well as the maximum capacity of each local substation in the base scenario, which is shown in Figure 6-12 as image diagram.

Table 6-14 Additional Necessary Reinforcement of Substations by 2020

Substation	Reinforcement (Objective)
Kansanshi	Install one more unit of 330/66kV transformer to connect between Solwezi 66kV system and Kansanshi 66kV system (Voltage instability prevention)
Leopards Hill	Install one more unit of 330/132kV Transformer (Overload prevention)
Leopards Hill	Install one more unit of 330/88kV Transformer (Overload prevention)
Kansuswa	Install one more unit of 330/66kV Transformer (Overload prevention)

Table 6-15 Additional Necessary Reinforcement of Transmission Lines by 2020

Transmission Line	Reinforcement (Objective)
66kV Kansanshi - Solwezi (Kansanshi 66kV system)	Connection of Kansanshi 66kV system and Solwezi 66kV system (Voltage instability prevention)
66kV Luano - Stadium (Luano 66kV system)	Install one more circuit (Overload prevention)
66kV Serenje – Mkushi (Pensulo 66kV system)	Install one more circuit (Voltage instability prevention)
66kV Kafue Town – Mazabuka (Kafue Town 88kV system)	Install one more circuit (Overload prevention)
66kV Kansuswa – Kankoyo (Kansuswa 66kV system)	Install one more circuit (Overload prevention)
66kV Maposa – Ndola (Maposa 66kV system)	Install one more circuit (Overload prevention)

Table 6-16 Maximum Transmitting Capacity of each Substation in 2020

Substation	Peak Demand [MW]	Remaining Availability [MW]	Maximum Capacity [MW]	Bottlenecks
System source substations of 88kV and 66kV				
Kasama 66kV	21	55	76	Overload (Kasama 330/66kV Tr)
Pensulo 66kV	50	75	125	Overload (Pensulo 330/66kV Tr)
Msoro 66kV **	4	50	54	Overload (Msoro 330/66kV Tr)
Michelo 66kV	122	15	137	Overload (Michelo 220/66kV Tr)
Luano 66kV	308	45	353	Overload (Luano 220/66kV Tr) [open BNCNT–BNCRF Line]
Kansuswa 66kV	238	65	303	Overload (Kanauswa 330/66kV Tr)
Kitwe 66kV	301	20	321	Overload (Kitwe 220/66kV Tr)
Maposa 66kV	335	25	360	Overload (Maposa 220/66kV Tr)
Kansanshi 66kV **	25	35	60	Overload (Kansanshi 330/66kV Tr)
Kabwe 66kV	23	1	24	Overload (Kabwe 88/66kV Tr)
Kabwe 88kV	87	20	107	Overload (Kabwe 330/88kV Tr)
Leopards Hill 88kV	192	60	252	Overload (Leopards Hill 330/88kV Tr)
Kafue Town 88kV	90	20	110	Overload (Kafue Town 330/88kV Tr)
Muzuma 88kV	22	30	52	Overload (Muzuma 330/88kV Tr)
Victoria Falls 33kV	0	55	55	Overload (330kV Muzuma–Victoria Falls Line)
Victoria Falls 66kV	10	0	10	Overload (Victoria Falls 33/66kV Tr)
Katimamulilo 66kV	6	40 *	46	Overload (Katimamulilo 330/66kV Tr)
Mongu 66kV	15	30 *	45	Overload (Mongu 132/66kV Tr)
System end substations of 88kV and 66kV				
Mbala 66kV	6	15	21	Voltage instability
Mporokoso 66kV	1	5	6	Voltage instability
Mansa 66kV	5	5	10	Voltage instability
Nakonde 66kV	1	5	6	Voltage instability
Mfuwe 66kV	1	20	21	Overload (66kV Msoro–Mfuwe Line)
Chipata 66kV	11	10	21	Overload (66kV Msoro–Chipata Line)
Azele 66kV	2	20	22	Overload (66kV Msoro–Azele Line)
Mufumbwe 66kV	4	5	9	Voltage instability
Kasempa 66kV	5	10	15	Voltage instability
Mumbwa 88kV	0	15	15	Overload (Kafue Town 330/88kV Tr)
Kaoma 66kV	4	5	9	Voltage instability
Kalabo 66kV	1	15 *	16	Voltage instability
Kabompo 66kV	1	5	6	Voltage instability
Chavuma 66kV	1	5	6	Voltage instability

Note: * These are calculated based on the assumption that Victoria Falls 33/66kV transformers, which are apt to be overloaded as a result of loop power flow balancing when the system load at 66kV level becomes high, shall be isolated.

** Newly installed substations

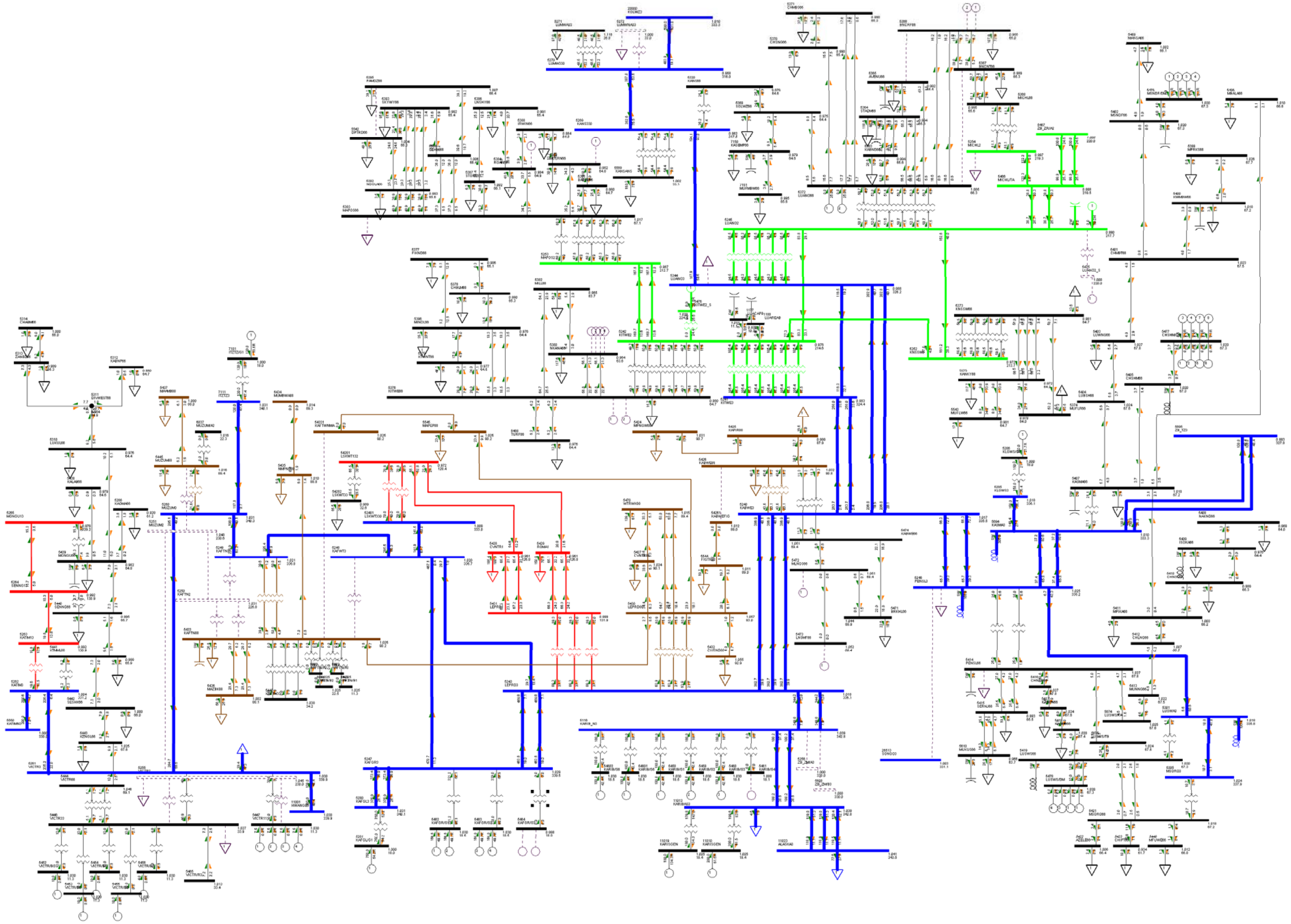


Figure 6-11 Power Flow Diagram of the Base Scenario in 2020

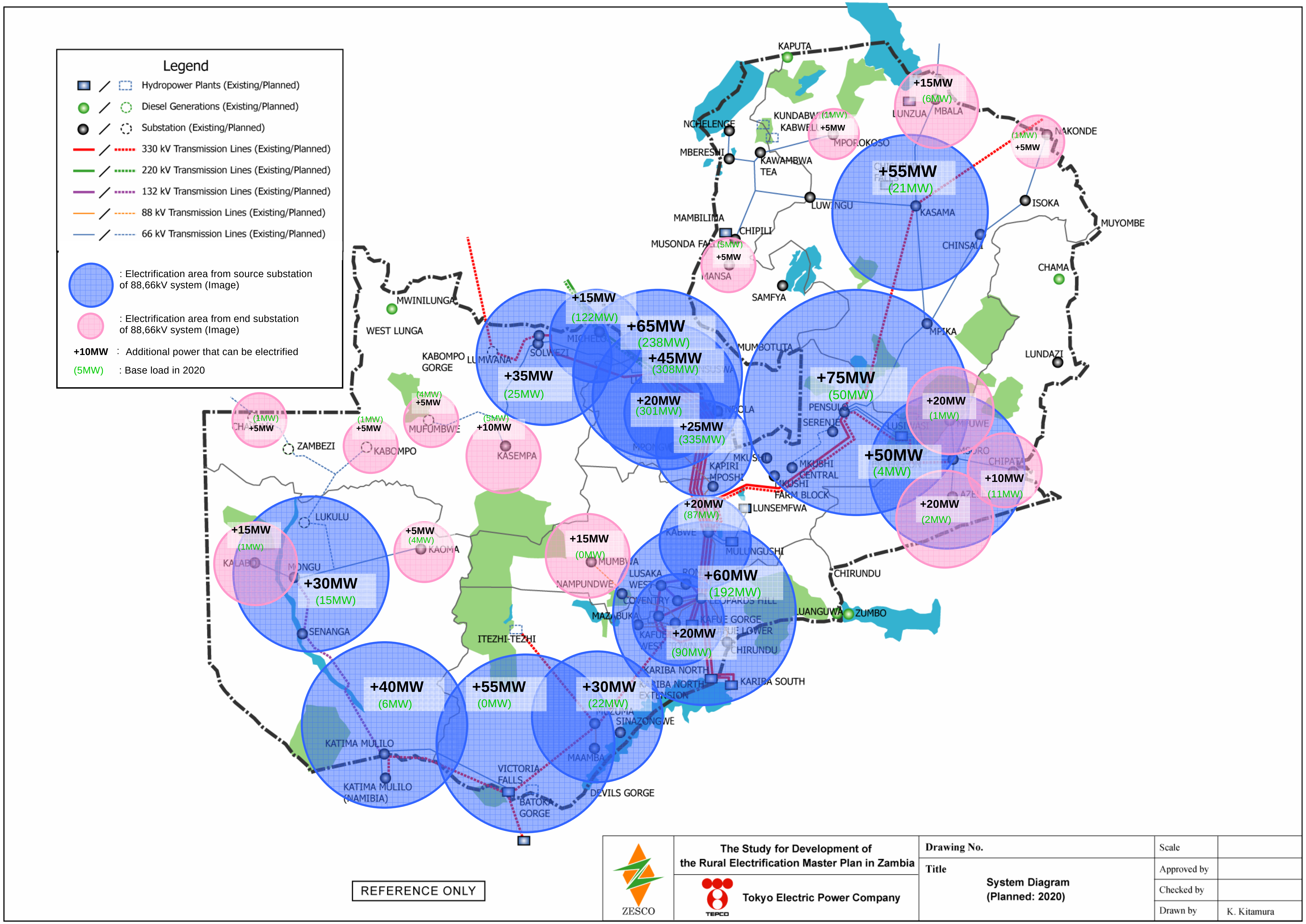


Figure 6-12 Image Diagram of Remaining Availability for Electrification Projects in 2020

6.4.5. Transmission System in 2030

Transmission system diagram in 2030 is shown in Figure 6-5 The list of reinforcement of substations necessary to be done by 2030 is shown in Table 6-17 and that of transmission lines are shown in Table 6-18 These reinforcements are considered in the base scenario in addition to the reinforcement projects already planned by ZESCO (refer to Table 6-4 The demand growth and power development plan up to 2030 are considered as explained in "(1) Assumptions of the Analysis". This simulation model assumes that the installation of capacitors is done properly to keep the system voltage stable.

Power flow diagram of the base scenario as of 2030 is shown in Figure 6-13 Table 6-19 shows the remaining availability that can be used for electrification projects, as well as the maximum capacity of each local substation in the base scenario, which is shown in Figure 6-14 as image diagram.

Table 6-17 Additional Necessary Reinforcement of Substations by 2030

Substation	Reinforcement (Objective)
Maposa	Install one more unit of 220/66kV Transformer (Overload prevention)
Kitwe	Install three more units of 330/220kV Transformer (Overload prevention)
Kitwe	Install two more units of 220/66kV Transformer (Overload prevention)
Kabwe	Install one more unit of 330/88kV Transformer (Overload prevention)
Kabwe	Install one more unit of 88/66kV Transformer (Overload prevention)
Kansanshi	Install one more unit of 330/33kV Transformer (Overload prevention)
Luano	Install one more unit of 330/220kV Transformer (Overload prevention)
Luano	Install two more units of 220/66kV Transformer (Overload prevention)
Maposa	Install one more unit of 220/66kV Transformer (Overload prevention)
Michelo	Install one more unit of 220/66kV Transformer (Overload prevention)
Kansuswa	Install one more unit of 220/66kV Transformer (Overload prevention)
Leopards Hill	Install one more unit of 330/132kV Transformer (Overload prevention)

Table 6-18 Additional Necessary Reinforcement of Transmission Lines by 2030

Transmission line	Reinforcement
66kV Maposa – Roan (Maposa 66kV system)	Install one more circuit (Overload prevention)
66kV Irwin – Maclaren (Maposa 66kV system)	Install one more circuit (Overload prevention)
66kV Maposa – Ndola (Maposa 66kV system)	Install two more circuits (Overload prevention)
66kV Skyways – Depot Road (Maposa 66kV system)	Install one more circuit (Overload prevention)
66kV Dolahll – Pamodzi (Maposa 66kV system)	Install one more circuit (Overload prevention)
66kV Maposa – Balub (Maposa 66kV system)	Install one more circuit (Overload prevention)
66kV Skyways – Ndola (Maposa 66kV system)	Install one more circuit (Overload prevention)
66kV Kitwe – Scaw Mill (Kitwe 66kV system)	Install one more circuit (Overload prevention)
66kV Mindolo – Chibuluma (Kitwe 66kV system)	Install one more circuit (Overload prevention)
132kV Lusaka West – Coventry (Leopards Hill 132kV system)	Install one more circuit (Overload prevention)
132kV Leopards Hill – Roma (Leopards Hill 132kV system)	Install one more circuit (Overload prevention)
88kV Leopards Hill – Waterworks (Leopards Hill 88kV system)	Install one more circuit (Overload prevention)
66kV Luano – Kabundi (Luano 66kV system)	Install one more circuit (Overload prevention)
66kV BNCNT – BNCRF (Michelo 66kV system)	Install one more circuit (Overload prevention)
66kV Luano – Stadium (Luano Michelo 66kV system)	Install one more circuit (Overload prevention)
66kV Kansuswa – Kankoyo (Kansuswa 66kV system)	Install one more circuit (Overload prevention)
66kV Kankoyo – Mufulira (Kansuswa 66kV system)	Install one more circuit (Overload prevention)

Table 6-19 Maximum Transmitting Capacity of each Substation in 2030

Substation	Peak Demand [MW]	Remaining Availability [MW]	Maximum Capacity [MW]	Bottlenecks
System source substations of 88kV and 66kV				
Kasama 66kV	33	45	78	Overload (Kasama 330/66kV Tr)
Pensulo 66kV	67	60	127	Overload (Pensulo 330/66kV Tr)
Msoro 66kV **	8	55	63	Overload (Msoro 330/66kV Tr)
Michelo 66kV	174	30	204	Overload (Michelo 220/66kV Tr)
Luano 66kV	404	55	459	Overload (Luano 220/66kV Tr)
Kansuswa 66kV	320	65	385	Overload (Kansuswa 330/66kV Tr)
Kitwe 66kV	399	45	444	Overload (Kitwe 220/66kV Tr)
Maposa 66kV	449	60	509	Overload (Maposa 220/66kV Tr)
Kansanshi 66kV **	32	20	52	Overload (Kansanshi 330/66kV Tr)
Kabwe 66kV	20	4	24	Overload (Kabwe 88/66kV Tr)
Kabwe 88kV	119	35	154	Overload (Kabwe 330/88kV Tr)
Leopards Hill 88kV	243	20	263	Overload (Leopards Hill 330/88kV Tr)
Kafue Town 88kV	135	35	170	Overload (Kafue Town 330/88kV Tr)
Muzuma 88kV	29	20	49	Overload (Muzuma 330/88kV Tr)
Victoria Falls 33kV	0	40	40	Overload (330kV Muzuma–Victoria Falls Line)
Victoria Falls 66kV	12	4	16	Overload (Victoria Falls 33/66kV Tr)
Katimamulilo 66kV	8	35	43	Overload (330kV Muzuma–Victoria Falls Line)
Mongu 66kV	15	25	40	Overload (330kV Muzuma–Victoria Falls Line)
System end substations of 88kV and 66kV				
Mbala 66kV	8	15	23	Voltage instability
Mporokoso 66kV	1	3	4	Voltage instability
Mansa 66kV	6	5	11	Voltage instability
Nakonde 66kV	2	4	6	Voltage instability
Mfuwe 66kV	2	20	22	Overload (66kV Msoro–Mfuwe Line)
Chipata 66kV	15	5	20	Overload (66kV Msoro–Chipata Line)
Azele 66kV	3	20	23	Overload (66kV Msoro–Azele Line)
Mufumbwe 66kV	5	4	9	Voltage instability
Kasempa 66kV	7	5	12	Voltage instability
Mwinilunga 66kV **	0	15	15	Voltage instability
Mumbwa 88kV	0	25	25	Overload (Kafue Town 330/88kV Tr)
Chirundu 66kV **	0	70	70	Overload (132kV Leopards Hill–Chirundu Line)
Kaoma 66kV	5	5	10	Voltage instability
Kalabo 66kV	1	15	16	Voltage instability
Kabompo 66kV	1	5	6	Voltage instability
Chavuma 66kV	2	3	5	Voltage instability

Note: ** Newly installed substations

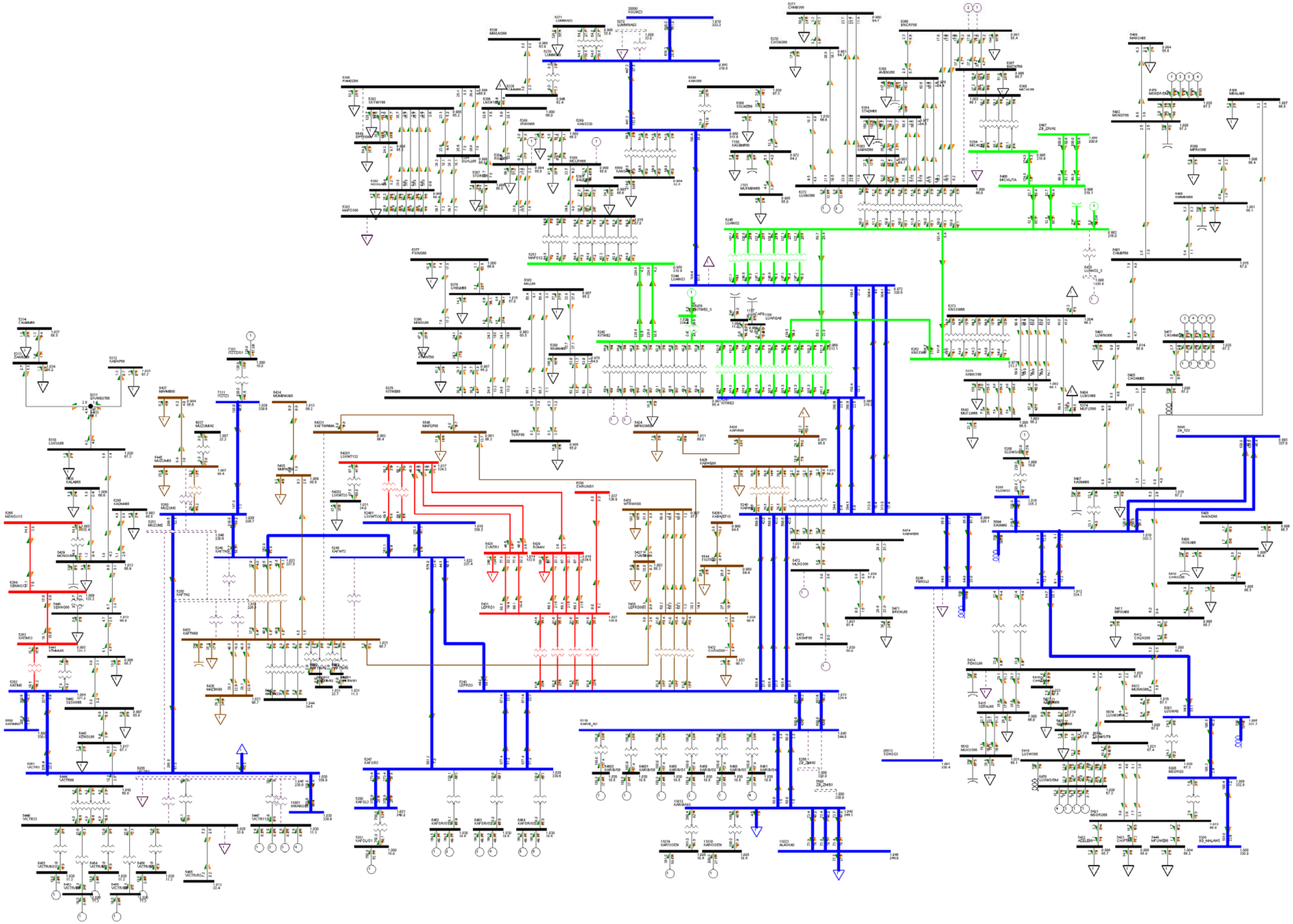


Figure 6-13 Power Flow Diagram of the Base Scenario in 2030

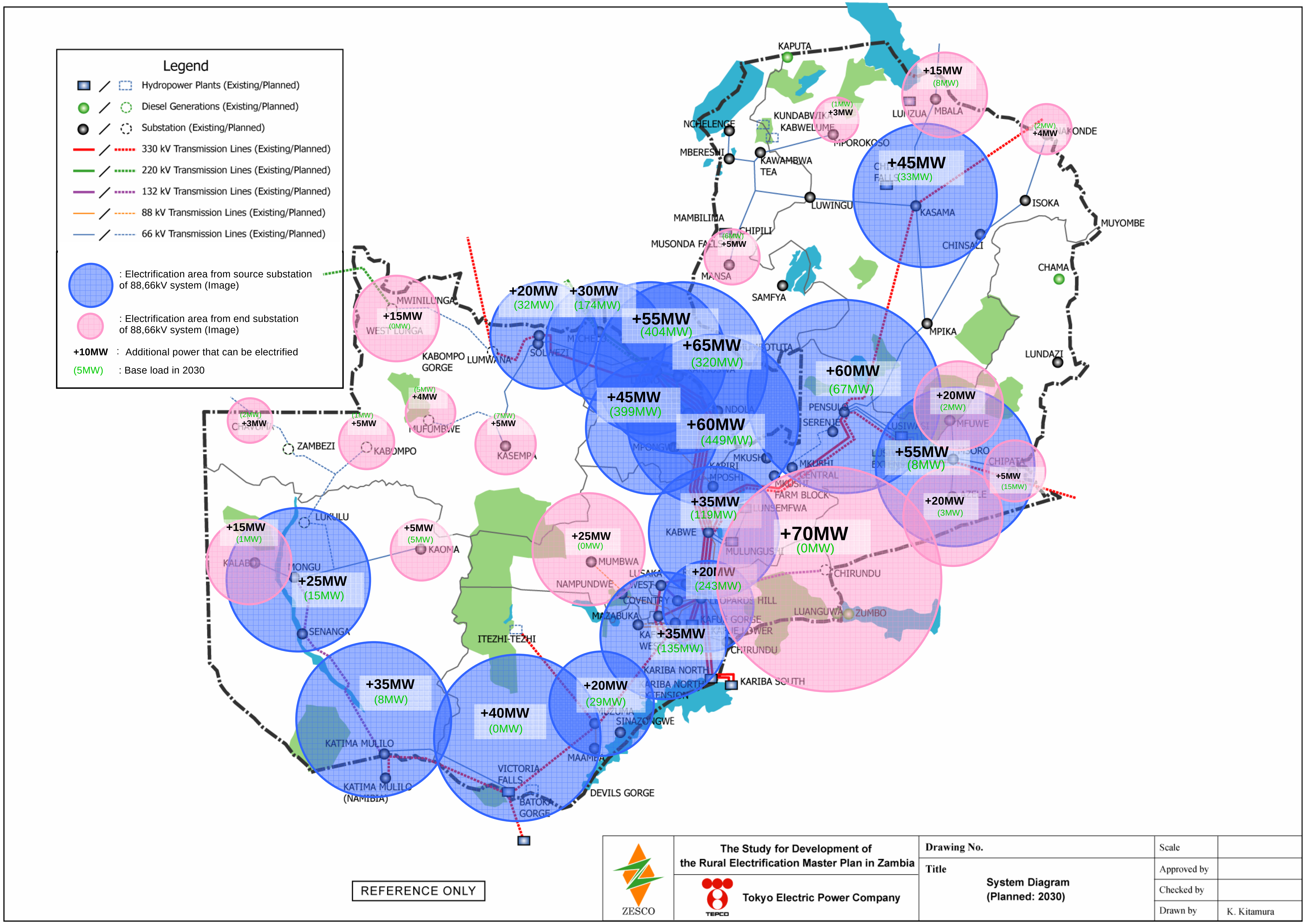


Figure 6-14 Image Diagram of Remaining Availability for Electrification Projects asof 2030

6.4.6. Observations on the Simulation Results

In this section, the capacity of source substations and end substations in local network system at 88kV and 66kV, which are the main source of local power supply, was analysed. The capacity of substations that are placed between a source substation and an end substation is estimated to come in-between. The system's remaining availability for electrification projects shall be referred to as basic data when considering electrification projects through grid extension.

The following features regarding Zambia's transmission system are observed through the analysis.

- Each source substation has in general around 20-70MW availability and each end substation has in general around 0-20MW availability for electrification projects.
- The capacity of source substations in the local network system is in general determined by the restriction deriving from equipment capacity whereas the capacity of end substations is determined by the restriction deriving voltage instability.
- Since the network system in the western region is underdeveloped and the transmission lines have a long span, the network system is vulnerable to voltage instability and its remaining availability is small. Implementation of large-scale electrification projects is not feasible without system reinforcement.
- Since the network system in the northern region is also underdeveloped and the transmission lines have a long, implementation of large-scale electrification projects is not feasible without system reinforcement.
- In general, the remaining availability for electrification projects becomes smaller as the power demand grows. However, this availability can be expanded with the implementation of the reinforcement of network system and the development of power stations. This possibility needs to be analysed in detail for each individual case.

Concerning the simulation model, the following issues should be paid attention to as important notice.

- Since the simulation was executed on each individual case, the results may not be the same as what would happen in reality, where many electrification projects are implemented in parallel. The simulation with comprehensive analysis should be carried out after the list of candidate sites for electrification is finalized and the schedule of implementing electrification projects is determined.
- If a candidate site for electrification is far from the existing grid, the availability of substations may be smaller than this simulation results due to the restriction of voltage instability. This effect should be analysed in detail after the list of candidate sites is finalized.

Chapter 7

Distribution System Planning

Chapter 7. Distribution System Planning

7.1. Current Status of Distribution System

The distribution system in Zambia comprises the "interconnected system", i.e. the main distribution network, which is connected to the national grid, and the "isolated system", which is fed from stand-alone power stations (diesel or hydro) and is often called "off-grid" system. All the distribution system is owned and operated by ZESCO with some exceptions[23]. The distribution network reaches all of the 9 Provincial Centres and most of the 72 District Centres (BOMAs) countrywide, but the network is still too underdeveloped to cover the villages countrywide.

Distribution network is operated at 33kV and 11kV middle voltages and 400V/230 V low voltage. Total length of 33kV and 11kV lines is 2,245 km and 7,000 km respectively, and detailed facility data (type of support, type of conductor, location of facilities, etc) and operation data is not maintained. In addition, the statistics of 400V/230V lines are not available. Almost all the distribution lines are overhead wires, whereas underground cables are installed in some parts of town centres.

ZESCO has segmented the whole country in four (4) areas called "Divisions", and Division Managers are responsible for the operation and maintenance of distribution lines in their respective area. Under the Divisions, there are 13 Regional Offices whose coverage area roughly corresponds to each Province[24], and under Regional Offices are District Offices that are in charge of forefront operation and maintenance activities.

Table 7-1 ZESCO's Operation and Maintenance Divisions

	Headquarters	Covering Area
Lusaka Division	Lusaka	• Lusaka province (except Luangwa District) • Mumbwa District of Central Province • Siavonga District of Southern Province
Copperbelt Division	Kitwe	• Luanshya, Kitwe, Kalulushi, Mufulira, Chingola & Chiliabombwe Districts of Copperbelt Province
Northern Division	Ndola	• Northern, Luapula & North-Western Provinces • Ndola, Lufwanyama, Masaiti & Mpongwe Districts[25] of Copperbelt Province
Southern Division	Lusaka	• Southern Province (except Siavonga District) • Central Province (except Mumbwa District) • Western & Eastern Provinces

ZESCO has developed distribution network maps, some electronically and some manually, but since not all of them are complete and frequently updated, the JICA Study Team has prepared a map that

[23] Small isolated power network with mini-hydro in remote area owned by private entities (refer to Section 3.3.2).

[24] There are 4 Regional Offices in Lusaka Province and Copperbelt Province has Regional Offices in Kitwe and Ndola, which turns out to be "13 Regional Offices in 9 Provinces". For technical reasons, the covering area of each Regional Office does not necessarily match the area of a Province (some Districts, where distribution lines are not extended from its Provincial centre but from another Province, are administrated by the Regional Office of that Province).

[25] Lufwanyama, Masaiti & Mpongwe Districts used be a part of Ndola District ("Ndola-rural"). Some ZESCO documents still define "Ndola District" as including these four Districts.

covers the complete distribution network countrywide at 11kV and above, based on the information collected from ZESCO's regional offices. GIS Software is used to compile the collected information electronically and to generate a map. The latest output of this GIS map is shown in Figure 13-2.

7.2. Data Collection

The following sections discuss the data that have been collected so far from DoE, REA and ZESCO.

7.2.1. Specification of distribution system

Design standard of transmission and distribution system were developed in 1997, and consists of following items.

- General Parameters
- Monitoring Trip Circuits
- Plant Control
- Multicore Cables in Substations
- System Earthing
- Instruments
- Control, & Relay Panel Wiring & Layout
- System Phasing & Switchgear Phase Marking
- Substation SLDs and Protection Schemes
- Design Philosophy
- Township Electrification

Allowable voltage and conductor sizes for overhead lines prescribed in this standard are as follows.

Table 7-2 ZESCO's Standard on Overhead Distribution Lines

Allowable voltage:	Between -5% to +5%
Conductor size:	ACSR 100mm^2, 200mm^2 and 300mm^2

7.2.2. Unit Cost of Equipment

The list of unit equipment cost provided by ZESCO was the one as of 2000 or 2003. For this Study, the Study Team shall adjust the costs taking into account the price escalation. The unit cost after adjustment is shown in Table 7-3.

Table 7-3 Unit Cost of Equipment

	Item	Unit	Unit Cost
Transmission Line	66 kV Transmission Line	US$/km	40,000
Distribution Line	33 kV Distribution Line (including pole and accessories)	US$/km	36,000
	33/0.4kV Transformer on the pole (100kVA)	US$/Unit	13,700
66/33kV Substation	New substation (2.5MVA)	US$/Unit	600,000
	New substation (5MVA)	US$/Unit	800,000
	New substation (10MVA)	US$/Unit	1,000,000
	New substation (15MVA)	US$/Unit	1,300,000
	33 kV bay	US$/Unit	99,300

7.2.3. Current Distribution Lines Extension Planning

The list of rural electrification projects to be executed in 2006 is shown in Table 3-2, which is publicized by Rural Electrification Authority (REA). All these projects, except for two micro-hydro projects in North-Western Province, deal with either distribution network extension or isolated network with diesel power plant, and are contracted ZESCO. The detailed scope of works of these projects is shown in Table 7-4.

Table 7-4 Rural Electrification Projects slated for 2006 and their Scope of Works

	Project	Scope of Works
Central Province	Mungule's Area-Mungule Clinic and Court and Mutakwa School, Chibombo (Phase I)	● Constructing 13km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Installing 1 X 100kVA, 11/0.4kV pole mounted transformers substations. ● Installing 1 X 50kVA, 11/0.4kV pole mounted transformers substations. ● Constructing 1,630m of 50mm^2 ACSR medium voltage overhead line. ● Providing 23 x standard single phase overhead service connections as follows: a) One (1) for Chieftainess Mungule's palace main house b) Three (3) Chieftainess Mungule's palace, guest & families' houses. c) One (1) Chieftainess Mungule's Palace Courthouse. d) One (1) Chieftainess Mungule's Retainer house. e) One (1) for Mungule's court. f) Four (4) for Mungule's courthouse. g) One (1) for Mungule's clinic block. h) Six (6) for Mungule's staff houses. i) Five (5) for Mutakwa school staff houses. ● Providing 3 x standard single-phase underground service connections as follows. a) One (1) for Chieftainess Mungule's palace borehole b) One (1) for Mungule Clinic borehole c) One (1) for Mutakwa School classroom blocks. ● Carry out internal wiring of Chieftainess Mungule's Palace, Mutakwa School and staff houses, Mungule clinic and staff houses and Mungule court and staff houses.
	Mutombe Basic School, Mumbwa	● Constructing 5km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Installing 1 X 50kVA, 11/0.4kV pole mounted transformers substations. ● Constructing 300m of 50mm^2 ACSR medium voltage overhead line. ● Providing 8 x standard single-phase overhead service connections to staff houses. ● Providing 2 x standard three phase underground service connections to the classroom block and to the school borehole.
	Nambala High School, Mumbwa	● Constructing 15km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Installing 1 X 100kVA, 11/0.4kV pole mounted transformer substation. ● Constructing 800m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Providing 16 X standard single-phase overhead service connections to staff houses for the school and rural health centre. ● Providing 2 X standard three phase underground service connections for the school and rural health centre.
	Serenje's Area-Muzamene Basic School, Serenje	● Tee-off through 20m of 66kV overhead line. ● Establishing a 100kVA, 66/0.4kV pole mounted transformer substation. ● Laying and connecting 30m of 70mm^2 4core PVC medium voltage cable. ● Constructing 500m of medium voltage overhead line. ● Providing 1 x three-phase service connection to Chief Serenje's palace. ● Carrying out internal wiring of Chief Serenje's palace.
Copperbelt Province	Lubendo Basic School, Masaiti	● Constructing 4km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Installing 1 X 25kVA, 11/0.4kV pole mounted transformer substation. ● Laying & connecting 30m of 16mm^2 4core PVC medium voltage cable. ● Providing 1 X standard three-phase underground service connection to Lubendo School. ● Providing 4 X standard single-phase overhead service connections to Lubendo school staff houses.
	Mushili School, Masaiti	● Constructing 8.1km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Installing 1 X 25kVA, 11/0.4kV pole mounted transformer. ● Providing eight standard single-phase overhead service connections.

	Kabushi Township, Ndola (Phase I)	• Reinforcing existing feeder by constructing 6km of 100mm^2 ACSR 11kV overhead line from Mushili substation. • Upgrading existing 1,110m of 25mm^2 ACSR 11kV overhead line to 50mm^2 ACSR three phase three-wire 11kV overhead lines. • Upgrading existing 2 x 50kVA, 11/0.4kV and 3 X 100kVA to 200kVA, 11/0.4kV pole mounted transformer substations. • Constructing 6.5km additional total route length of 50mm^2 ACSR three phase three-wire 11kV overhead line within the township. • Installing 25 X 200kVA, 11/0.4kV pole mounted transformer substations. • Constructing 14.5km of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. • Laying and connecting a total of 540m of 120mm^2 4-core PVC medium voltage cable. • Providing 4500 X single-phase overhead services.
	Kankoyo/Chibolya, Mufulira	• Construction of 1.12km of 50mm^2 ACSR, 11kV overhead line. • Installation of 7 X 200kVA, 11/0.4kV pole mounted transformer substations. • Laying and connecting a total of 320m of 185mm^2 4-core PVC medium voltage cable. • Construction of 7.6km of 100mm^2 ACSR three phase four-wire medium voltage overhead lines. • Providing 820 X standard single-phase services.
Eastern Province	Mphamba Basic School, Lundazi	• Construction of 1.2km of 50mm^2 ACSR11kV overhead line. • Installing a 50kVA, 11/0.4kV transformer. • Constructing 600m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. • Provision of 12 X single-phase overhead services. • Laying and connecting a total of 320m of 185mm^2 4-core PVC medium voltage cable.
	Mtenguleni Areas-Katinta Basic School, Chipungu Rural Health Centre and Chankanga Basic School, Chipata	• Constructing 8km of 100mm^2 ACSR three phase three-wire 11kV overhead lines. • Installing three sets of 11kV drop out fuses at the tee offs. • Installing 2 X 100kVA, 11/0.4kV pole mounted transformers. • Laying and connecting 120m of 70mm^2 4-core PVC medium voltage cable from the pole mounted transformers to the medium voltage lines (2 x 30m per transformer) • Constructing a total of 2050m of 100mm^2 ACSR three phase four-wire MV overhead lines. • Providing 9 X standard single-phase overhead services as follows: 01 to the main arena, 01 school block, 01 VCT building, 04 school staff houses and 02 Chief's structures.
	Ndake Area – Ndake Basic School, Ndake Court House and Ndake Rural Health Centre, Nyimba	• Constructing 7.4km of 100mm^2 ACSR three-phase, three wire, 11kV overhead line. • Installing 100kVA, 11/0.4kV pole mounted transformer. • Laying and connecting 30m of 70mm^2 4core PVC medium voltage cable. • Constructing 1220m of 100mm^2 ACSR three-phase four-wire medium voltage overhead line. • Providing 2 x standard underground services up to 15kVA to the palace and the school. • Providing 13 x standard single-phase overhead services up to 15kVA to eleven (11) teachers' houses, court building and court clerk's house.
	Lumezi, Lundazi	• Survey and pole peg of 35km, 33kV overhead line wayleave. • Bush clear 35km of 33kV overhead line wayleave. • Construct 35km of 50mm^2 ACSR three phase three-wire 33kV overhead lines. • Install 3 X sets 33kV drop out fuses. • Lay and terminate 2 X 30m of 95mm^2 3 core XLPE 33kV copper cables • Install 2 X 500kVA, 33/0.4kV ground mounted transformers. • Lay and terminate 2 X 40m of 185mm^2 4Core PVC medium voltage cable. • Install 1 X 6Way, 1200A feeder Pillar complete with earthing. • Install 1 X 1500A kWh metering.
Luapula Province	Lukwesa High School, Mwense	• Constructing 700m of 50mm^2 ACSR three phase three-wire 33kV overhead lines. • Installing 1 X 25kVA, 33/0.4kV pole mounted transformer substation. • Constructing 450m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. • Providing 10 X standard single-phase overhead service connections to staff houses. • Providing 1 X standard three-phase underground service connections to classroom block.
	Bakashiwa Home Care, Kawambwa	• Constructing 1.7km of 50mm^2 ACSR three phase three-wire 33kV overhead lines. • Installing 1 x 25kVA, 33/0.4kV pole mounted transformer substation. • Laying and connecting 30m of 16mmsq 4-core PVC medium voltage cable. • Providing 1 X standard single-phase underground service connection.
	Schools in Samfya (Nsengaila Basic School)	• Constructing 50m of 50mm^2 ACSR three phase three-wire 33kV overhead lines. • Installing 1 X 25kVA, 33/0.4kV pole mounted transformer substation. • Constructing 300m of 50mm^2 three-phase four-wire medium voltage overhead line. • Providing 6 X standard single-phase overhead service connections.

	(Nshungu Basic School)	• Constructing 400m of 50mm^2 ACSR three phase three-wire 33kV overhead lines. • Installing 1 X 25kVA, 33/0.4kV pole mounted transformer substation. • Constructing 600m of 50mm^2 three-phase four-wire medium voltage overhead line. • Providing 5 X standard single-phase overhead service connections.
	(Mashitolo Basic School)	• Constructing 200m of 50mm^2 ACSR three phase three-wire 33kV overhead lines. • Installing 1 X 25kVA, 33/0.4kV pole mounted transformer. • Constructing 400m of 50mm^2 three-phase four-wire medium voltage overhead line. • Providing 4 X standard single-phase overhead service connections.
	(Mambilima Mwange Basic School)	• Constructing 600m of 50mm^2 ACSR three phase three-wire 33kV overhead lines. • Installing 1 X 25kVA, 33/0.4kV pole mounted transformer substation. • Constructing 400m of 50mm^2 three-phase four-wire medium voltage overhead line. • Providing 5 x standard single-phase overhead service connections. • Constructing 200m of 50mm^2 ACSR three phase three-wire 33kV overhead lines. • Installing 1 X 25kVA, 33/0.4kV pole mounted transformer. • Constructing 400m of 50mm^2 three-phase four-wire medium voltage overhead line. • Providing 4 X standard single-phase overhead service connections.
	Schools in Kawambwa (Lubansa Basic School)	• Constructing 400m of 50mm^2 ACSR three phase three-wire 33kV overhead lines. • Installing 1 X 25kVA, 33/0.4kV pole mounted transformers substations. • Constructing 430m of 50mm^2 three-phase four-wire medium voltage overhead line. • Constructing 100m of 50mm^2 single-phase two-wire low voltage overhead line. • Providing 5 x standard single-phase overhead service connections. • Providing 5 x ready boards.
	(Kalasa Basic School)	• Constructing 400m of 50mm^2 ACSR three phase three-wire 11kV overhead lines. • Constructing 150m of 50mm^2 single-phase two-wire low voltage overhead line. • Providing 8 x standard single-phase overhead service connections.
	Chabilikila Middle Basic School, Nchelenge	• Constructing 100m of 50mm^2 ACSR three-phase three wire, 33kV overhead line. • Installing 50kVA, 33/0.4kV pole mounted transformer. • Laying and connecting 30m of 35mm^2 4core PVC medium voltage cable. • Constructing 400m of 50mm^2 three-phase four-wire medium voltage overhead line. • Providing 2 x standard single-phase overhead services up to the school.
Lusaka Province	Palabana	• Reinforcement of 24km of 50mm^2 ACSR three phase three-wire 11kV line has been done in Palabana area. • Material procurement is in progress for the remaining works.
	Mupelekesi Area-Schools and Rural Health Centres	• Constructing 48km of 50mm^2 ACSR 3phase 3wire 11kV overhead line. • Installing 5 X 50kVA, 11/0.4kV pole mounted transformer substations. • Constructing 1380m of 50mm^2 three-phase four-wire medium voltage overhead line. • Providing a total of 5 X standard three phase overhead services to Mulola, Mpango, Mwapula and Mupelekesi classroom blocks and Mpango clinic respectively. • Providing a total of 24 x standard single-phase overhead services to Mulola, Mpango, Mwapula and Mupelekesi schools and Mpango clinic staff houses.
	Luangwa (Phase I)	• Reinforcement and stabilization of power supply in Luangwa.
North- Western Province	Schools in Solwezi (Kimiteto Primary School)	• Constructing 600m of 50mm^2 ACSR three phase three-wire 11kV overhead lines. • Constructing 950m of 50mm^{2}2 ACSR three phase four-wire medium voltage overhead lines. • Installing 1 X 25kVA, 11/0.4kV pole mounted transformer substation. • Laying and connecting 30m of 35mm^2 4core PVC medium voltage cable. • Providing 11 X standard single-phase overhead services. • Providing 1 X standard three phase overhead service. • Carrying out internal wiring for Kimiteto Primary School and eleven (11) staff houses.
	(Rodwell Mwepu Primary School)	• Constructing 800m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. • Providing 3 X standard single-phase overhead services. • Providing 1 X standard three phase underground service. • Carrying out internal wiring for Rodwell Mwepu Primary School and three (3) staff houses.
	(Kisalala Basic School)	• Constructing 80m of 50mm^2 ACSR three phase three-wire 11kV overhead lines. • Constructing 1150m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. • Installing 1 X 25kVA, 11/0.4kV pole mounted transformer substation. • Laying and connecting 60m of 35mm^2 4 core PVC medium voltage cable • Providing 6 X standard single-phase overhead services. • Providing 1 X standard three phase overhead service. • Carrying out internal wiring for Kisalala School & six (6) staff houses.

	(Tumvwana'nai Basic School)	● Providing 1 standard single-phase overhead service. ● Carrying out internal wiring for Tumvwana'nai Basic School.
	(Kapijimpanga Basic School)	● Constructing 600m of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Constructing 500m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Installing 1 X 25kVA, 11/0.4kV pole mounted transformer substation. ● Laying and connecting 30m of 35mm^2 4core PVC medium voltage cable. ● Providing 9 X standard single-phase overhead services. ● Providing 1 X standard three phase overhead service. ● Carrying out internal wiring for Kapijimpanga Basic School and nine (9) staff houses.
	(Kaimbwe School, Kasempa)	● Constructing 12km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Establishing 1 X 50kVA, 11/0.4kV pole mounted transformer substation. ● Constructing 300m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Providing 9 X single-phase overhead standard service connections. ● Providing 1 X three phase overhead standard service connection.
Northern Province	Chikwanda Basic School, Court House and Rural Health Centre, Mpika	● Constructing 100m of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Establishing 1 X 25kVA, 11/0.4kV pole mounted transformer substation. ● Constructing 350m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Providing 2 X single-phase overhead standard service connections to Chikwanda courthouse and Rural Health Centre. ● Providing 2 X three phase underground standard service connection to Chikwanda's palace and Chikwanda Basic School. ● Carrying out internal wiring of the chief's palace.
	Luwingu High School Cooks Compound, Luwingu	● Establishing 1 X 100kVA, 11/0.4kV pole mounted transformer substation. ● Construction of 950m of 50mm^2 ACSR medium voltage overhead line. ● Providing 45 X single-phase service connections.
	Saili Basic School, Luwingu	● Construction of 600m of 50mm^2 ACSR 11kV overhead line. ● Establishing 1 X 50kVA, 11/0.4kV pole mounted transformer substation. ● Construction of 500m of 50mm^2 ACSR medium voltage overhead line. ● Providing 6 X single-phase service connections.
	Connection of Kaputa District to the Grid (Phase I)	● Construction of 125km of 100mm^2 ACSR three phase wire 33kV overhead line from Mununga to Kaputa. ● Establishment of a 2.5MVA, 33/11kV substation at Kaputa and connecting to the existing 11kV network.
	Waitwika's Area, Nakonde	● Constructing 8km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Establishing 1 X 25kVA, 11/0.4kV pole mounted transformer substation. ● Constructing 300m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Providing 6 X single-phase overhead standard service connections to Chieftainess Waitwika's palace. ● Providing 1 X three phase underground standard service connection to Chieftainess Waitwika's palace. ● Carrying out internal wiring of six structures at chief Waitwika's palace.
	Mpumba Basic School And Court House, Mpika	● Tee-off through 1.8km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Establishing 1 X 25kVA, 11/0.4kV pole mounted transformer substation. ● Constructing 700m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Providing 7 X single-phase overhead standard service connections to Chief Mpumba, Mpumba Basic School and courthouse. ● Carrying out internal wiring of six structures at Chief Mpumba's palace.
	Mulilansolo, Chinsali (Phase I)	● Construction of 45km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Establishing 1 X 500kVA, 11/0.4kV ground mounted transformer substation. ● Construction of 1600m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Providing 10 X single-phase service connections. ● Providing 1 X single-phase service connection.
	Chitimukulu Rural Health Centre, Police, Kapolyo Basic and Kanyanta Basic Schools, Kasama	● Constructing 11.4km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Establishing 1 X 50kVA, 11/0.4kV pole mounted transformer substation. ● Constructing 400m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Laying and connecting 60m of 35mm^2 4-core PVC medium voltage cable. ● Providing 3 X single-phase overhead service connections to the Chiefs Chitimukulu's palace. ● Providing 2 X single-phase overhead service connections to clinic staff houses. ● Providing 1 X three phase overhead service connection to the Clinic. ● Carrying out internal wiring for Chief Chitimukulu's palace.

	Kafwimbi Basic School and Rural Health Centre, Isoka	• Constructing 15km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. • Establishing 1 X 50kVA, 11/0.4kV pole mounted transformer substation. • Constructing 300m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. • Laying and connecting 30m of 35mm^2 4core PVC medium voltage cable. • Providing 6 X single-phase overhead service connections to Chief Kafwimbi's Palace, Basic school and Rural Health Centre. • Providing 2 X three phase overhead service connections to the Clinic and school. • Carrying out internal wiring of six structures at the Chief's palace.
Southern Province	Sianjalika Area– School and Rural Health Centre, Mazabuka	• Construct 4.3km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. • Install 1X 25kVA, 11/0.4kV pole mounted transformer substation. • Laying and connecting 16m of 35mm^2 4core PVC medium voltage line. • Providing 3 X three phase service connections to Chief Sianjalika's Palace, school and Rural Health Centre.
	Sikalongo Mission, Choma	• Construct 21km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. • Install 1 X 25kVA, 11/0.4kV pole mounted transformer substation. • Install 1 X 200kVA, 11/0.4kV pole mounted transformer substation. • Construct 2450m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. • Lay and connect 30m of 185mm^2 PVC Medium voltage cable • Lay and connect 60m of 35mm^2 PVC Medium voltage cable. • Providing 47 X service connections.
	Mwanachingwala –School and Rural Health Centre, Mazabuka	• Install 1 X 50kVA, 11/0.4kV pole mounted transformer substation. • Laying and connecting 35m of 35mm^2 4Core PVC medium voltage line. • Constructing 430m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. • Providing 3 X single-phase service connections to Chief Mwanachingwala's palace. • Providing 1 X three phase service connection to Chief Mwanachingwala's Palace.
	Gwembe Tonga	(Supply to Sianyolo's Area, School and Rural Health Centre – Siavonga) • Providing 16 X single-phase standard services & 1 X three phase standard service.
		(Supply to Simamba's Area and Rural Health Centre – Siavonga) • Providing 12 X single-phase standard services.
		(Supply to Sikongo's Area and School – Siavonga) • Providing 12 X single-phase standard services & 1 X three phase standard overhead service.
		(Supply to Chipepo's Area- Syakalyabanyama –Siavonga) • Providing 16 X single-phase standard services & 1X three-phase standard overhead service.
		(Supply to Chikanta's Area And School – Kalomo) • Providing 8 X standard single-phase overhead services& 1X three phase standard overhead service.
	Schools in Mazabuka (Nansenga Basic School)	• Constructing 100m of 50mm^2 ACSR three phase three-wire 11kV overhead lines. • Establishing 1X25kVA, 11/0.4kV pole mounted transformer substation. • Constructing 250m of 50mm^2 ACSR three phase three-wire medium voltage overhead lines. • Providing 5 X single-phase overhead standard service connections.
	(Mulawo Academic Production Unit (APU))	• Constructing 2km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. • Establishing 1 X 25kVA, 11/0.4kV pole mounted transformer substation. • Constructing 400m of 50mm^2 ACSR three phase three-wire medium voltage overhead lines. • Providing 5 X single-phase overhead standard service connections. • Providing 1 X three phase overhead standard service connection
	(Kaunga Basic School)	• Constructing 2km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. • Establishing 1 X 25kVA, 11/0.4kV pole mounted transformer substation. • Constructing 300m of 50mm^2 ACSR three phase three-wire medium voltage overhead lines. • Providing 5X single-phase overhead standard service connections. • Providing 1 X three phase overhead standard service connection
	(Malala Basic School)	• Constructing 900m of 50mm^2 ACSR three phase three-wire 11kV overhead lines. • Establishing 1X25kVA, 11/0.4kV pole mounted transformer substation. • Constructing 600m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. • Providing 9 X single-phase overhead standard service connections. • Providing 1 X three phase overhead standard service connection
	Choongo's Area – Ntema Basic School, Monze	• Constructing 6.5 km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. • Installing 1 X 25kVA 11/0.4 kV pole mounted transformer substation. • Constructing 1200m of 50mm^2 three-phase four-wire medium voltage overhead line. • Connecting 30m X 35mm^2 4core PVC Medium voltage cable. • Providing 2 X three phase standard overhead service connections to Chief Choongo's area and Ntema Basic School.

Western Province	Shang'ombo District by Diesel Generators	● Construction of the powerhouse building. ● Installation of 2 X 400kVA, 400V diesel generators. ● Establishing 2 X 400kVA, 0.4/11kV ground-mounted transformer substations. ● Construction of 4.6km of 50mm^2 ACSR 3-phase 3-wire 11kV overhead line. ● Installing 2 X 100kVA, 11/0.4kV pole mounted transformer substations. ● Installing 3 X 50kVA, 11/0.4kV pole mounted transformer substations. ● Laying and connecting 4 X 30m of 70mm^2 4core PVC medium voltage cable. ● Laying and connecting 4 X 30m of 35mm^2 4core PVC medium voltage cable. ● Construction of 5,950m of 50mm^2 ACSR medium voltage line. ● Provision of 102 X single-phase service connections. ● Provision of 6 X three phase service connections.
	Luampa Mission	● Construction of part of 54km of 100mm^2 ACSR 33kV overhead line.
	Kalabo Basic School & Kalabo Training Centre, Kalabo	● Constructing 1.5km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Installing 2 X 25kVA, 11/0.4kV pole mounted transformer substations. ● Constructing 800m of 50mm^2 ACSR medium voltage overhead line. ● Providing 13 x standard single-phase overhead service connections to staff houses. ● Providing 2 X standard three phase underground service connections to classroom block at Kalabo Basic School and Kalabo Farm Training Centre.
	Mwandi Basic School, Royal Court and Market, Sesheke	● Installing 1 X 25kVA, 11/0.4kV pole mounted transformers substation. ● Constructing 700m of 50mm^2 medium voltage overhead line. ● Providing 10 x standard single-phase overhead service connections to staff houses for school and court. ● Providing 1 x standard three phase underground service connections to classroom block at Mwandi Basic School.
	Lukulu	● Refurbishment of generator set

7.3. Review of Existing Distribution Extension Plans

As observed in Table 7-4, most of the on-going rural electrification projects are relatively small-scaled ones that simply consist of the construction of short-span distribution lines and the installation of on-site transformers, and the projects' target of electrification is limited to public facilities such as schools, hospitals, as well as chief's palaces in some projects. On top of that, not all the projects in the list literally deal with "rural electrification", since two projects in Copperbelt Province, namely "Kabushi" and "Kankoyo", obviously have their objective rather strengthening electricity supply in urban area. In short, clear and long-term aspects in planning rural electrification projects don't appear to exist, though each individual project may have its reason to be implemented.

7.4. Preliminary Study for Planning Distribution Line Extension

This section explains how to proceed with the planning of distribution line extension projects as preliminary deskwork before the field study.

7.4.1. Assumptions of Distribution System Expansion Planning

As existing distribution system is spreading dispersedly as observed in Figure 13-2, not many Rural Growth Centres (RGCs) in remote areas (e.g. Eastern, Northern, Luapula, North-Western and Western Provinces) are easily accessible from existing distribution lines while RGCs in Copperbelt, Lusaka, Central and Southern Provinces are relatively close to existing lines. Main scope of works of rural electrification projects is the extension of 33 kV and 11 kV overhead lines with 50 mm^2 or 100 mm^2 ACSR. Based on these preconditions, together with the information obtained through the interviews with ZESCO staff, the Study Team applies the following assumptions in planning distribution network expansion from existing substation including construction of bulky substation.

- Applying 33kV and ACSR100mm^2 lines shall be considered in this study, taking into account minimizing the voltage drop on long-span distribution lines.
- Because of the demand increase in electrified RGC and capacity limitation of existing lines, T-off and/or Extension from existing lines shall not be considered.
- In case the capacity of one circuit is not enough to cover the increasing power load, addition of one more circuit shall be constructed instead of increasing the conductor size of existing lines.
- Distribution routes shall be constructed alongside the public roads taking into account the easiness of construction works and maintenance.
- Step Voltage Regulator (SVR) shall not be applied in this study, because SVR has not been used so far in Zambia.
- Demand growth up to the year 2030 shall be considered.
- Transformer capacity of 100kVA shall be applied. In other words, the number of necessary transformers is calculated by dividing the demand of RGC by 100kVA. The 20% capacity margin shall be considered in determining transformer capacity.
- When electrifying a candidate RGC with high priority, RGCs with lower priority that are positioned between the target RGC and the existing distribution line (or substation) shall be electrified as well.

7.4.2. Flowchart of the Study

Figure 7-1 shows the flowchart of the study that visualized the above-mentioned assumptions.

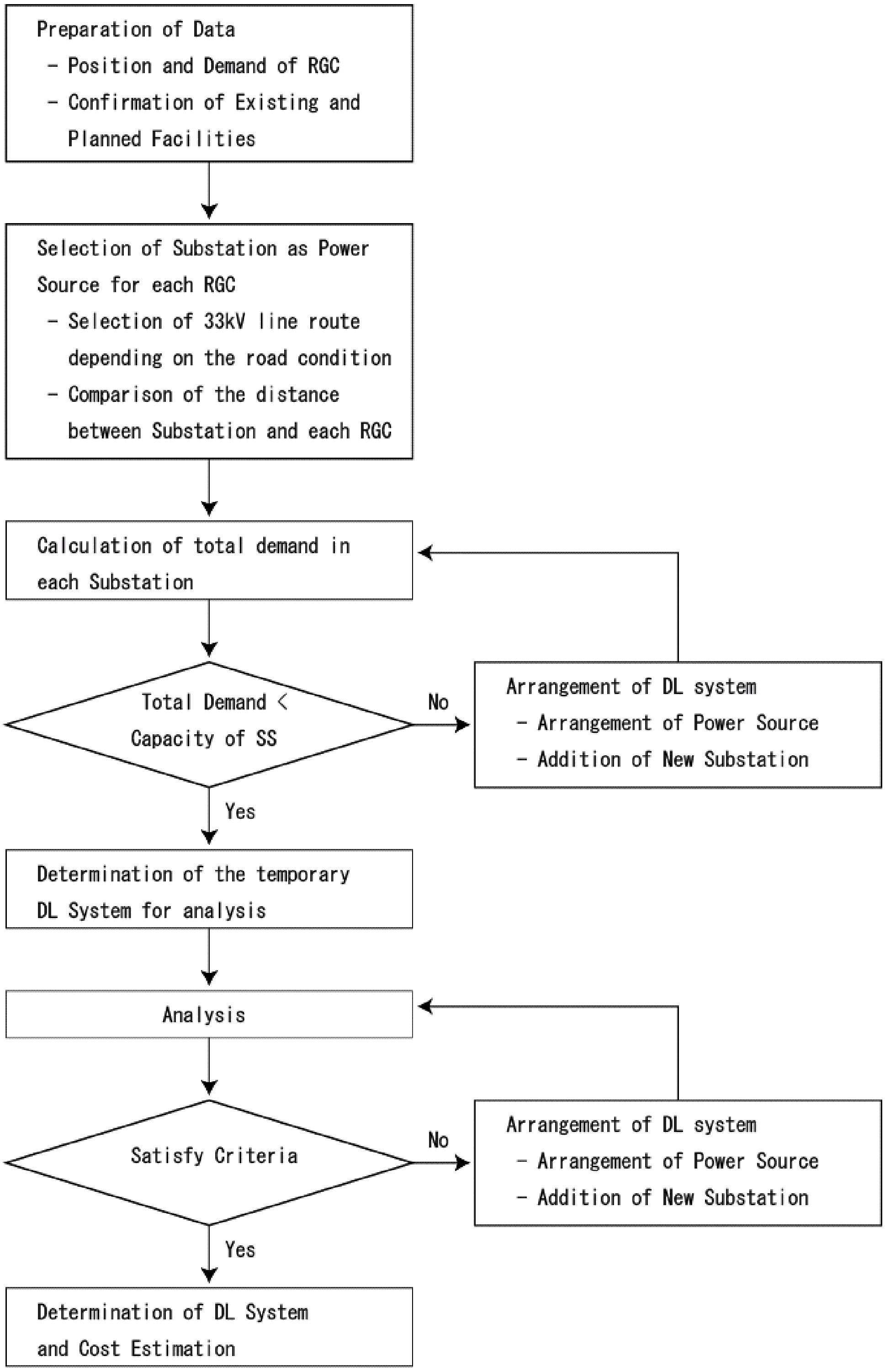


Figure 7-1 Flowchart of the Study

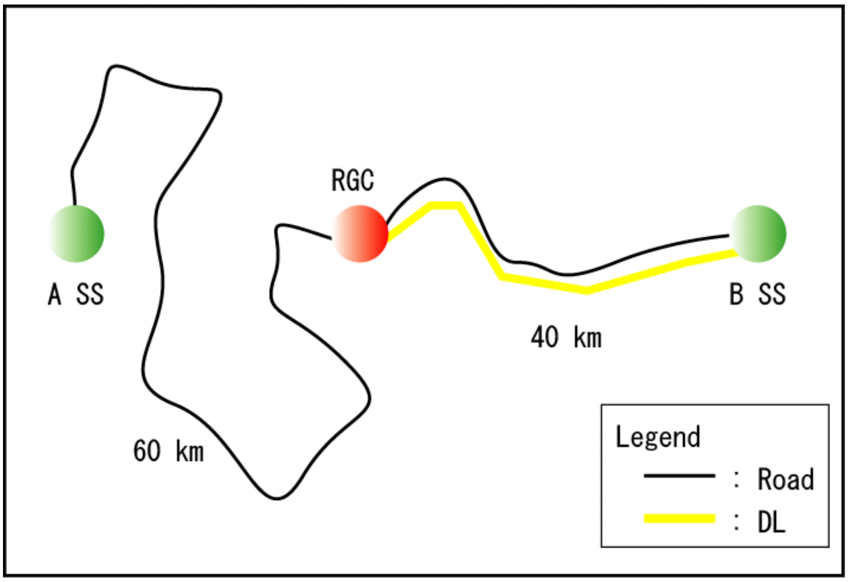
7.4.3. Result of the Study

(1) Data Collection

Demand and Priority of RGC is shown in Table 5-11. The position of RGC was input on the GIS map based on the data obtained from each district's representative and REA. In addition, existing distribution facility data was also input confirming with ZESCO.

(2) Selection of Power Source and Result of Analysis

Comparing with the distance between each RGC and near substations, the nearest substation was selected as a power source. Below figure is example. Although the direct distance between a substation and RGC is shorter than the direct distance between B substation and RGC, actual distance between B substation and RGC is shorter. Therefore, the electric power for this RGC should be supplied from B substation.



As a result of selection of power source based on the above-mentioned rule, the total demand of some substations became very large. Therefore, it was necessary to arrange the demand and/or add the new substation.

Based on the above distribution system, power flow and voltage analysis of each distribution line was carried out. The condition and model for analysis was shown in Table 7-5 and Figure 7-2 respectively.

Table 7-5 Condition for Analysis

Voltage		33 kV
Specification of Conductor	Conductor size	100 mm^2
	Capacity of conductor	313 A
	R	0.323
	X	0.349
	Y	3.147×10^{-6}
Power factor		0.85

$$\dot{V}s = Vr + \dot{Z}\left(\dot{I}r + \frac{\dot{Y}Vr}{2}\right)$$

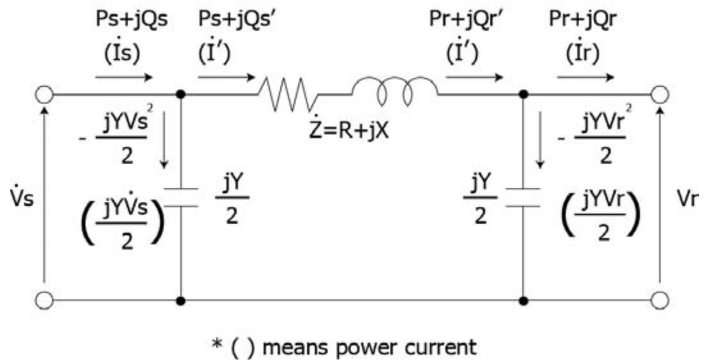


Figure 7-2 Model and Formula for Analysis

As a result of analysis, there were large voltage drop in some distribution lines, and it was necessary to add new substations. The total demand supplied from each substation, the number of RGC and the number of feeder is shown in Table 7-6-1 - 7-6-3.

The maps of each distribution line route are attached Appendix B, and the results of voltage analysis for each package of distribution line are attached Appendix C.

Table 7-6-1 Total Demand and Number of RGC (Existing SS)

Province	Substation	Total Demand (kW)	# of RGC	# of feeder
Central	Kabwe	7,257	15	2
	Fig Tree	2,053	10	1
	Kapiri Mposhi	12,703	10	2
	Mkushi	3,502	12	1
	Mkushi Farm Block	3,234	12	1
	Mumbwa	8,583	18	3
	Pensulo	520	1	1
	Nampundwe	5,291	10	1
	Serenje	2,039	4	1
Copperbelt	Kansunswa	10,115	9	1
	Kitwe	8,555	28	3
	Luano	5,063	12	2
	Maposa	6,317	16	2
	Mpongwe	5,970	29	3
	Ndola	4,180	6	1
Eastern	Azele	10,573	4	2
	Chipata	10,097	15	2
	Lundazi	11,919	19	3
	Msoro	1,328	2	1
Luapula	Chipili	3,878	12	2
	Kawambwa Tea	3,702	9	1
	Mansa	1,572	19	2
	Mbereshi	6,835	13	2
	Nchelenge	7,877	18	2
	Samfya	1,251	3	1

Province	Substation	Total Demand (kW)	# of RGC	# of feeder
Lusaka	Coventry	1,678	8	1
	Kafwe Town	936	3	1
	Leopard's Hill	3,669	13	1
Northwestern	Kasempa	2,620	18	2
	Solwezi	6,947	14	3
Northern	Chinsali	3,462	28	3
	Isoka	8,837	11	3
	Kasama	6,843	22	2
	Luwingu	12,039	22	3
	Mbala	7,557	26	2
	Mfuwe	4,293	4	1
	Mpika	5,679	11	3
	Mporokoso	8,938	13	2
	Nakonde	3,848	10	1
Southern	Chilundu	3,384	17	2
	Maamba	2,021	14	1
	Mazabuka	1,756	7	1
	Muzuma	2,711	11	3
	Sinazongwe	2,548	22	1
	Victoria Falls	4,440	33	3
西部	Kalabo	11,894	37	3
	Kaoma	11,360	40	4
	Mongu	9,754	14	2
	Senanga	11,974	9	3
	Sesheke	3,808	6	1
Total		287,410	719	95

Table 7-6-2 Total Demand and Number of RGC (Proposed SS by ZESCO)

Province	Substation	Total Demand (kW)	# of RGC	# of feeder
Eastern	New SS at Chama	4,707	11	2
	New SS at Nyimba	1,120	14	1
Lusaka	New SS at Chilundu	5,013	16	2
Northwestern	New SS at Chavuma	1,335	13	1
	New SS at Kabompo	7,116	14	2
	New SS at Mufumbwe	3,570	14	1
	New SS at Mumbezi	1,333	4	1
	New SS at Mwinilunga	6,323	16	3
	New SS at Zambezi	6,686	17	2
Western	New SS at Lukulu	7,631	17	2
Total		44,834	136	17

Table 7-6-3 Total Demand and Number of RGC (Proposed SS by Consultant)

Province	Substation	Total Demand (kW)	# of RGC	# of feeder
Central	Pensulo 1	6,522	10	2
	Pensulo 2	8,247	15	2
	Kabwe 1	4,226	3	1
	Kabwe 2	5,538	4	1
Copperbelt	Luano 1	3,457	16	2
	Luano 2	3,695	9	1
	Ndola 1	6,773	4	1
Eastern	Azele 1	12,201	10	2
	Azele 2	12,082	6	2
	Azele 3	10,217	3	2
	Azele 4	12,327	9	2
	Azele 5	11,154	4	1
	Azele 6	5,392	11	2
	Lundazi 1	2,728	3	1
	Mfuwe 1	3,172	7	1
Luapula	Mbereshi 1	9,933	17	2
	Nchelenge 1	6,954	12	2
	Samfya 1	5,742	10	2
	Samfya 2	6,110	8	2
Northwestern	Mwinilunga 1	3,530	5	1
	Zambezi 1	2,891	6	1

Province	Substation	Total Demand (kW)	# of RGC	# of feeder
Northern	Isoka 1	6,550	3	3
	Kasama 1	6,531	4	1
	Kasama 2	6,484	4	1
	Luwingu 1	5,791	5	1
	Luwingu 2	11,262	13	2
	Luwingu 3	7,391	12	2
	Mpika 1	7,201	8	2
	Mpika 2	3,126	3	1
Southern	Mazabuka 1	7,348	31	3
	Muzuma 1	8,996	19	3
	Muzuma 2	7,578	9	2
	Muzuma 3	6,250	10	2
Western	Mongu 1	11,888	20	2
	Mongu 2	13,149	10	2
	Senanga 1	6,156	5	1
	Senanga 2	4,038	6	2
	Senanga 3	10,275	10	2
	Sesheke 1	3,025	8	1
	Sesheke 2	3,010	9	1
Total		278,940	361	67

7.5. Cost Estimate for Distribution Line Extension

7.5.1. Condition

In case the distribution line is constructed from existing substation, following items should be considered to estimate the amount of equipment.

- Actual distance of distribution line between existing substation and RGC
- The number of transformer on the pole
- The number of bay

In case the distribution line is constructed from new substation, following items should be considered to estimate the amount of equipment.

- Distance of transmission line between existing substation and new substation
- Actual distance of distribution line between new substation and RGC
- The number of transformer on the pole
- New substation depending on the total demand of related RGCs

The capacity of substation should be selected following the below table. (e.g. If total demand of substation is 4.5MW, 10MVA capacity should be selected.)

Capacity of Substation (MVA)	Power Factor of Distribution Line	Capacity of Substation (MW)
2.5	0.85	2.125
5		4.25
10		8.5
15		12.75

Cost estimation shall be carried out depending on the above-mentioned amount and unit cost obtained from ZESCO. Cost shall be divided into foreign currency (material cost) and local currency (material cost, transport cost, overhead cost, labour cost) based on the following table obtained from ZESCO.

Item		Breakdown
F.C.	Material Cost	80.166747 %
L.C.	Material Cost, Transportation Cost, Overhead Cost	11.816629 %
	Skilled Labour	3.20667 %
	Unskilled Labour	4.810005 %

7.5.2. Result of Cost Estimation

Amount of facility and the result of cost estimation are shown in table 7-7-1 – 7-7-3. If all RGCs are electrified by distribution lines, total cost will be approximately 1,180 million USD.

Table 7-7-1 Result of Cost Estimation in each Package (Existing Substation)

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Azele	1	1 − 1	20	33	1	1,019,240	150,237	40,770	61,154	1,271,400
		1 − 2	23	41	1	1,193,683	175,950	47,747	71,621	1,489,000
	2	2 − 1	5	67	1	959,756	141,469	38,390	57,585	1,197,200
		2 − 2	13	87	1	1,410,293	207,878	56,412	84,618	1,759,200
Chilundu	1	1 − 1	34	9	1	1,159,692	170,939	46,388	69,582	1,446,600
		1 − 2	62	14	1	2,022,687	298,145	80,907	121,361	2,523,100
		1 − 3	76	20	1	2,492,625	367,414	99,705	149,557	3,109,300
		1 − 4	92	22	1	2,976,351	438,716	119,054	178,581	3,712,700
	2	2 − 1	85	8	1	2,620,571	386,274	104,823	157,234	3,268,900
		2 − 2	125	12	1	3,818,903	562,909	152,756	229,134	4,763,700
		2 − 3	155	16	1	4,728,636	697,004	189,145	283,718	5,898,500
		2 − 4	171	19	1	5,223,345	769,924	208,934	313,401	6,515,600
		2 − 5	188	22	1	5,746,914	847,099	229,877	344,815	7,168,700
		2 − 6	199	24	1	6,086,340	897,130	243,454	365,180	7,592,100
		2 − 7	204	25	1	6,241,623	920,019	249,665	374,497	7,785,800
		2 − 8	212	26	1	6,483,486	955,670	259,339	389,009	8,087,500
Chinsali	1	1 − 1	137	12	1	4,165,224	613,957	166,609	249,913	5,195,700
		1 − 2	198	16	1	5,969,617	879,925	238,785	358,177	7,446,500
		1 − 3	233	20	1	7,023,649	1,035,290	280,946	421,419	8,761,300
		1 − 4	239	22	1	7,218,775	1,064,052	288,751	433,127	9,004,700
	2	2 − 1	24	6	1	838,143	123,543	33,526	50,289	1,045,500
		2 − 2	58	14	1	1,907,247	281,129	76,290	114,435	2,379,100
		2 − 3	94	16	1	2,968,174	437,511	118,727	178,090	3,702,500
		2 − 4	99	18	1	3,134,440	462,018	125,378	188,066	3,909,900
		2 − 5	118	20	1	3,704,746	546,082	148,190	222,285	4,621,300
		2 − 6	139	21	1	4,321,789	637,034	172,872	259,307	5,391,000
	3	3 − 1	14	4	1	527,577	77,765	21,103	31,655	658,100
		3 − 2	77	7	1	2,378,708	350,623	95,148	142,722	2,967,200
		3 − 3	82	9	1	2,544,974	375,131	101,799	152,698	3,174,600
		3 − 4	89	10	1	2,757,977	406,527	110,319	165,479	3,440,300

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Chipata	1	1 － 1	72	11	1	2,278,339	335,829	91,134	136,700	2,842,000
		1 － 2	116	29	1	3,745,871	552,144	149,835	224,752	4,672,600
		1 － 3	122	34	1	3,973,946	585,762	158,958	238,437	4,957,100
		1 － 4	139	37	1	4,497,515	662,937	179,901	269,851	5,610,200
		1 － 5	186	39	1	5,875,902	866,112	235,036	352,554	7,329,600
		1 － 6	194	41	1	6,128,748	903,381	245,150	367,725	7,645,000
	2	2 － 1	62	81	1	2,758,538	406,610	110,342	165,512	3,441,000
		2 － 2	75	85	1	3,177,650	468,388	127,106	190,659	3,963,800
		2 － 3	92	88	1	3,701,219	545,562	148,049	222,073	4,616,900
Chipili	1	1 － 1	48	14	1	1,618,647	238,590	64,746	97,119	2,019,100
		1 － 2	57	19	1	1,933,301	284,970	77,332	115,998	2,411,600
		1 － 3	81	23	1	2,669,873	393,541	106,795	160,192	3,330,400
		1 － 4	99	26	1	3,222,302	474,969	128,892	193,338	4,019,500
		1 － 5	125	27	1	3,983,646	587,192	159,346	239,019	4,969,200
	2	2 － 1	184	21	1	5,620,491	828,464	224,820	337,229	7,011,000
		2 － 2	198	23	1	6,046,497	891,257	241,860	362,790	7,542,400
		2 － 3	211	24	1	6,432,660	948,178	257,306	385,960	8,024,100
		2 － 4	243	25	1	7,367,164	1,085,925	294,687	442,030	9,189,800
Coventry	1	1 － 1	39	6	1	1,271,044	187,353	50,842	76,263	1,585,500
		1 － 2	88	18	1	2,816,979	415,225	112,679	169,019	3,513,900
		1 － 3	124	21	1	3,888,889	573,225	155,556	233,333	4,851,000
		1 － 4	129	22	1	4,044,172	596,113	161,767	242,650	5,044,700
		1 － 5	141	23	1	4,401,475	648,780	176,059	264,089	5,490,400
Fig Tree	1	1 － 1	70	6	1	2,165,705	319,226	86,628	129,942	2,701,500
		1 － 2	95	12	1	2,953,102	435,289	118,124	177,186	3,683,700
		1 － 3	132	16	1	4,064,855	599,162	162,594	243,891	5,070,500
		1 － 4	151	21	1	4,668,110	688,082	186,724	280,087	5,823,000
		1 － 5	168	24	1	5,191,679	765,257	207,667	311,501	6,476,100
		1 － 6	175	26	1	5,415,665	798,272	216,627	324,940	6,755,500
		1 － 7	195	28	1	6,014,831	886,590	240,593	360,890	7,502,900
		1 － 8	206	29	1	6,343,274	935,003	253,731	380,596	7,912,600

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Isoka	1	1 − 1	2	33	1	499,760	73,665	19,990	29,986	623,400
		1 − 2	60	39	1	2,239,538	330,109	89,582	134,372	2,793,600
		1 − 3	73	40	1	2,625,701	387,030	105,028	157,542	3,275,300
	2	2 − 1	10	17	1	554,914	81,795	22,197	33,295	692,200
		2 − 2	34	20	1	1,280,503	188,747	51,220	76,830	1,597,300
		2 − 3	43	22	1	1,562,209	230,271	62,488	93,733	1,948,700
		2 − 4	113	26	1	3,626,343	534,525	145,054	217,581	4,523,500
		2 − 5	147	27	1	4,618,567	680,780	184,743	277,114	5,761,200
	3	3 − 1	39	29	1	1,523,649	224,587	60,946	91,419	1,900,600
		3 − 2	102	45	1	3,517,557	518,490	140,702	211,053	4,387,800
Kabwe	1	1 − 1	16	11	1	662,177	97,605	26,487	39,731	826,000
		1 − 2	91	18	1	2,903,559	427,986	116,142	174,214	3,621,900
		1 − 3	120	24	1	3,806,397	561,065	152,256	228,384	4,748,100
		1 − 4	126	28	1	4,023,489	593,065	160,940	241,409	5,018,900
		1 − 5	146	32	1	4,644,621	684,620	185,785	278,677	5,793,700
		1 − 6	150	35	1	4,793,009	706,493	191,720	287,581	5,978,800
		1 − 7	154	38	1	4,941,398	728,365	197,656	296,484	6,163,900
	2	2 − 1	26	16	1	1,005,692	148,240	40,228	60,342	1,254,500
		2 − 2	29	27	1	1,213,083	178,809	48,523	72,785	1,513,200
		2 − 3	48	38	1	1,882,235	277,443	75,289	112,934	2,347,900
		2 − 4	117	48	1	3,983,405	587,156	159,336	239,004	4,968,900
		2 − 5	137	54	1	4,626,503	681,949	185,060	277,590	5,771,100
		2 − 6	165	56	1	5,456,550	804,299	218,262	327,393	6,806,500
Kafwe Town	1	1 − 1	8	7	1	387,366	57,098	15,495	23,242	483,200
		1 − 2	25	10	1	910,935	134,272	36,437	54,656	1,136,300
		1 − 3	33	13	1	1,174,764	173,161	46,991	70,486	1,465,400

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Kalabo	1	1 − 1	40	28	1	1,541,526	227,222	61,661	92,492	1,922,900
		1 − 2	79	48	1	2,886,724	425,505	115,469	173,203	3,600,900
		1 − 3	132	59	1	4,537,117	668,774	181,485	272,227	5,659,600
		1 − 4	167	62	1	5,580,167	822,520	223,207	334,810	6,960,700
		1 − 5	208	66	1	6,807,359	1,003,409	272,294	408,442	8,491,500
		1 − 6	219	67	1	7,135,802	1,051,822	285,432	428,148	8,901,200
		1 − 7	227	68	1	7,377,666	1,087,473	295,107	442,660	9,202,900
	2	2 − 1	59	24	1	2,045,936	301,572	81,837	122,756	2,552,100
		2 − 2	107	29	1	3,486,131	513,858	139,445	209,168	4,348,600
		2 − 3	111	30	1	3,612,554	532,493	144,502	216,753	4,506,300
	3	3 − 1	74	19	1	2,423,922	357,288	96,957	145,435	3,023,600
		3 − 2	279	38	1	8,548,902	1,260,113	341,956	512,934	10,663,900
		3 − 3	364	44	1	11,067,901	1,631,416	442,716	664,074	13,806,100
		3 − 4	383	50	1	11,682,139	1,721,955	467,286	700,928	14,572,300
		3 − 5	389	56	1	11,921,196	1,757,192	476,848	715,272	14,870,500
		3 − 6	470	60	1	14,302,790	2,108,240	572,112	858,167	17,841,300
		3 − 7	494	62	1	15,017,396	2,213,574	600,696	901,044	18,732,700
		3 − 8	512	63	1	15,547,860	2,291,764	621,914	932,872	19,394,400
Kansunswa	1	1 − 1	14	33	1	846,080	124,713	33,843	50,765	1,055,400
		1 − 2	25	66	1	1,525,974	224,930	61,039	91,558	1,903,500
		1 − 3	32	86	1	1,947,651	287,085	77,906	116,859	2,429,500
		1 − 4	39	99	1	2,292,448	337,908	91,698	137,547	2,859,600
		1 − 5	46	109	1	2,604,297	383,875	104,172	156,258	3,248,600
		1 − 6	48	119	1	2,771,845	408,572	110,874	166,311	3,457,600
		1 − 7	61	123	1	3,190,957	470,349	127,638	191,457	3,980,400
		1 − 8	66	125	1	3,357,223	494,857	134,289	201,433	4,187,800

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Kaoma	1	1 − 1	55	21	1	1,897,547	279,700	75,902	113,853	2,367,000
		1 − 2	78	27	1	2,627,225	387,255	105,089	157,633	3,277,200
		1 − 3	136	30	1	4,334,055	638,842	173,362	260,043	5,406,300
		1 − 4	161	32	1	5,077,521	748,430	203,101	304,651	6,333,700
		1 − 5	166	34	1	5,243,787	772,938	209,751	314,627	6,541,100
		1 − 6	179	36	1	5,640,933	831,477	225,637	338,456	7,036,500
		1 − 7	201	38	1	6,297,819	928,303	251,913	377,869	7,855,900
		1 − 8	206	39	1	6,453,102	951,191	258,124	387,186	8,049,600
		1 − 9	210	40	1	6,579,525	969,826	263,181	394,772	8,207,300
	2	2 − 1	55	15	1	1,831,650	269,986	73,266	109,899	2,284,800
		2 − 2	144	28	1	4,542,969	669,637	181,719	272,578	5,666,900
		2 − 3	194	36	1	6,073,834	895,287	242,953	364,430	7,576,500
		2 − 4	245	40	1	7,589,626	1,118,716	303,585	455,378	9,467,300
		2 − 5	294	41	1	9,014,751	1,328,780	360,590	540,885	11,245,000
		2 − 6	305	42	1	9,343,194	1,377,193	373,728	560,592	11,654,700
		2 − 7	357	44	1	10,865,881	1,601,638	434,635	651,953	13,554,100
	3	3 − 1	177	24	1	5,451,419	803,543	218,057	327,085	6,800,100
		3 − 2	250	30	1	7,624,098	1,123,797	304,964	457,446	9,510,300
		3 − 3	260	32	1	7,934,664	1,169,574	317,387	476,080	9,897,700
	4	4 − 1	13	19	1	663,460	97,794	26,538	39,808	827,600
		4 − 2	71	34	1	2,502,084	368,809	100,083	150,125	3,121,100
		4 − 3	99	37	1	3,343,114	492,777	133,725	200,587	4,170,200
Kapiri Mposhi	1	1 − 1	51	13	1	1,694,244	249,733	67,770	101,655	2,113,400
		1 − 2	62	21	1	2,099,567	309,478	83,983	125,974	2,619,000
		1 − 3	98	28	1	3,215,408	473,953	128,616	192,924	4,010,900
		1 − 4	109	35	1	3,609,748	532,079	144,390	216,585	4,502,800
		1 − 5	113	42	1	3,802,068	560,427	152,083	228,124	4,742,700
		1 − 6	120	49	1	4,080,968	601,537	163,239	244,858	5,090,600
		1 − 7	145	52	1	4,835,418	712,744	193,417	290,125	6,031,700
	2	2 − 1	10	98	1	1,444,525	212,924	57,781	86,671	1,801,900
		2 − 2	26	107	1	2,005,131	295,558	80,205	120,308	2,501,200

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Kasama	1	1 − 1	11	8	1	484,929	71,479	19,397	29,096	604,900
		1 − 2	45	15	1	1,543,050	227,446	61,722	92,583	1,924,800
		1 − 3	64	20	1	2,146,304	316,367	85,852	128,778	2,677,300
		1 − 4	129	23	1	4,055,155	597,732	162,206	243,309	5,058,400
		1 − 5	140	26	1	4,405,564	649,383	176,223	264,334	5,495,500
		1 − 6	223	34	1	6,888,809	1,015,415	275,552	413,329	8,593,100
		1 − 7	260	36	1	7,978,595	1,176,050	319,144	478,716	9,952,500
		1 − 8	271	38	1	8,318,022	1,226,082	332,721	499,081	10,375,900
		1 − 9	277	40	1	8,513,147	1,254,843	340,526	510,789	10,619,300
		1 − 10	305	41	1	9,332,211	1,375,574	373,288	559,933	11,641,000
		1 − 11	307	42	1	9,400,914	1,385,701	376,037	564,055	11,726,700
		1 − 12	320	43	1	9,787,077	1,442,621	391,483	587,225	12,208,400
	2	2 − 1	58	19	1	1,962,161	289,224	78,486	117,730	2,447,600
		2 − 2	74	28	1	2,522,767	371,857	100,911	151,366	3,146,900
		2 − 3	83	35	1	2,859,388	421,476	114,376	171,563	3,566,800
		2 − 4	148	44	1	4,834,135	712,555	193,365	290,048	6,030,100
		2 − 5	161	48	1	5,253,247	774,332	210,130	315,195	6,552,900
Kasempa	1	1 − 1	19	2	1	649,912	95,797	25,996	38,995	810,700
		1 − 2	34	4	1	1,104,778	162,845	44,191	66,287	1,378,100
		1 − 3	67	6	1	2,079,125	306,464	83,165	124,747	2,593,500
		1 − 4	76	8	1	2,360,831	347,988	94,433	141,650	2,944,900
		1 − 5	125	10	1	3,796,938	559,671	151,878	227,816	4,736,300
		1 − 6	130	12	1	3,963,203	584,179	158,528	237,792	4,943,700
		1 − 7	145	14	1	4,418,070	651,226	176,723	265,084	5,511,100
		1 − 8	199	16	1	5,998,477	884,179	239,939	359,909	7,482,500
	2	2 − 1	91	13	1	2,848,645	419,892	113,946	170,919	3,553,400
		2 − 2	133	16	1	4,093,715	603,416	163,749	245,623	5,106,500
		2 − 3	150	18	1	4,606,301	678,972	184,252	276,378	5,745,900
		2 − 4	159	20	1	4,888,007	720,495	195,520	293,280	6,097,300
		2 − 5	237	23	1	7,172,038	1,057,163	286,882	430,322	8,946,400

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL (36,000)	33/0.4 Tr 100kVA (13,700)	33kV Bay Extension (99,300)	Foreign Costs (0.80166747)	Domestic Costs (0.11816629)	Skilled Labor (0.0320667)	Unskilled Labor (0.04810005)	
Kawambwa Tea	1	1 − 1	34	22	1	1,302,469	191,985	52,099	78,148	1,624,700
		1 − 2	83	30	1	2,804,473	413,381	112,179	168,268	3,498,300
		1 − 3	85	36	1	2,928,090	431,602	117,124	175,685	3,652,500
		1 − 4	91	39	1	3,134,199	461,983	125,368	188,052	3,909,600
		1 − 5	99	42	1	3,398,028	500,871	135,921	203,882	4,238,700
		1 − 6	109	44	1	3,708,594	546,649	148,344	222,516	4,626,100
		1 − 7	128	46	1	4,278,900	630,713	171,156	256,734	5,337,500
		1 − 8	148	47	1	4,867,084	717,411	194,683	292,025	6,071,200
Kitwe	1	1 − 1	23	31	1	1,083,854	159,761	43,354	65,031	1,352,000
		1 − 2	29	36	1	1,311,929	193,379	52,477	78,716	1,636,500
		1 − 3	40	41	1	1,684,303	248,267	67,372	101,058	2,101,000
		1 − 4	54	44	1	2,121,292	312,680	84,852	127,278	2,646,100
	2	2 − 1	33	12	1	1,163,781	171,542	46,551	69,827	1,451,700
		2 − 2	56	26	1	1,981,321	292,048	79,253	118,879	2,471,500
		2 − 3	61	30	1	2,169,553	319,793	86,782	130,173	2,706,300
		2 − 4	69	32	1	2,422,399	357,063	96,896	145,344	3,021,700
		2 − 5	75	33	1	2,606,542	384,206	104,262	156,393	3,251,400
	3	3 − 1	75	13	1	2,386,885	351,828	95,475	143,213	2,977,400
		3 − 2	89	22	1	2,889,771	425,954	115,591	173,386	3,604,700
		3 − 3	91	27	1	3,002,405	442,556	120,096	180,144	3,745,200
		3 − 4	94	30	1	3,121,934	460,175	124,877	187,316	3,894,300
		3 − 5	120	33	1	3,905,243	575,635	156,210	234,315	4,871,400
		3 − 6	154	36	1	4,919,432	725,127	196,777	295,166	6,136,500
		3 − 7	156	38	1	4,999,118	736,873	199,965	299,947	6,235,900
		3 − 8	160	40	1	5,136,524	757,127	205,461	308,191	6,407,300
		3 − 9	178	42	1	5,677,970	836,936	227,119	340,678	7,082,700

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Leopard's Hill	1	1 − 1	66	14	1	2,138,127	315,161	85,525	128,288	2,667,100
		1 − 2	98	19	1	3,116,562	459,383	124,663	186,994	3,887,600
		1 − 3	118	24	1	3,748,677	552,557	149,947	224,921	4,676,100
		1 − 4	123	29	1	3,947,892	581,922	157,916	236,874	4,924,600
		1 − 5	179	33	1	5,607,985	826,620	224,319	336,479	6,995,400
		1 − 6	223	37	1	6,921,757	1,020,271	276,870	415,305	8,634,200
		1 − 7	233	41	1	7,254,289	1,069,287	290,172	435,257	9,049,000
		1 − 8	265	44	1	8,210,758	1,210,271	328,430	492,646	10,242,100
		1 − 9	284	46	1	8,781,065	1,294,334	351,243	526,864	10,953,500
		1 − 10	304	48	1	9,380,231	1,382,652	375,209	562,814	11,700,900
		1 − 11	309	50	1	9,546,497	1,407,160	381,860	572,790	11,908,300
Luano	1	1 − 1	22	13	1	857,303	126,367	34,292	51,438	1,069,400
		1 − 2	32	24	1	1,266,715	186,715	50,669	76,003	1,580,100
		1 − 3	48	28	1	1,772,407	261,254	70,896	106,344	2,210,900
		1 − 4	73	30	1	2,515,873	370,841	100,635	150,952	3,138,300
	2	2 − 1	13	15	1	619,529	91,319	24,781	37,172	772,800
		2 − 2	31	22	1	1,215,889	179,223	48,636	72,953	1,516,700
		2 − 3	42	25	1	1,566,298	230,873	62,652	93,978	1,953,800
		2 − 4	57	31	1	2,065,095	304,396	82,604	123,906	2,576,000
		2 − 5	83	33	1	2,837,422	418,238	113,497	170,245	3,539,400
		2 − 6	93	35	1	3,147,988	464,015	125,920	188,879	3,926,800

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Lundazi	1	1 − 1	55	19	1	1,875,581	276,462	75,023	112,535	2,339,600
		1 − 2	59	26	1	2,067,901	304,810	82,716	124,074	2,579,500
		1 − 3	116	30	1	3,756,854	553,763	150,274	225,411	4,686,300
		1 − 4	207	37	1	6,459,997	952,208	258,400	387,600	8,058,200
	2	2 − 1	46	17	1	1,593,875	234,938	63,755	95,633	1,988,200
		2 − 2	109	29	1	3,543,851	522,366	141,754	212,631	4,420,600
		2 − 3	124	38	1	4,075,597	600,746	163,024	244,536	5,083,900
		2 − 4	133	47	1	4,434,183	653,601	177,367	266,051	5,531,200
		2 − 5	177	53	1	5,769,921	850,490	230,797	346,195	7,197,400
		2 − 6	181	58	1	5,940,276	875,600	237,611	356,417	7,409,900
		2 − 7	186	62	1	6,128,507	903,346	245,140	367,710	7,644,700
	3	3 − 1	25	39	1	1,229,437	181,220	49,177	73,766	1,533,600
		3 − 2	47	54	1	2,029,101	299,091	81,164	121,746	2,531,100
Luwingu	1	1 − 1	122	50	1	4,149,671	611,664	165,987	248,980	5,176,300
		1 − 2	137	56	1	4,648,469	685,187	185,939	278,908	5,798,500
		1 − 3	142	62	1	4,858,666	716,170	194,347	291,520	6,060,700
		1 − 4	170	68	1	5,732,644	844,995	229,306	343,959	7,150,900
	2	2 − 1	66	25	1	2,258,939	332,969	90,358	135,536	2,817,800
		2 − 2	86	31	1	2,902,036	427,762	116,081	174,122	3,620,000
		2 − 3	118	37	1	3,891,454	573,603	155,658	233,487	4,854,200
		2 − 4	122	43	1	4,072,791	600,332	162,912	244,367	5,080,400
		2 − 5	152	49	1	5,004,489	737,665	200,180	300,269	6,242,600
		2 − 6	190	52	1	6,134,119	904,173	245,365	368,047	7,651,700
		2 − 7	204	54	1	6,560,125	966,967	262,405	393,608	8,183,100
	3	3 − 1	10	12	1	500,000	73,700	20,000	30,000	623,700
		3 − 2	17	18	1	767,917	113,191	30,717	46,075	957,900
		3 − 3	24	24	1	1,035,835	152,683	41,433	62,150	1,292,100

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Maamba	1	1 − 1	240	141	1	8,554,594	1,260,952	342,184	513,276	10,671,000
		1 − 2	271	143	1	9,471,220	1,396,064	378,849	568,273	11,814,400
		1 − 3	274	145	1	9,579,766	1,412,064	383,191	574,786	11,949,800
		1 − 4	296	147	1	10,236,652	1,508,889	409,466	614,199	12,769,200
		1 − 5	302	149	1	10,431,778	1,537,651	417,271	625,907	13,012,600
		1 − 6	308	151	1	10,626,904	1,566,412	425,076	637,614	13,256,000
		1 − 7	314	153	1	10,822,030	1,595,174	432,881	649,322	13,499,400
		1 − 8	327	154	1	11,208,193	1,652,095	448,328	672,492	13,981,100
		1 − 9	339	155	1	11,565,496	1,704,761	462,620	693,930	14,426,800
Mansa	1	1 − 1	81	5	1	2,472,182	364,401	98,887	148,331	3,083,800
		1 − 2	132	7	1	3,966,009	584,592	158,640	237,961	4,947,200
		1 − 3	144	9	1	4,334,295	638,878	173,372	260,058	5,406,600
		1 − 4	174	11	1	5,222,062	769,735	208,882	313,324	6,514,000
		1 − 5	186	13	1	5,590,348	824,021	223,614	335,421	6,973,400
		1 − 6	245	15	1	7,315,055	1,078,244	292,602	438,903	9,124,800
		1 − 7	283	16	1	8,422,719	1,241,514	336,909	505,363	10,506,500
		1 − 8	329	18	1	9,772,246	1,440,435	390,890	586,335	12,189,900
		1 − 9	350	19	1	10,389,290	1,531,388	415,572	623,357	12,959,600
	2	2 − 1	15	2	1	534,472	78,781	21,379	32,068	666,700
		2 − 2	26	3	1	862,915	127,194	34,517	51,775	1,076,400
		2 − 3	37	5	1	1,202,341	177,226	48,094	72,140	1,499,800
		2 − 4	67	6	1	2,079,125	306,464	83,165	124,747	2,593,500
		2 − 5	76	7	1	2,349,848	346,369	93,994	140,991	2,931,200

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Maposa	1	1 − 1	55	22	1	1,908,530	281,318	76,341	114,512	2,380,700
		1 − 2	126	35	1	4,100,369	604,397	164,015	246,022	5,114,800
		1 − 3	142	44	1	4,660,975	687,031	186,439	279,659	5,814,100
		1 − 4	186	52	1	6,018,679	887,157	240,747	361,121	7,507,700
		1 − 5	207	55	1	6,657,688	981,347	266,308	399,461	8,304,800
		1 − 6	211	57	1	6,795,094	1,001,601	271,804	407,706	8,476,200
		1 − 7	214	58	1	6,892,657	1,015,982	275,706	413,559	8,597,900
	2	2 − 1	41	13	1	1,405,644	207,193	56,226	84,339	1,753,400
		2 − 2	68	19	1	2,250,762	331,764	90,030	135,046	2,807,600
		2 − 3	72	22	1	2,399,150	353,636	95,966	143,949	2,992,700
		2 − 4	80	27	1	2,684,945	395,763	107,398	161,097	3,349,200
Mazabuka	1	1 − 1	44	9	1	1,448,292	213,479	57,932	86,898	1,806,600
		1 − 2	76	16	1	2,448,693	360,939	97,948	146,922	3,054,500
		1 − 3	86	19	1	2,770,242	408,335	110,810	166,215	3,455,600
		1 − 4	131	22	1	4,101,892	604,621	164,076	246,114	5,116,700
		1 − 5	163	25	1	5,058,361	745,606	202,334	303,502	6,309,800

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Mbala	1	1 − 1	55	4	1	1,710,839	252,179	68,434	102,650	2,134,100
		1 − 2	146	14	1	4,446,930	655,480	177,877	266,816	5,547,100
		1 − 3	180	16	1	5,450,136	803,354	218,005	327,008	6,798,500
		1 − 4	216	18	1	6,511,063	959,735	260,443	390,664	8,121,900
		1 − 5	236	19	1	7,099,246	1,046,433	283,970	425,955	8,855,600
		1 − 6	272	20	1	8,149,190	1,201,196	325,968	488,951	10,165,300
		1 − 7	303	21	1	9,054,834	1,334,688	362,193	543,290	11,295,000
	2	2 − 1	37	27	1	1,443,963	212,841	57,759	86,638	1,801,200
		2 − 2	44	38	1	1,766,795	260,427	70,672	106,008	2,203,900
		2 − 3	95	55	1	3,425,365	504,901	137,015	205,522	4,272,800
		2 − 4	104	65	1	3,794,933	559,376	151,797	227,696	4,733,800
		2 − 5	150	69	1	5,166,426	761,534	206,657	309,986	6,444,600
		2 − 6	211	72	1	6,959,836	1,025,884	278,393	417,590	8,681,700
		2 − 7	265	78	1	8,584,175	1,265,313	343,367	515,051	10,707,900
		2 − 8	314	81	1	10,031,265	1,478,615	401,251	601,876	12,513,000
		2 − 9	321	84	1	10,266,234	1,513,249	410,649	615,974	12,806,100
		2 − 10	367	85	1	11,604,778	1,710,552	464,191	696,287	14,475,800
Mbereshi	1	1 − 1	19	29	1	946,449	139,507	37,858	56,787	1,180,600
		1 − 2	40	42	1	1,695,286	249,886	67,811	101,717	2,114,700
		1 − 3	46	49	1	1,945,326	286,742	77,813	116,720	2,426,600
		1 − 4	85	52	1	3,103,816	457,504	124,153	186,229	3,871,700
		1 − 5	93	54	1	3,356,662	494,774	134,266	201,400	4,187,100
	2	2 − 1	32	34	1	1,376,543	202,903	55,062	82,593	1,717,100
Mfuwe	1	1 − 1	160	28	1	5,004,730	737,700	200,189	300,284	6,242,900
		1 − 2	167	43	1	5,371,493	791,761	214,860	322,290	6,700,400
		1 − 3	170	54	1	5,578,884	822,331	223,155	334,733	6,959,100

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Mkushi	1	1 － 1	23	11	1	864,198	127,383	34,568	51,852	1,078,000
		1 － 2	52	21	1	1,810,967	266,938	72,439	108,658	2,259,000
		1 － 3	88	26	1	2,904,842	428,176	116,194	174,291	3,623,500
		1 － 4	106	31	1	3,479,237	512,842	139,169	208,754	4,340,000
		1 － 5	115	35	1	3,782,908	557,603	151,316	226,975	4,718,800
		1 － 6	129	39	1	4,230,880	623,634	169,235	253,853	5,277,600
		1 － 7	135	42	1	4,436,989	654,015	177,480	266,219	5,534,700
		1 － 8	183	48	1	5,888,167	867,920	235,527	353,290	7,344,900
		1 － 9	187	50	1	6,025,573	888,173	241,023	361,534	7,516,300
Mkushi Farm Block	1	1 － 1	73	14	1	2,340,148	344,939	93,606	140,409	2,919,100
		1 － 2	107	20	1	3,387,286	499,288	135,491	203,237	4,225,300
		1 － 3	119	26	1	3,799,503	560,049	151,980	227,970	4,739,500
		1 － 4	156	35	1	4,966,170	732,017	198,647	297,970	6,194,800
		1 － 5	167	38	1	5,316,578	783,667	212,663	318,995	6,631,900
		1 － 6	250	42	1	7,755,892	1,143,223	310,236	465,354	9,674,700
		1 － 7	274	44	1	8,470,499	1,248,557	338,820	508,230	10,566,100
		1 － 8	301	45	1	9,260,702	1,365,033	370,428	555,642	11,551,800
Mongu	1	1 － 1	47	41	1	1,886,324	278,045	75,453	113,179	2,353,000
		1 － 2	55	48	1	2,194,084	323,409	87,763	131,645	2,736,900
		1 － 3	70	52	1	2,670,916	393,695	106,837	160,255	3,331,700
		1 － 4	76	56	1	2,888,007	425,694	115,520	173,280	3,602,500
	2	2 － 1	16	28	1	848,886	125,126	33,955	50,933	1,058,900
		2 － 2	136	52	1	4,575,677	674,458	183,027	274,541	5,707,700
		2 － 3	142	58	1	4,814,735	709,695	192,589	288,884	6,005,900
		2 － 4	147	64	1	5,024,932	740,678	200,997	301,496	6,268,100
		2 － 5	160	67	1	5,433,061	800,837	217,322	325,984	6,777,200

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL (36,000)	33/0.4 Tr 100kVA (13,700)	33kV Bay Extension (99,300)	Foreign Costs (0.80166747)	Domestic Costs (0.11816629)	Skilled Labor (0.0320667)	Unskilled Labor (0.04810005)	
Mpika	1	1 － 1	26	9	1	928,812	136,907	37,152	55,729	1,158,600
		1 － 2	54	13	1	1,780,824	262,495	71,233	106,849	2,221,400
	2	2 － 1	51	9	1	1,650,313	243,257	66,013	99,019	2,058,600
		2 － 2	67	18	1	2,210,919	325,891	88,437	132,655	2,757,900
		2 － 3	86	25	1	2,836,139	418,049	113,446	170,168	3,537,800
		2 － 4	138	31	1	4,402,758	648,969	176,110	264,165	5,492,000
		2 － 5	156	34	1	4,955,187	730,398	198,207	297,311	6,181,100
	3	3 － 1	58	17	1	1,940,196	285,986	77,608	116,412	2,420,200
		3 － 2	154	24	1	4,787,638	705,701	191,506	287,258	5,972,100
		3 － 3	191	26	1	5,877,425	866,336	235,097	352,646	7,331,500
Mpongwe	1	1 － 1	27	6	1	924,723	136,305	36,989	55,483	1,153,500
		1 － 2	74	14	1	2,369,008	349,193	94,760	142,140	2,955,100
		1 － 3	179	24	1	5,509,139	812,051	220,366	330,548	6,872,100
		1 － 4	202	31	1	6,249,800	921,224	249,992	374,988	7,796,000
		1 － 5	206	32	1	6,376,223	939,859	255,049	382,573	7,953,700
		1 － 6	213	33	1	6,589,226	971,256	263,569	395,354	8,219,400
		1 － 7	224	34	1	6,917,669	1,019,669	276,707	415,060	8,629,100
		1 － 8	243	35	1	7,476,992	1,102,113	299,080	448,620	9,326,800
		1 － 9	245	36	1	7,545,695	1,112,240	301,828	452,742	9,412,500
		1 － 10	254	37	1	7,816,418	1,152,145	312,657	468,985	9,750,200
	2	2 － 1	38	9	1	1,275,132	187,955	51,005	76,508	1,590,600
		2 － 2	48	10	1	1,574,715	232,114	62,989	94,483	1,964,300
		2 － 3	66	11	1	2,105,179	310,305	84,207	126,311	2,626,000
	3	3 － 1	27	17	1	1,045,535	154,112	41,821	62,732	1,304,200
		3 － 2	37	34	1	1,520,843	224,173	60,834	91,251	1,897,100
		3 － 3	41	35	1	1,647,266	242,808	65,891	98,836	2,054,800
		3 － 4	57	36	1	2,120,010	312,491	84,800	127,201	2,644,500
		3 － 5	113	39	1	3,769,120	555,571	150,765	226,147	4,701,600
		3 － 6	122	40	1	4,039,843	595,475	161,594	242,391	5,039,300
		3 － 7	142	41	1	4,628,026	682,174	185,121	277,682	5,773,000

Substation	Feeder	Package	Unit Cost (US$) & Amount 33kV DL (36,000)	33/0.4 Tr 100kVA (13,700)	33kV Bay Extension (99,300)	FC (US$) Foreign Costs (0.80166747)	LC (US$) Domestic Costs (0.11816629)	Skilled Labor (0.0320667)	Unskilled Labor (0.04810005)	Total (US$)
Mporokoso	1	1 − 1	15	8	1	600,369	88,495	24,015	36,022	748,900
		1 − 2	27	16	1	1,034,552	152,494	41,382	62,073	1,290,500
		1 − 3	40	22	1	1,475,629	217,509	59,025	88,538	1,840,700
		1 − 4	62	28	1	2,176,447	320,810	87,058	130,587	2,714,900
		1 − 5	90	33	1	3,039,442	448,016	121,578	182,367	3,791,400
	2	2 − 1	71	6	1	2,194,565	323,480	87,783	131,674	2,737,500
		2 − 2	74	32	1	2,566,699	378,333	102,668	154,002	3,201,700
		2 − 3	112	58	1	3,948,934	582,075	157,957	236,936	4,925,900
		2 − 4	114	66	1	4,094,517	603,534	163,781	245,671	5,107,500
		2 − 5	150	72	1	5,199,375	766,391	207,975	311,962	6,485,700
		2 − 6	158	78	1	5,496,152	810,136	219,846	329,769	6,855,900
Msoro	1	1 − 1	29	17	1	1,103,255	162,620	44,130	66,195	1,376,200
Mumbwa	1	1 − 1	11	12	1	528,860	77,954	21,154	31,732	659,700
		1 − 2	25	23	1	1,053,712	155,318	42,148	63,223	1,314,400
		1 − 3	37	33	1	1,509,861	222,554	60,394	90,592	1,883,400
		1 − 4	54	36	1	2,033,430	299,729	81,337	122,006	2,536,500
		1 − 5	98	37	1	3,314,254	488,523	132,570	198,855	4,134,200
		1 − 6	140	38	1	4,537,358	668,809	181,494	272,241	5,659,900
		1 − 7	194	39	1	6,106,782	900,144	244,271	366,407	7,617,600
	2	2 − 1	43	14	1	1,474,347	217,320	58,974	88,461	1,839,100
		2 − 2	98	22	1	3,149,511	464,240	125,980	188,971	3,928,700
		2 − 3	102	25	1	3,297,900	486,112	131,916	197,874	4,113,800
	3	3 − 1	30	20	1	1,165,063	171,731	46,603	69,904	1,453,300
		3 − 2	87	34	1	2,963,845	436,873	118,554	177,831	3,697,100
		3 − 3	125	43	1	4,159,372	613,094	166,375	249,562	5,188,400
		3 − 4	134	47	1	4,463,043	657,855	178,522	267,783	5,567,200

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Muzuma	1	1 − 1	84	7	1	2,580,728	380,401	103,229	154,844	3,219,200
		1 − 2	106	10	1	3,248,597	478,845	129,944	194,916	4,052,300
		1 − 3	118	12	1	3,616,883	533,131	144,675	217,013	4,511,700
		1 − 4	124	14	1	3,812,009	561,893	152,480	228,721	4,755,100
		1 − 5	127	16	1	3,920,555	577,892	156,822	235,233	4,890,500
	2	2 − 1	95	7	1	2,898,188	427,195	115,928	173,891	3,615,200
		2 − 2	98	14	1	3,061,648	451,289	122,466	183,699	3,819,100
	3	3 − 1	68	8	1	2,129,950	313,956	85,198	127,797	2,656,900
		3 − 2	92	10	1	2,844,557	419,289	113,782	170,673	3,548,300
Nakonde	1	1 − 1	19	10	1	737,775	108,748	29,511	44,266	920,300
		1 − 2	60	43	1	2,283,470	336,585	91,339	137,008	2,848,400
		1 − 3	156	47	1	5,097,964	751,443	203,919	305,878	6,359,200
		1 − 4	169	49	1	5,495,110	809,983	219,804	329,707	6,854,600
		1 − 5	211	51	1	6,729,197	991,888	269,168	403,752	8,394,000
		1 − 6	230	52	1	7,288,520	1,074,332	291,541	437,311	9,091,700
Nampundwe	1	1 − 1	27	38	1	1,276,174	188,109	51,047	76,570	1,591,900
		1 − 2	76	48	1	2,800,144	412,743	112,006	168,009	3,492,900
		1 − 3	101	55	1	3,598,525	530,425	143,941	215,912	4,488,800
		1 − 4	123	60	1	4,288,360	632,107	171,534	257,302	5,349,300
		1 − 5	136	63	1	4,696,489	692,265	187,860	281,789	5,858,400
		1 − 6	165	66	1	5,566,378	820,488	222,655	333,983	6,943,500
		1 − 7	196	68	1	6,483,005	955,599	259,320	388,980	8,086,900
Nchelenge	1	1 − 1	16	14	1	695,126	102,462	27,805	41,708	867,100
		1 − 2	19	20	1	847,603	124,937	33,904	50,856	1,057,300
		1 − 3	30	30	1	1,274,892	187,920	50,996	76,494	1,590,300
		1 − 4	38	34	1	1,549,703	228,427	61,988	92,982	1,933,100
		1 − 5	65	37	1	2,361,873	348,142	94,475	141,712	2,946,200
	2	2 − 1	13	19	1	663,460	97,794	26,538	39,808	827,600
		2 − 2	20	34	1	1,030,223	151,855	41,209	61,813	1,285,100
		2 − 3	66	59	1	2,632,355	388,011	105,294	157,941	3,283,600
		2 − 4	82	63	1	3,138,047	462,550	125,522	188,283	3,914,400
		2 − 5	121	65	1	4,285,554	631,693	171,422	257,133	5,345,800

Substation	Feeder	Package	Unit Cost (US$) & Amount 33kV DL (36,000)	33/0.4 Tr 100kVA (13,700)	33kV Bay Extension (99,300)	FC (US$) Foreign Costs (0.80166747)	LC (US$) Domestic Costs (0.11816629)	Skilled Labor (0.0320667)	Unskilled Labor (0.04810005)	Total (US$)
Ndola	1	1 － 1	41	33	1	1,625,301	239,570	65,012	97,518	2,027,400
		1 － 2	89	44	1	3,131,393	461,569	125,256	187,884	3,906,100
		1 － 3	99	52	1	3,507,856	517,060	140,314	210,471	4,375,700
Pensulo	1	1 － 1	10	7	1	445,086	65,606	17,803	26,705	555,200
Samfya	1	1 － 1	25	14	1	954,866	140,748	38,195	57,292	1,191,100
		1 － 2	37	15	1	1,312,169	193,415	52,487	78,730	1,636,800
		1 － 3	47	16	1	1,611,752	237,573	64,470	96,705	2,010,500
Senanga	1	1 － 1	38	38	1	1,593,635	234,903	63,745	95,618	1,987,900
	2	2 － 1	26	26	1	1,115,520	164,428	44,621	66,931	1,391,500
		2 － 2	80	38	1	2,805,756	413,570	112,230	168,345	3,499,900
		2 － 3	202	58	1	6,546,336	964,934	261,853	392,780	8,165,900
	3	3 － 1	19	19	1	836,620	123,318	33,465	50,197	1,043,600
		3 － 2	37	38	1	1,564,775	230,649	62,591	93,886	1,951,900
		3 － 3	92	50	1	3,283,870	484,045	131,355	197,032	4,096,300
Serenje	1	1 － 1	61	7	1	1,916,947	282,559	76,678	115,017	2,391,200
		1 － 2	144	21	1	4,466,089	658,304	178,644	267,965	5,571,000
		1 － 3	175	28	1	5,437,630	801,510	217,505	326,258	6,782,900
Sesheke	1	1 － 1	154	26	1	4,809,604	708,939	192,384	288,576	5,999,500
		1 － 2	161	36	1	5,121,453	754,905	204,858	307,287	6,388,500
		1 － 3	174	43	1	5,573,513	821,539	222,941	334,411	6,952,400
		1 － 4	202	49	1	6,447,491	950,364	257,900	386,849	8,042,600

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Sinazongwe	1	1 − 1	83	16	1	2,650,713	390,717	106,029	159,043	3,306,500
		1 − 2	90	20	1	2,896,665	426,970	115,867	173,800	3,613,300
		1 − 3	100	24	1	3,229,197	475,986	129,168	193,752	4,028,100
		1 − 4	106	26	1	3,424,323	504,747	136,973	205,459	4,271,500
		1 − 5	108	28	1	3,504,008	516,493	140,160	210,241	4,370,900
		1 − 6	112	30	1	3,641,414	536,747	145,657	218,485	4,542,300
		1 − 7	115	32	1	3,749,960	552,746	149,998	224,998	4,677,700
		1 − 8	120	34	1	3,916,226	577,254	156,649	234,974	4,885,100
		1 − 9	143	36	1	4,601,972	678,334	184,079	276,118	5,740,500
		1 − 10	172	38	1	5,460,879	804,937	218,435	327,653	6,811,900
		1 − 11	204	39	1	6,395,382	942,683	255,815	383,723	7,977,600
		1 − 12	208	40	1	6,521,805	961,318	260,872	391,308	8,135,300
		1 − 13	221	41	1	6,907,969	1,018,239	276,319	414,478	8,617,000
Solwezi	1	1 − 1	65	38	1	2,372,856	349,760	94,914	142,371	2,959,900
	2	2 − 1	11	10	1	506,894	74,717	20,276	30,414	632,300
		2 − 2	32	15	1	1,167,869	172,145	46,715	70,072	1,456,800
		2 − 3	41	19	1	1,471,541	216,906	58,862	88,292	1,835,600
		2 − 4	57	23	1	1,977,233	291,445	79,089	118,634	2,466,400
	3	3 − 1	52	5	1	1,635,241	241,036	65,410	98,114	2,039,800
		3 − 2	127	17	1	3,931,538	579,511	157,262	235,892	4,904,200
		3 − 3	157	22	1	4,852,253	715,225	194,090	291,135	6,052,700
		3 − 4	234	26	1	7,118,406	1,049,258	284,736	427,104	8,879,500
		3 − 5	246	30	1	7,508,658	1,106,781	300,346	450,519	9,366,300

Substation	Feeder	Package	Unit Cost (US$) & Amount 33kV DL (36,000)	33/0.4 Tr 100kVA (13,700)	33kV Bay Extension (99,300)	FC (US$) Foreign Costs (0.80166747)	LC (US$) Domestic Costs (0.11816629)	Skilled Labor (0.0320667)	Unskilled Labor (0.04810005)	Total (US$)
Victoria Falls	1	1 − 1	64	7	1	2,003,527	295,321	80,141	120,212	2,499,200
		1 − 2	72	9	1	2,256,373	332,591	90,255	135,382	2,814,600
		1 − 3	83	10	1	2,584,816	381,004	103,393	155,089	3,224,300
		1 − 4	87	11	1	2,711,239	399,638	108,450	162,674	3,382,000
		1 − 5	94	13	1	2,935,225	432,654	117,409	176,114	3,661,400
	2	2 − 1	58	10	1	1,863,316	274,654	74,533	111,799	2,324,300
		2 − 2	116	14	1	3,581,129	527,861	143,245	214,868	4,467,100
		2 − 3	122	16	1	3,776,255	556,622	151,050	226,575	4,710,500
		2 − 4	124	18	1	3,855,940	568,368	154,238	231,356	4,809,900
		2 − 5	151	20	1	4,657,127	686,463	186,285	279,428	5,809,300
		2 − 6	155	21	1	4,783,550	705,098	191,342	287,013	5,967,000
	3	3 − 1	32	21	1	1,233,766	181,858	49,351	74,026	1,539,000
		3 − 2	71	23	1	2,381,273	351,001	95,251	142,876	2,970,400
		3 − 3	109	26	1	3,510,903	517,509	140,436	210,654	4,379,500
		3 − 4	113	28	1	3,648,308	537,763	145,932	218,899	4,550,900
		3 − 5	147	30	1	4,651,515	685,636	186,061	279,091	5,802,300
		3 − 6	151	31	1	4,777,938	704,271	191,118	286,676	5,960,000
		3 − 7	155	32	1	4,904,361	722,906	196,174	294,262	6,117,700
		3 − 8	164	34	1	5,186,067	764,430	207,443	311,164	6,469,100

Table 7-7-2 Result of Cost Estimation in each Package (Proposed Substation by ZESCO)

Substation	Feeder	Package	33kV DL (36,000)	66kV TL (40,000)	33/0.4 Tr 100kVA (13,700)	New SS 2.5MVA (600,000)	New SS 5MVA (800,000)	New SS 10MVA (1,000,000)	New SS 15MVA (1,300,000)	FC (US$) Foreign Costs (0.80166747)	LC (US$) Domestic Costs (0.11816629)	LC (US$) Skilled Labor (0.0320667)	LC (US$) Unskilled Labor (0.04810005)	Total (US$)
New SS at Chama	1	1 − 1	230	70.5	21	0	0	0.5	0	9,529,982	1,404,725	381,199	571,799	11,887,700
		1 − 2	268	70.5	29	0	0	0.5	0	10,714,526	1,579,328	428,581	642,872	13,365,300
		1 − 3	278	70.5	32	0	0	0.5	0	11,036,075	1,626,724	441,443	662,165	13,766,400
	2	2 − 1	11	70.5	6	0	0	0.5	0	3,044,893	448,819	121,796	182,694	3,798,200
		2 − 2	84	70.5	16	0	0	0.5	0	5,261,504	775,549	210,460	315,690	6,563,200
		2 − 3	130	70.5	22	0	0	0.5	0	6,654,962	980,946	266,199	399,298	8,301,400
		2 − 4	171	70.5	26	0	0	0.5	0	7,882,155	1,161,835	315,286	472,929	9,832,200
		2 − 5	189	70.5	30	0	0	0.5	0	8,445,567	1,244,882	337,823	506,734	10,535,000
New SS at Chavuma	1	1 − 1	3	72	2	1	0	0	0	2,898,349	427,218	115,934	173,901	3,615,400
		1 − 2	12	72	4	1	0	0	0	3,180,055	468,742	127,202	190,803	3,966,800
		1 − 3	17	72	6	1	0	0	0	3,346,320	493,250	133,853	200,779	4,174,200
		1 − 4	40	72	10	1	0	0	0	4,054,032	597,567	162,161	243,242	5,057,000
		1 − 5	44	72	12	1	0	0	0	4,191,438	617,821	167,658	251,486	5,228,400
		1 − 6	49	72	14	1	0	0	0	4,357,704	642,328	174,308	261,462	5,435,800
		1 − 7	54	72	16	1	0	0	0	4,523,970	666,836	180,959	271,438	5,643,200
		1 − 8	61	72	19	1	0	0	0	4,758,939	701,471	190,358	285,536	5,936,300
		1 − 9	110	72	21	1	0	0	0	6,195,046	913,154	247,802	371,703	7,727,700
		1 − 10	122	72	22	1	0	0	0	6,552,349	965,820	262,094	393,141	8,173,400
New SS at Chilundu	1	1 − 1	22	90	12	0	0	0.5	0	4,053,551	597,496	162,142	243,213	5,056,400
		1 − 2	50	90	14	0	0	0.5	0	4,883,598	719,845	195,344	293,016	6,091,800
		1 − 3	95	90	15	0	0	0.5	0	6,193,282	912,894	247,731	371,597	7,725,500
	2	2 − 1	182	90	49	0	0	0.5	0	9,077,521	1,338,032	363,101	544,651	11,323,300
		2 − 2	216	90	51	0	0	0.5	0	10,080,728	1,485,906	403,229	604,844	12,574,700
New SS at Kabompo	1	1 − 1	42	68	10	0	0	0.5	0	3,903,319	575,352	156,133	234,199	4,869,000
		1 − 2	127	68	20	0	0	0.5	0	6,466,250	953,129	258,650	387,975	8,066,000
		1 − 3	162	68	23	0	0	0.5	0	7,509,299	1,106,875	300,372	450,558	9,367,100
		1 − 4	200	68	25	0	0	0.5	0	8,627,946	1,271,765	345,118	517,677	10,762,500
	2	2 − 1	36	68	32	0	0	0.5	0	3,971,781	585,443	158,871	238,307	4,954,400
		2 − 2	86	68	50	0	0	0.5	0	5,612,474	827,282	224,499	336,748	7,001,000
		2 − 3	150	68	60	0	0	0.5	0	7,569,344	1,115,726	302,774	454,161	9,442,000
		2 − 4	182	68	63	0	0	0.5	0	8,525,814	1,256,710	341,033	511,549	10,635,100
		2 − 5	186	68	65	0	0	0.5	0	8,663,220	1,276,964	346,529	519,793	10,806,500
New SS at Lukulu	1	1 − 1	3	47.5	31	0	0	0.5	0	2,351,050	346,546	94,042	141,063	2,932,700
		1 − 2	89	47.5	43	0	0	0.5	0	4,964,807	731,816	198,592	297,888	6,193,100
		1 − 3	114	47.5	50	0	0	0.5	0	5,763,187	849,497	230,528	345,791	7,189,000
		1 − 4	127	47.5	53	0	0	0.5	0	6,171,316	909,656	246,853	370,279	7,698,100
		1 − 5	130	47.5	56	0	0	0.5	0	6,290,845	927,275	251,634	377,451	7,847,200
	2	2 − 1	20	47.5	19	0	0	0.5	0	2,709,877	399,438	108,395	162,593	3,380,300
		2 − 2	57	47.5	29	0	0	0.5	0	3,887,526	573,024	155,501	233,252	4,849,300
		2 − 3	142	47.5	35	0	0	0.5	0	6,406,526	944,326	256,261	384,392	7,991,500
		2 − 4	261	47.5	38	0	0	0.5	0	9,873,818	1,455,407	394,953	592,429	12,316,600
		2 − 5	305	47.5	41	0	0	0.5	0	11,176,607	1,647,439	447,064	670,596	13,941,700

Substation	Feeder	Package	Unit Cost (US$) & Amount							FC (US$)	LC (US$)			Total (US$)
			33kV DL	66kV TL	33/0.4 Tr 100kVA	New SS 2.5MVA	5MVA	10MVA	15MVA	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(40,000)	(13,700)	(600,000)	(800,000)	(1,000,000)	(1,300,000)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
New SS at Mufumbwe	1	1 － 1	14	95	4	0	1	0	0	4,135,642	609,596	165,426	248,139	5,158,800
		1 － 2	59	95	15	0	1	0	0	5,555,155	818,833	222,206	333,309	6,929,500
		1 － 3	80	95	22	0	1	0	0	6,238,095	919,499	249,524	374,286	7,781,400
		1 － 4	95	95	26	0	1	0	0	6,714,927	989,784	268,597	402,896	8,376,200
		1 － 5	150	95	35	0	1	0	0	8,401,074	1,238,324	336,043	504,064	10,479,500
		1 － 6	198	95	38	0	1	0	0	9,819,304	1,447,372	392,772	589,158	12,248,600
		1 － 7	206	95	41	0	1	0	0	10,083,133	1,486,260	403,325	604,988	12,577,700
		1 － 8	232	95	44	0	1	0	0	10,866,442	1,601,720	434,658	651,987	13,554,800
New SS at Mumbezi	1	1 － 1	31	68	9	1	0	0	0	3,655,042	538,756	146,202	219,303	4,559,300
		1 － 2	72	68	17	1	0	0	0	4,926,166	726,120	197,047	295,570	6,144,900
New SS at Mwinilunga	1	1 － 1	132	52	17	0	0	0.33	0	5,928,251	873,828	237,130	355,695	7,394,900
		1 － 2	223	52	22	0	0	0.33	0	8,609,428	1,269,035	344,377	516,566	10,739,400
		1 － 3	334	52	31	0	0	0.33	0	11,911,736	1,755,797	476,469	714,704	14,858,700
		1 － 4	446	52	36	0	0	0.33	0	15,198,974	2,240,338	607,959	911,938	18,959,200
	2	2 － 1	44	52	17	0	0	0.33	0	3,388,568	499,477	135,543	203,314	4,226,900
		2 － 2	91	52	27	0	0	0.33	0	4,854,818	715,603	194,193	291,289	6,055,900
		2 － 3	123	52	33	0	0	0.33	0	5,844,236	861,444	233,769	350,654	7,290,100
		2 － 4	153	52	37	0	0	0.33	0	6,753,968	995,539	270,159	405,238	8,424,900
	3	3 － 1	12	52	7	0	0	0.33	0	2,355,219	347,161	94,209	141,313	2,937,900
		3 － 2	22	52	11	0	0	0.33	0	2,687,751	396,176	107,510	161,265	3,352,700
New SS at Nyimba	1	1 － 1	23	53	4	1	0	0	0	2,888,248	425,730	115,530	173,295	3,602,800
		1 － 2	32	53	6	1	0	0	0	3,169,954	467,253	126,798	190,197	3,954,200
		1 － 3	38	53	8	1	0	0	0	3,365,079	496,015	134,603	201,905	4,197,600
		1 － 4	55	53	11	1	0	0	0	3,888,648	573,189	155,546	233,319	4,850,700
		1 － 5	76	53	13	1	0	0	0	4,516,675	665,761	180,667	271,000	5,634,100
		1 － 6	85	53	14	1	0	0	0	4,787,398	705,665	191,496	287,244	5,971,800
		1 － 7	147	53	17	1	0	0	0	6,609,668	974,269	264,387	396,580	8,244,900
		1 － 8	173	53	18	1	0	0	0	7,371,012	1,086,492	294,840	442,261	9,194,600
		1 － 9	190	53	19	1	0	0	0	7,872,615	1,160,428	314,905	472,357	9,820,300
New SS at Zambezi	1	1 － 1	30	47.5	11	0	0	0.5	0	2,910,614	429,026	116,425	174,637	3,630,700
		1 － 2	79	47.5	27	0	0	0.5	0	4,500,481	663,374	180,019	270,029	5,613,900
		1 － 3	81	47.5	33	0	0	0.5	0	4,624,098	681,595	184,964	277,446	5,768,100
		1 － 4	126	47.5	39	0	0	0.5	0	5,988,697	882,738	239,548	359,322	7,470,300
		1 － 5	156	47.5	44	0	0	0.5	0	6,909,412	1,018,452	276,376	414,565	8,618,800
		1 － 6	172	47.5	49	0	0	0.5	0	7,426,086	1,094,610	297,043	445,565	9,263,300
		1 － 7	221	47.5	52	0	0	0.5	0	8,873,176	1,307,912	354,927	532,391	11,068,400
		1 － 8	230	47.5	55	0	0	0.5	0	9,165,865	1,351,054	366,635	549,952	11,433,500
		1 － 9	251	47.5	56	0	0	0.5	0	9,782,908	1,442,007	391,316	586,975	12,203,200
		1 － 10	270	47.5	57	0	0	0.5	0	10,342,232	1,524,451	413,689	620,534	12,900,900
	2	2 － 1	27	47.5	18	0	0	0.5	0	2,900,914	427,597	116,037	174,055	3,618,600
		2 － 2	60	47.5	30	0	0	0.5	0	3,985,089	587,405	159,404	239,105	4,971,000
		2 － 3	83	47.5	33	0	0	0.5	0	4,681,818	690,103	187,273	280,909	5,840,100

Table 7-7-3 Result of Cost Estimation in each Package (Proposed Substation by Consultant)

Substation	Feeder	Package	Unit Cost (US$) & Amount							FC (US$)	LC (US$)			Total (US$)
			33kV DL	66kV TL	33/0.4 Tr 100kVA	New SS 2.5MVA	5MVA	10MVA	15MVA	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(40,000)	(13,700)	(600,000)	(800,000)	(1,000,000)	(1,300,000)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Azele 1	1	1 − 1	6	13	32	0	0	0	0.5	1,462,562	215,583	58,502	87,754	1,824,400
		1 − 2	10	13	59	0	0	0	0.5	1,874,539	276,308	74,982	112,472	2,338,300
		1 − 3	14	13	73	0	0	0	0.5	2,143,739	315,988	85,750	128,624	2,674,100
		1 − 4	15	13	80	0	0	0	0.5	2,249,479	331,575	89,979	134,969	2,806,000
		1 − 5	27	13	87	0	0	0	0.5	2,672,679	393,955	106,907	160,361	3,333,900
	2	2 − 1	17	13	40	0	0	0	0.5	1,867,885	275,327	74,715	112,073	2,330,000
		2 − 2	37	13	57	0	0	0	0.5	2,631,794	387,928	105,272	157,908	3,282,900
		2 − 3	74	13	60	0	0	0	0.5	3,732,564	550,182	149,303	223,954	4,656,000
		2 − 4	78	13	63	0	0	0	0.5	3,880,952	572,055	155,238	232,857	4,841,100
		2 − 5	85	13	65	0	0	0	0.5	4,104,938	605,070	164,198	246,296	5,120,500
Azele 2	1	1 − 1	9	11	53	0	0	0	0.5	1,715,649	252,888	68,626	102,939	2,140,100
		1 − 2	22	11	71	0	0	0	0.5	2,288,520	337,329	91,541	137,311	2,854,700
		1 − 3	56	11	80	0	0	0	0.5	3,368,607	496,535	134,744	202,116	4,202,000
	2	2 − 1	11	11	67	0	0	0	0.5	1,927,128	284,060	77,085	115,628	2,403,900
Azele 3	1	1 − 1	4	21.5	41	0	0	0	0.5	1,776,255	261,821	71,050	106,575	2,215,700
		1 − 2	14	21.5	82	0	0	0	0.5	2,515,152	370,735	100,606	150,909	3,137,400
	2	2 − 1	7	21.5	41	0	0	0	0.5	1,862,835	274,583	74,513	111,770	2,323,700
Azele 4	1	1 − 1	46	22.5	27	0	0	0	0.5	2,866,683	422,551	114,667	172,001	3,575,900
		1 − 2	107	22.5	49	0	0	0	0.5	4,868,767	717,659	194,751	292,126	6,073,300
		1 − 3	205	22.5	71	0	0	0	0.5	7,938,672	1,170,165	317,547	476,320	9,902,700
		1 − 4	220	22.5	86	0	0	0	0.5	8,536,316	1,258,258	341,453	512,179	10,648,200
	2	2 − 1	23	22.5	22	0	0	0	0.5	2,147,988	316,615	85,920	128,879	2,679,400
		2 − 2	31	22.5	44	0	0	0	0.5	2,620,491	386,262	104,820	157,229	3,268,800
		2 − 3	71	22.5	63	0	0	0	0.5	3,983,566	587,180	159,343	239,014	4,969,100
		2 − 4	101	22.5	65	0	0	0	0.5	4,871,332	718,037	194,853	292,280	6,076,500
		2 − 5	129	22.5	66	0	0	0	0.5	5,690,396	838,768	227,616	341,424	7,098,200
Azele 5	1	1 − 1	23	33	75	0	0	0	1	3,587,863	528,853	143,515	215,272	4,475,500
		1 − 2	43	33	110	0	0	0	1	4,549,463	670,594	181,979	272,968	5,675,000
		1 − 3	60	33	137	0	0	0	1	5,336,620	786,621	213,465	320,197	6,656,900
Azele 6	1	1 − 1	12	20	10	0	0	0.5	0	1,498,317	220,853	59,933	89,899	1,869,000
		1 − 2	99	20	36	0	0	0.5	0	4,294,693	633,040	171,788	257,682	5,357,200
		1 − 3	131	20	42	0	0	0.5	0	5,284,111	778,881	211,364	317,047	6,591,400
		1 − 4	145	20	43	0	0	0.5	0	5,699,134	840,056	227,965	341,948	7,109,100
	2	2 − 1	16	20	14	0	0	0.5	0	1,657,688	244,344	66,308	99,461	2,067,800
		2 − 2	51	20	25	0	0	0.5	0	2,788,600	411,041	111,544	167,316	3,478,500

Substation	Feeder	Package	Unit Cost (US$) & Amount							FC (US$)	LC (US$)			Total (US$)
			33kV DL	66kV TL	33/0.4 Tr	New SS				Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
					100kVA	2.5MVA	5MVA	10MVA	15MVA					
			(36,000)	(40,000)	(13,700)	(600,000)	(800,000)	(1,000,000)	(1,300,000)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Isoka 1	1	1 － 1	14	75	33	0	0	0.33	0	3,436,027	506,473	137,441	206,162	4,286,100
	2	2 － 1	9	75	32	0	0	0.33	0	3,280,744	483,584	131,230	196,845	4,092,400
	3	3 － 1	50	75	15	0	0	0.33	0	4,277,297	630,476	171,092	256,638	5,335,500
Kabwe 1	1	1 － 1	8	26	42	0	1	0	0	2,167,228	319,451	86,689	130,034	2,703,400
		1 － 2	27	26	49	0	1	0	0	2,792,448	411,609	111,698	167,547	3,483,300
		1 － 3	43	26	53	0	1	0	0	3,298,140	486,148	131,926	197,888	4,114,100
Kabwe 2	1	1 － 1	1	38	47	0	0	1	0	2,565,256	378,120	102,610	153,915	3,199,900
		1 － 2	56	38	68	0	0	1	0	4,383,197	646,086	175,328	262,992	5,467,600
Kasama 1	1	1 － 1	1	12	67	0	0	1	0	1,951,178	287,605	78,047	117,071	2,433,900
		1 － 2	36	12	77	0	0	1	0	3,071,108	452,683	122,844	184,266	3,830,900
		1 － 3	55	12	80	0	0	1	0	3,652,397	538,366	146,096	219,144	4,556,000
Kasama 2	1	1 － 1	1	66	49	0	0	1	0	3,485,089	513,704	139,404	209,105	4,347,300
		1 － 2	6	66	66	0	0	1	0	3,816,097	562,495	152,644	228,966	4,760,200
		1 － 3	40	66	74	0	0	1	0	4,885,201	720,082	195,408	293,112	6,093,800
		1 － 4	66	66	80	0	0	1	0	5,701,459	840,399	228,058	342,088	7,112,000
Luano 1	1	1 － 1	33	41.5	11	0	0.5	0	0	2,724,627	401,612	108,985	163,478	3,398,700
		1 － 2	39	41.5	16	0	0.5	0	0	2,952,702	435,230	118,108	177,162	3,683,200
		1 － 3	45	41.5	19	0	0.5	0	0	3,158,810	465,611	126,352	189,529	3,940,300
		1 － 4	50	41.5	21	0	0.5	0	0	3,325,076	490,118	133,003	199,505	4,147,700
		1 － 5	60	41.5	22	0	0.5	0	0	3,624,659	534,277	144,986	217,480	4,521,400
	2	2 － 1	34	41.5	13	0	0.5	0	0	2,775,453	409,104	111,018	166,527	3,462,100
		2 － 2	57	41.5	21	0	0.5	0	0	3,527,096	519,896	141,084	211,626	4,399,700
		2 － 3	84	41.5	26	0	0.5	0	0	4,361,231	642,848	174,449	261,674	5,440,200
		2 － 4	94	41.5	28	0	0.5	0	0	4,671,797	688,626	186,872	280,308	5,827,600
Luano 2	1	1 － 1	20	44	21	0	1	0	0	2,860,109	421,582	114,404	171,607	3,567,700
		1 － 2	38	44	33	0	1	0	0	3,511,384	517,580	140,455	210,683	4,380,100
		1 － 3	55	44	39	0	1	0	0	4,067,901	599,611	162,716	244,074	5,074,300
		1 － 4	62	44	42	0	1	0	0	4,302,870	634,246	172,115	258,172	5,367,400
		1 － 5	77	44	48	0	1	0	0	4,801,667	707,769	192,067	288,100	5,989,600
		1 － 6	85	44	49	0	1	0	0	5,043,531	743,420	201,741	302,612	6,291,300
Lundazi 1	1	1 － 1	2	46	25	0	1	0	0	2,448,693	360,939	97,948	146,922	3,054,500
		1 － 2	8	46	32	0	1	0	0	2,698,733	397,795	107,949	161,924	3,366,400
		1 － 3	19	46	35	0	1	0	0	3,128,748	461,179	125,150	187,725	3,902,800

Substation	Feeder	Package	Unit Cost (US$) & Amount							FC (US$)	LC (US$)			Total (US$)
			33kV DL	66kV TL	33/0.4 Tr 100kVA	New SS 2.5MVA	5MVA	10MVA	15MVA	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(40,000)	(13,700)	(600,000)	(800,000)	(1,000,000)	(1,300,000)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Luwingu 1	1	1 − 1	24	50	27	0	0	1	0	3,394,180	500,304	135,767	203,651	4,233,900
		1 − 2	42	50	50	0	0	1	0	4,166,266	614,110	166,651	249,976	5,197,000
		1 − 3	47	50	59	0	0	1	0	4,409,412	649,950	176,376	264,565	5,500,300
		1 − 4	71	50	65	0	0	1	0	5,167,949	761,759	206,718	310,077	6,446,500
		1 − 5	80	50	71	0	0	1	0	5,493,587	809,758	219,743	329,615	6,852,700
Luwingu 2	1	1 − 1	11	37	25	0	0	0	0.5	2,299,583	338,960	91,983	137,975	2,868,500
		1 − 2	44	37	37	0	0	0	0.5	3,383,758	498,768	135,350	203,026	4,220,900
		1 − 3	63	37	47	0	0	0	0.5	4,041,927	595,783	161,677	242,516	5,041,900
		1 − 4	81	37	56	0	0	0	0.5	4,660,253	686,924	186,410	279,615	5,813,200
		1 − 5	113	37	63	0	0	0	0.5	5,660,654	834,384	226,426	339,639	7,061,100
	2	2 − 1	19	37	28	0	0	0	0.5	2,563,412	377,849	102,536	153,805	3,197,600
		2 − 2	37	37	47	0	0	0	0.5	3,291,566	485,179	131,663	197,494	4,105,900
		2 − 3	44	37	61	0	0	0	0.5	3,647,346	537,621	145,894	218,841	4,549,700
		2 − 4	72	37	72	0	0	0	0.5	4,576,239	674,540	183,050	274,574	5,708,400
		2 − 5	79	37	78	0	0	0	0.5	4,844,156	714,032	193,766	290,649	6,042,600
Luwingu 3	1	1 − 1	13	26	17	0	0	0.5	0	1,796,457	264,799	71,858	107,787	2,240,900
		1 − 2	19	26	25	0	0	0.5	0	2,057,480	303,274	82,299	123,449	2,566,500
		1 − 3	41	26	38	0	0	0.5	0	2,835,177	417,907	113,407	170,111	3,536,600
	2	2 − 1	8	26	27	0	0	0.5	0	1,761,985	259,718	70,479	105,719	2,197,900
		2 − 2	15	26	38	0	0	0.5	0	2,084,816	307,303	83,393	125,089	2,600,600
		2 − 3	20	26	46	0	0	0.5	0	2,316,979	341,524	92,679	139,019	2,890,200
		2 − 4	32	26	53	0	0	0.5	0	2,740,180	403,904	109,607	164,411	3,418,100
		2 − 5	44	26	56	0	0	0.5	0	3,119,448	459,809	124,778	187,167	3,891,200
Mazabuka 1	1	1 − 1	14	20	4	0	0	0.33	0	1,353,856	199,559	54,154	81,231	1,688,800
		1 − 2	42	20	14	0	0	0.33	0	2,271,765	334,860	90,871	136,306	2,833,800
		1 − 3	68	20	17	0	0	0.33	0	3,055,075	450,320	122,203	183,304	3,810,900
		1 − 4	80	20	19	0	0	0.33	0	3,423,361	504,606	136,934	205,402	4,270,300
	2	2 − 1	26	20	13	0	0	0.33	0	1,799,022	265,177	71,961	107,941	2,244,100
		2 − 2	38	20	23	0	0	0.33	0	2,255,171	332,414	90,207	135,310	2,813,100
		2 − 3	68	20	31	0	0	0.33	0	3,208,834	472,984	128,353	192,530	4,002,700
		2 − 4	73	20	35	0	0	0.33	0	3,397,066	500,730	135,883	203,824	4,237,500
		2 − 5	88	20	40	0	0	0.33	0	3,884,881	572,634	155,395	233,093	4,846,000
		2 − 6	108	20	43	0	0	0.33	0	4,495,030	662,570	179,801	269,702	5,607,100
	3	3 − 1	43	20	18	0	0	0.33	0	2,344,557	345,589	93,782	140,673	2,924,600
		3 − 2	58	20	21	0	0	0.33	0	2,810,406	414,256	112,416	168,624	3,505,700
		3 − 3	66	20	24	0	0	0.33	0	3,074,234	453,144	122,969	184,454	3,834,800
		3 − 4	71	20	26	0	0	0.33	0	3,240,500	477,652	129,620	194,430	4,042,200
		3 − 5	78	20	28	0	0	0.33	0	3,464,486	510,667	138,579	207,869	4,321,600
		3 − 6	86	20	30	0	0	0.33	0	3,717,332	547,937	148,693	223,040	4,637,000
		3 − 7	104	20	33	0	0	0.33	0	4,269,761	629,365	170,790	256,186	5,326,100
		3 − 8	114	20	36	0	0	0.33	0	4,591,310	676,762	183,652	275,479	5,727,200
		3 − 9	120	20	38	0	0	0.33	0	4,786,436	705,524	191,457	287,186	5,970,600

Substation	Feeder	Package	Unit Cost (US$) & Amount							FC (US$)	LC (US$)			Total (US$)
			33kV DL	66kV TL	33/0.4 Tr 100kVA	New SS 2.5MVA	5MVA	10MVA	15MVA	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(40,000)	(13,700)	(600,000)	(800,000)	(1,000,000)	(1,300,000)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Mbereshi 1	1	1 － 1	17	25	31	0	0	0	0.5	2,153,840	317,477	86,154	129,230	2,686,700
		1 － 2	23	25	38	0	0	0	0.5	2,403,880	354,333	96,155	144,233	2,998,600
		1 － 3	53	25	44	0	0	0	0.5	3,335,578	491,666	133,423	200,135	4,160,800
		1 － 4	67	25	47	0	0	0	0.5	3,772,567	556,079	150,903	226,354	4,705,900
		1 － 5	75	25	48	0	0	0	0.5	4,014,430	591,730	160,577	240,866	5,007,600
	2	2 － 1	6	25	15	0	0	0	0.5	1,660,654	244,781	66,426	99,639	2,071,500
		2 － 2	25	25	42	0	0	0	0.5	2,505,532	369,317	100,221	150,332	3,125,400
		2 － 3	36	25	61	0	0	0	0.5	3,031,666	446,869	121,267	181,900	3,781,700
		2 － 4	75	25	69	0	0	0	0.5	4,245,070	625,726	169,803	254,704	5,295,300
		2 － 5	88	25	75	0	0	0	0.5	4,686,147	690,741	187,446	281,169	5,845,500
		2 － 6	111	25	79	0	0	0	0.5	5,393,859	795,058	215,754	323,632	6,728,300
Mfuwe 1	1	1 － 1	11	32	13	0	1	0	0	2,127,706	313,625	85,108	127,662	2,654,100
		1 － 2	28	32	24	0	1	0	0	2,739,137	403,751	109,566	164,348	3,416,800
		1 － 3	32	32	31	0	1	0	0	2,931,457	432,099	117,258	175,887	3,656,700
		1 － 4	48	32	36	0	1	0	0	3,448,132	508,257	137,925	206,888	4,301,200
		1 － 5	51	32	40	0	1	0	0	3,578,644	527,494	143,146	214,719	4,464,000
		1 － 6	80	32	42	0	1	0	0	4,437,550	654,098	177,502	266,253	5,535,400
Mongu 1	1	1 － 1	58	26	22	0	0	0	0.5	3,270,322	482,048	130,813	196,219	4,079,400
		1 － 2	86	26	38	0	0	0	0.5	4,254,129	627,061	170,165	255,248	5,306,600
		1 － 3	94	26	46	0	0	0	0.5	4,572,872	674,044	182,915	274,372	5,704,200
		1 － 4	97	26	53	0	0	0	0.5	4,736,332	698,138	189,453	284,180	5,908,100
		1 － 5	236	26	72	0	0	0	0.5	8,956,550	1,320,201	358,262	537,393	11,172,400
	2	2 － 1	60	26	25	0	0	0	0.5	3,360,991	495,412	134,440	201,659	4,192,500
		2 － 2	64	26	37	0	0	0	0.5	3,608,225	531,855	144,329	216,494	4,500,900
		2 － 3	77	26	46	0	0	0	0.5	4,082,251	601,726	163,290	244,935	5,092,200
		2 － 4	100	26	58	0	0	0	0.5	4,877,826	718,995	195,113	292,670	6,084,600
		2 － 5	136	26	65	0	0	0	0.5	5,993,667	883,470	239,747	359,620	7,476,500
		2 － 6	155	26	71	0	0	0	0.5	6,607,904	974,009	264,316	396,474	8,242,700
		2 － 7	161	26	76	0	0	0	0.5	6,835,979	1,007,628	273,439	410,159	8,527,200
		2 － 8	185	26	80	0	0	0	0.5	7,572,551	1,116,199	302,902	454,353	9,446,000
Mongu 2	1	1 － 1	3	19	22	0	0	0	0.5	1,458,554	214,992	58,342	87,513	1,819,400
		1 － 2	15	19	43	0	0	0	0.5	2,035,514	300,036	81,421	122,131	2,539,100
		1 － 3	42	19	64	0	0	0	0.5	3,045,374	448,890	121,815	182,722	3,798,800
		1 － 4	51	19	66	0	0	0	0.5	3,327,080	490,414	133,083	199,625	4,150,200
	2	2 － 1	31	19	48	0	0	0	0.5	2,552,189	376,194	102,088	153,131	3,183,600
		2 － 2	58	19	70	0	0	0	0.5	3,573,032	526,667	142,921	214,382	4,457,000
		2 － 3	71	19	92	0	0	0	0.5	4,189,835	617,584	167,593	251,390	5,226,400
		2 － 4	93	19	95	0	0	0	0.5	4,857,704	716,029	194,308	291,462	6,059,500

Substation	Feeder	Package	Unit Cost (US$) & Amount							FC (US$)	LC (US$)			Total (US$)
			33kV DL	66kV TL	33/0.4 Tr 100kVA	New SS 2.5MVA	5MVA	10MVA	15MVA	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(40,000)	(13,700)	(600,000)	(800,000)	(1,000,000)	(1,300,000)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Mpika 1	1	1 − 1	74	52.5	31	0	0	0.5	0	4,560,446	672,213	182,418	273,627	5,688,700
		1 − 2	108	52.5	45	0	0	0.5	0	5,695,447	839,512	227,818	341,727	7,104,500
	2	2 − 1	33	52.5	21	0	0	0.5	0	3,267,356	481,610	130,694	196,041	4,075,700
		2 − 2	168	52.5	39	0	0	0.5	0	7,361,151	1,085,038	294,446	441,669	9,182,300
		2 − 3	216	52.5	46	0	0	0.5	0	8,823,313	1,300,562	352,933	529,399	11,006,200
Mpika 2	1	1 − 1	57	78	15	0	1	0	0	4,952,301	729,972	198,092	297,138	6,177,500
		1 − 2	118	78	30	0	1	0	0	6,877,505	1,013,749	275,100	412,650	8,579,000
		1 − 3	124	78	39	0	1	0	0	7,149,511	1,053,842	285,980	428,971	8,918,300
Muzuma 1	1	1 − 1	39	11	16	0	0	0	0.33	1,997,916	294,494	79,917	119,875	2,492,200
		1 − 2	46	11	30	0	0	0	0.33	2,353,696	346,936	94,148	141,222	2,936,000
		1 − 3	100	11	42	0	0	0	0.33	4,043,931	596,078	161,757	242,636	5,044,400
		1 − 4	117	11	49	0	0	0	0.33	4,611,432	679,728	184,457	276,686	5,752,300
		1 − 5	168	11	56	0	0	0	0.33	6,160,173	908,013	246,407	369,610	7,684,200
		1 − 6	306	11	58	0	0	0	0.33	10,164,823	1,498,301	406,593	609,889	12,679,600
		1 − 7	319	11	59	0	0	0	0.33	10,550,986	1,555,222	422,039	633,059	13,161,300
	2	2 − 1	32	11	27	0	0	0	0.33	1,916,707	282,524	76,668	115,002	2,390,900
		2 − 2	118	11	35	0	0	0	0.33	4,486,532	661,318	179,461	269,192	5,596,500
		2 − 3	142	11	43	0	0	0	0.33	5,267,035	776,364	210,681	316,022	6,570,100
	3	3 − 1	40	11	12	0	0	0	0.33	1,982,844	292,273	79,314	118,971	2,473,400
		3 − 2	105	11	15	0	0	0	0.33	3,891,695	573,638	155,668	233,502	4,854,500
		3 − 3	120	11	16	0	0	0	0.33	4,335,578	639,067	173,423	260,135	5,408,200
Muzuma 2	1	1 − 1	66	46	20	0	0	0.5	0	4,000,321	589,650	160,013	240,019	4,990,000
		1 − 2	75	46	27	0	0	0.5	0	4,336,941	639,268	173,478	260,216	5,409,900
		1 − 3	95	46	41	0	0	0.5	0	5,067,901	747,012	202,716	304,074	6,321,700
		1 − 4	114	46	47	0	0	0.5	0	5,682,139	837,551	227,286	340,928	7,087,900
		1 − 5	145	46	49	0	0	0.5	0	6,598,765	972,662	263,951	395,926	8,231,300
	2	2 − 1	12	46	48	0	0	0.5	0	2,749,399	405,263	109,976	164,964	3,429,600
Muzuma 3	1	1 − 1	16	39	25	0	0	0.5	0	2,387,767	351,958	95,511	143,266	2,978,500
		1 − 2	26	39	36	0	0	0.5	0	2,797,178	412,306	111,887	167,831	3,489,200
		1 − 3	39	39	40	0	0	0.5	0	3,216,290	474,083	128,652	192,977	4,012,000
	2	2 − 1	8	39	17	0	0	0.5	0	2,069,024	304,975	82,761	124,141	2,580,900
		2 − 2	15	39	25	0	0	0.5	0	2,358,907	347,704	94,356	141,534	2,942,500
		2 − 3	41	39	29	0	0	0.5	0	3,153,199	464,783	126,128	189,192	3,933,300
		2 − 4	48	39	33	0	0	0.5	0	3,399,150	501,037	135,966	203,949	4,240,100
		2 − 5	54	39	36	0	0	0.5	0	3,605,259	531,417	144,210	216,316	4,497,200
		2 − 6	63	39	39	0	0	0.5	0	3,897,948	574,560	155,918	233,877	4,862,300
Nchelenge 1	1	1 − 1	4	44	9	0	0	0.5	0	2,026,054	298,642	81,042	121,563	2,527,300
		1 − 2	32	44	29	0	0	0.5	0	3,053,792	450,131	122,152	183,228	3,809,300
		1 − 3	46	44	40	0	0	0.5	0	3,578,644	527,494	143,146	214,719	4,464,000
	2	2 − 1	1	44	8	0	0	0.5	0	1,928,491	284,261	77,140	115,709	2,405,600
		2 − 2	49	44	18	0	0	0.5	0	3,423,601	504,641	136,944	205,416	4,270,600
		2 − 3	70	44	42	0	0	0.5	0	4,293,250	632,828	171,730	257,595	5,355,400
		2 − 4	103	44	48	0	0	0.5	0	5,311,528	782,923	212,461	318,692	6,625,600

Substation	Feeder	Package	Unit Cost (US$) & Amount							FC (US$)	LC (US$)			Total (US$)
			33kV DL	66kV TL	33/0.4 Tr	New SS				Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
					100kVA	2.5MVA	5MVA	10MVA	15MVA					
			(36,000)	(40,000)	(13,700)	(600,000)	(800,000)	(1,000,000)	(1,300,000)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Ndola 1	1	1 − 1	4	14	45	0	0	1	0	1,860,269	274,205	74,411	111,616	2,320,500
		1 − 2	7	14	74	0	0	1	0	2,265,352	333,914	90,614	135,921	2,825,800
		1 − 3	16	14	81	0	0	1	0	2,601,972	383,532	104,079	156,118	3,245,700
		1 − 4	20	14	82	0	0	1	0	2,728,395	402,167	109,136	163,704	3,403,400
Mwinilunga 1	1	1 − 1	1	60	24	0	1	0	0	2,857,784	421,239	114,311	171,467	3,564,800
		1 − 2	28	60	36	0	1	0	0	3,768,799	555,523	150,752	226,128	4,701,200
		1 − 3	41	60	40	0	1	0	0	4,187,911	617,301	167,516	251,275	5,224,000
		1 − 4	60	60	43	0	1	0	0	4,769,200	702,983	190,768	286,152	5,949,100
Zambezi 1	1	1 − 1	35	53	12	0	1	0	0	3,482,764	513,362	139,311	208,966	4,344,400
		1 − 2	47	53	22	0	1	0	0	3,938,913	580,598	157,557	236,335	4,913,400
		1 − 3	63	53	29	0	1	0	0	4,477,553	659,994	179,102	268,653	5,585,300
		1 − 4	69	53	35	0	1	0	0	4,716,611	695,231	188,664	282,997	5,883,500
		1 − 5	86	53	37	0	1	0	0	5,229,197	770,787	209,168	313,752	6,522,900
		1 − 6	124	53	38	0	1	0	0	6,336,861	934,057	253,474	380,212	7,904,600
Pensulo 1	1	1 − 1	31	15.5	7	0	0	0.5	0	1,869,408	275,552	74,776	112,165	2,331,900
		1 − 2	40	15.5	14	0	0	0.5	0	2,206,029	325,170	88,241	132,362	2,751,800
		1 − 3	57	15.5	21	0	0	0.5	0	2,773,529	408,820	110,941	166,412	3,459,700
		1 − 4	94	15.5	35	0	0	0.5	0	3,995,110	588,882	159,804	239,707	4,983,500
	2	2 − 1	26	15.5	25	0	0	0.5	0	1,922,799	283,422	76,912	115,368	2,398,500
		2 − 2	34	15.5	32	0	0	0.5	0	2,230,560	328,786	89,222	133,834	2,782,400
		2 − 3	64	15.5	39	0	0	0.5	0	3,173,240	467,738	126,930	190,394	3,958,300
		2 − 4	71	15.5	45	0	0	0.5	0	3,441,158	507,229	137,646	206,469	4,292,500
		2 − 5	87	15.5	51	0	0	0.5	0	3,968,815	585,006	158,753	238,129	4,950,700
Pensulo 2	1	1 − 1	36	51.5	14	0	0	0.5	0	3,244,990	478,314	129,800	194,699	4,047,800
		1 − 2	77	51.5	28	0	0	0.5	0	4,582,011	675,391	183,280	274,921	5,715,600
		1 − 3	115	51.5	35	0	0	0.5	0	5,755,572	848,375	230,223	345,334	7,179,500
		1 − 4	122	51.5	42	0	0	0.5	0	6,034,472	889,485	241,379	362,068	7,527,400
		1 − 5	171	51.5	49	0	0	0.5	0	7,525,493	1,109,262	301,020	451,530	9,387,300
	2	2 − 1	214	51.5	52	0	0	0.5	0	8,799,423	1,297,040	351,977	527,965	10,976,400
		2 − 2	238	51.5	58	0	0	0.5	0	9,557,961	1,408,849	382,318	573,478	11,922,600
		2 − 3	250	51.5	59	0	0	0.5	0	9,915,264	1,461,516	396,611	594,916	12,368,300

Substation	Feeder	Package	Unit Cost (US$) & Amount							FC (US$)	LC (US$)			Total (US$)
			33kV DL	66kV TL	33/0.4 Tr 100kVA	New SS 2.5MVA	5MVA	10MVA	15MVA	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(40,000)	(13,700)	(600,000)	(800,000)	(1,000,000)	(1,300,000)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Samfya 1	1	1 − 1	57	19.5	11	0	0	0.5	0	2,791,967	411,538	111,679	167,518	3,482,700
		1 − 2	77	19.5	17	0	0	0.5	0	3,435,065	506,331	137,403	206,104	4,284,900
		1 − 3	84	19.5	22	0	0	0.5	0	3,691,999	544,203	147,680	221,520	4,605,400
		1 − 4	108	19.5	26	0	0	0.5	0	4,428,571	652,774	177,143	265,714	5,524,200
		1 − 5	127	19.5	30	0	0	0.5	0	5,020,843	740,075	200,834	301,251	6,263,000
	2	2 − 1	1	19.5	13	0	0	0.5	0	1,197,771	176,552	47,911	71,866	1,494,100
		2 − 2	25	19.5	24	0	0	0.5	0	2,011,223	296,456	80,449	120,673	2,508,800
		2 − 3	57	19.5	43	0	0	0.5	0	3,143,418	463,342	125,737	188,605	3,921,100
Samfya 2	1	1 − 1	28	19	33	0	0	0.5	0	2,180,616	321,424	87,225	130,837	2,720,100
		1 − 2	66	19	39	0	0	0.5	0	3,343,194	492,789	133,728	200,592	4,170,300
		1 − 3	70	19	45	0	0	0.5	0	3,524,531	519,518	140,981	211,472	4,396,500
	2	2 − 1	16	19	21	0	0	0.5	0	1,702,501	250,950	68,100	102,150	2,123,700
		2 − 2	24	19	31	0	0	0.5	0	2,043,210	301,170	81,728	122,593	2,548,700
Senanga 1	1	1 − 1	1	118	16	0	0	1	0	4,790,123	706,067	191,605	287,407	5,975,200
		1 − 2	184	118	50	0	0	1	0	10,444,925	1,539,589	417,797	626,696	13,029,000
		1 − 3	232	118	68	0	0	1	0	12,027,898	1,772,920	481,116	721,674	15,003,600
		1 − 4	266	118	76	0	0	1	0	13,097,002	1,930,506	523,880	785,820	16,337,200
Senanga 2	1	1 − 1	8	11	12	0	0.5	0	0	1,036,075	152,718	41,443	62,165	1,292,400
		1 − 2	20	11	19	0	0.5	0	0	1,459,275	215,098	58,371	87,557	1,820,300
		1 − 3	52	11	27	0	0.5	0	0	2,470,659	364,177	98,826	148,240	3,081,900
	2	2 − 1	24	11	14	0	0.5	0	0	1,519,801	224,020	60,792	91,188	1,895,800
		2 − 2	38	11	24	0	0.5	0	0	2,033,670	299,764	81,347	122,020	2,536,800
Senanga 3	1	1 − 1	30	11.5	39	0	0	0	0.5	2,183,983	321,920	87,359	131,039	2,724,300
		1 − 2	87	11.5	63	0	0	0	0.5	4,092,593	603,251	163,704	245,556	5,105,100
	2	2 − 1	18	11.5	36	0	0	0	0.5	1,804,714	266,016	72,189	108,283	2,251,200
		2 − 2	46	11.5	50	0	0	0	0.5	2,766,554	407,792	110,662	165,993	3,451,000
		2 − 3	140	11.5	66	0	0	0	0.5	5,655,123	833,569	226,205	339,307	7,054,200
Sesheke 1	1	1 − 1	37	107	9	0	1	0	0	5,239,137	772,252	209,566	314,348	6,535,300
		1 − 2	62	107	16	0	1	0	0	6,037,518	889,934	241,501	362,251	7,531,200
		1 − 3	120	107	22	0	1	0	0	7,777,297	1,146,378	311,092	466,638	9,701,400
		1 − 4	154	107	28	0	1	0	0	8,824,435	1,300,727	352,977	529,466	11,007,600
		1 − 5	164	107	33	0	1	0	0	9,167,949	1,351,362	366,718	550,077	11,436,100
		1 − 6	253	107	36	0	1	0	0	11,769,440	1,734,823	470,778	706,166	14,681,200
		1 − 7	274	107	39	0	1	0	0	12,408,450	1,829,013	496,338	744,507	15,478,300
		1 − 8	293	107	41	0	1	0	0	12,978,756	1,913,077	519,150	778,725	16,189,700
Sesheke 2	1	1 − 1	95	45	17	0	1	0	0	5,012,747	738,882	200,510	300,765	6,252,900
		1 − 2	437	45	32	0	1	0	0	15,047,619	2,218,029	601,905	902,857	18,770,400
		1 − 3	450	45	35	0	1	0	0	15,455,748	2,278,187	618,230	927,345	19,279,500
		1 − 4	477	45	40	0	1	0	0	16,289,883	2,401,139	651,595	977,393	20,320,000

7.6. Discussion on Low Cost Electrification

7.6.1. Present Situation

We had a discussion with REA and ZESCO, and following contents were confirmed.

- Commission year's demand is used for distribution system design.
- As for the voltage calculation for distribution line, it is carried out by hand calculation by ordinary. In case more detailed calculation is needed, PSS/E (Power System Simulation for Engineers) is used.
- The design and construction of distribution line is carried out according to the ZESCO standard. This standard was established referring to British standard (BS).
- To reduce the distribution cost, SWER (Single Wire Earth Return) system is adopted in a part of distribution system.
- Some conductor disconnection accidents were occurred by the thunder.

7.6.2. Present Situation

Based on the result of present situation, following contents were proposed.

- If distribution system is designed by using the commission year's demand, it has a possibility to construct new distribution line shortly after new distribution line construction is finished. Therefore, it is necessary to make the distribution system reasonable in consideration of the future plan (future demand, distribution system planning around the target area), distribution system loss and so on.
- Distribution line route will be selected in consideration of distance, road condition, geographical condition, etc. In addition, distribution system will be expanded and constitute the complex network in the future, and some loads of substation may be shift to other substations or construct new substation. Depending on this situation, it is recommended to adopt the software that could carry out distribution analysis easily base on the map information system. The following table shows the comparison of some kinds of software.
- The facility cost of SWER is cheaper, but this it is easy to cause the unbalance of phase current by this system. Therefore, it is necessary to adjust the load on each phase to control the phase current.
- As the ground wire is not applied to 33kV distribution line, the conductor disconnection by the thunder is occurred in some area. Therefore, it is necessary to collect and analyse the accident data, and compare the total cost of facility cost and O&M cost in the case of with or without ground wire. If the total cost is reduced in the case of with ground wire, it is recommended to modify the existing facilities in that area.

	Software	SynerGEE Electric	CYMDIST	PSS/ADEPT	PSS/Engines
	Company	ADVANTICA (USA)	CYME (Canada)	Shaw Power Technologies International (USA)	Shaw Power Technologies International (USA)
	System Modeling	Stand-Alone	Stand-Alone	Stand-Alone	Enterprise-Wide (Application Programming Interface)
	PC Requirement	Windows NT/2000/XP Intel Pentium II or higher	Windows 95/98/ME/NT/2000/XP Pentium based CPU	Windows ME/2000/XP	-
	User Interface	Geographical Background	Geographical Background	One-Line Diagram	-
Loss Reduction	Load Flow Analysis	Basic Module	Basic Module	Basic Module	Basic Module
	Load Balancing	Basic Module	Basic Module	-	-
	Optimal Switching (System Reconfiguration)	Switching Module (Add-on Module)	Switching Optimization Module (Add-on Module)	Tie Open Point Optimization (Add-on Module)	Tie Open Point Optimization (Add-on Module)
	Optimal Capacitor Placement	Basic Module	Basic Module	Capacitor Placement Optimization (Add-on Module)	Capacitor Placement Optimization (Add-on Module)
	Re-Conductoring	-	Basic Module	Basic Module	Basic Module
	Re-Phasing	-	Basic Module	-	-
	Geographic Information System (GIS)	Middle Link(Add-on Module)	Geographic Map Overlay Module (Add-on Module)	-	Basic Module
Functions	Line Property Calculation	Basic Module	Basic Module	Line Properties Calculator(Add-on Module)	Line Properties Calculator(Add-on Module)
	Load Scaling	Basic Module	Basic Module	-	Load Scaling(Add-on Module)
	Load Growth Study	Basic Module	Basic Module	-	-
	RMS Fault Analysis	Basic Module	Basic Module	Basic Module	Basic Module
	Contingency Analysis (System Restoration)	Switching Module (Add-on Module)	Contingency Analysis Module (Add-on Module)	-	-
	Protection and Coordination	Protection Coordination (Add-on Module)	CYMTCC (Add-on Module)	Protection and Coordination (Add-on Module)	Protection and Coordination (Add-on Module)
	Reliability Analysis	Basic Module(Only Basic Analysis)/ Predictive Reliability(Add-on Module)	Reliability Assessment Module (Add-on Module)	Distribution Reliability Analysis (Add-on Module)	Distribution Reliability Analysis (Add-on Module)
	Motor Starting Analysis	Motor Start Analysis(Add-on Module)	Basic Module	Basic Module	Basic Module
	Harmonic Analysis	Additional Module	Harmonic Analysis Module(Add-on Module)	Harmonics(Add-on Module)	Harmonics(Add-on Module)
	Optimal Voltage Regulator Placement	-	-	-	Voltage Regulator Placement Optimization (Add-on Module)
	Time Based Load Modeling	Basic Module	-	-	-
	GIS Data Format	AutoDesk - AutoCAD(.dxf and .dwg) ESRI - ArcView(.shp) Bentley Systems - Microstation(.dgn) MapInfo - MapInfo(.mif) Raster file formats - .tiff / .jpg / .bmp	AutoDesk - AutoCAD(.dxf and .dwg) ESRI - ArcView(.shp) Bentley Systems - Microstation(.dgn) Intergraph - GeoMedia GE Energy - SmallWorld Raster file formats - .bmp	Raster file formats - .tiff / .jpg / .bmp	Several kinds of GIS data format (unidentified)
	Remarks	SynerGEE Electric has users around the world, particularly Philippines in Asia. This tool includes functions needed for Loss Reduction and GIS. ADVANTICA provides Gas distribution, Electric and Petroleum software. They are dominant position in the US Gas distribution software market.	CYMDIST is recommended as the most suitable tool for distribution analysis by Oak Ridge National Laboratory (USA) in their technical report. A utility has handled up to 250,000 sections and 3.4 million customers with CYMDIST. CGI-CYME totally develops Electrical Engineering tools.	PSS/ADEPT creates one-line diagram for distribution system analysis, which is commonly used for transmission system analysis. PTI totally develops Electrical Engineering tools.	PSS/Engines must be embedded in enterprise-wide system, which means that this tool is application programming interface (API) and does not have user interface. API prepares the tools for each analysis, so programmer is not needed to be experts in that field. However, user needs to built user interface themselves.

Chapter 8

Micro-Hydropower Generation Planning

Chapter 8. Micro-Hydropower Generation Planning

8.1. Current Status of Micro-Hydropower Development

In Zambia, there already exist some micro-hydropower plants (hereinafter referred to as “Mc-HPs”) as shown in Chapter 3. These Mc-HPs, located in a remote area far from ZESCO’s distribution lines, are operated by local cooperatives for supplying electricity to local hospitals, clinics, schools, farm, and so on. In the Rural Electrification Master Plan Study, development of Mc-HPs like that is considered to be an option to enhance rural electrification in some remote areas in Zambia.

According to the estimate of some preceding studies, Zambia has a potential of hydropower generation of more than 6,000 MW and only 1,700MW out of that has been developed so far. However, not many Mc-HP projects to serve rural electrification have been discussed so far, with some exceptions like “Chitokoloki Mission” and “Zengamene” projects that REA selected for REF release in 2006 (refer to Table 3-2). This modest approach toward Mc-HPs shows a clear contrast with the case of large hydropower development to be connected to the national grid, where many projects have come up for consideration in these days, and some of them will possibly be realized, for improving the country’s supply-demand balance that has become seriously tight due to the rapid growth of domestic electricity consumption such as the recovery of mining sector.

8.2. Data Collection

8.2.1. Rainfall Data

Table 8-1 shows the annual rainfall data at 39 meteorological stations that are monitored by Zambia Meteorological Department (ZMD). The locations of these stations are plotted in Figure 8-1. “Rainfall” in this table indicates the average of past 30 years (1963-1992), and these data are extracted from GIS database that REA obtained from ZMD. This database shall be incorporated into the Rural Electrification GIS database in this REMP Study.

Table 8-1 Rainfall Data (1963-1992 average)

Station	Longitude (E)	Latitude (S)	Rainfall (mm)	Station	Longitude (E)	Latitude (S)	Rainfall (mm)
Chipata	32.58	13.57	980.4	Mansa	28.85	11.10	1179.2
Chipepo	27.88	16.80	776.5	Mbala	31.33	8.85	1202.4
Choma	27.07	16.85	770.7	Mfuwe	31.93	13.27	810.8
Isoka	32.63	10.17	1086.2	Misamfu	31.22	10.18	1330.7
Kabompo	24.20	13.60	1040.6	Mkushi	29.80	13.60	1178.4
Kabwe Met	28.48	14.42	901.4	Mongu	23.17	15.25	914.4
Kabwe Agro	28.50	14.40	878.2	Mpika	31.43	11.90	993.6
Kafironda	28.17	12.63	1274.8	Msekera	32.57	13.65	1010.3
Kafue	27.92	15.77	746.3	Mtmakulu	28.32	15.55	878.2
Kalabo	22.70	14.95	807.8	Mumbwa	27.07	14.98	820.6
Kaoma	24.80	14.80	904.5	Mwinilunga	24.43	11.75	1390.4
Kasama	31.13	10.22	1309.5	Ndola	28.66	13.00	1185
Kasempa	25.83	13.47	1155.4	Petauke	31.28	14.25	967.8
Kawambwa	29.25	9.80	1361.9	Samfya	29.32	11.21	1478.7
Livingstone	25.82	17.82	637.1	Senanga	23.27	16.12	727
Lundazi	33.20	12.28	874.2	Serenje	30.22	13.23	1058.7
Lusaka Hq	28.32	15.42	821.5	Sesheke	24.30	17.47	627.7
Lusaka Airport	28.43	15.32	934	Solwezi	26.38	12.18	1341.9
Lusitu	28.82	16.18	534.7	Zambezi	23.12	13.53	1022.3
Magoye	27.63	16.13	715.1				

Source: ZMD

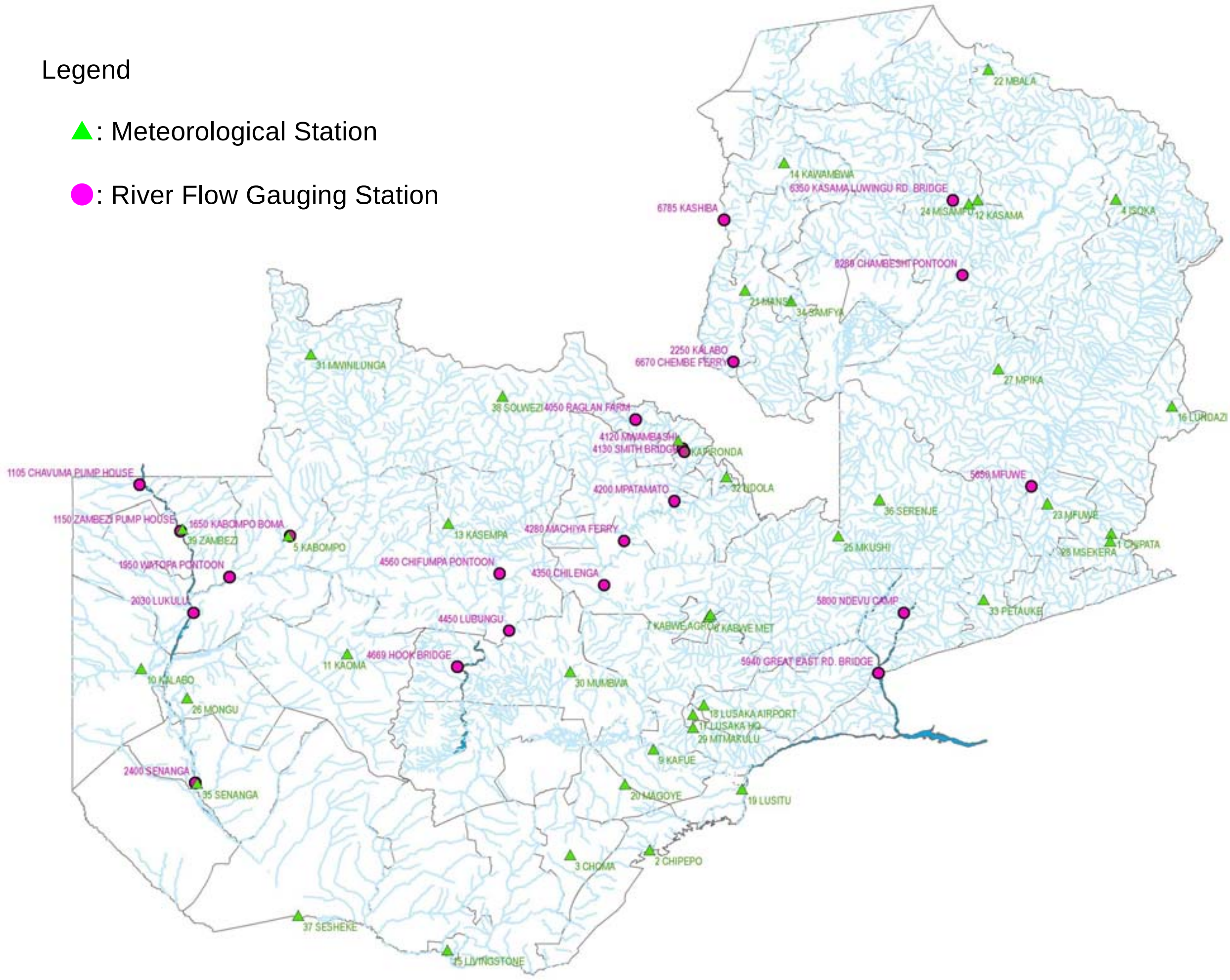


Figure 8-1 Location of Meteorological Stations and River Flow Gauging Stations

8.2.2. River Flow Data

Table 8-2 shows the river flow data at 24 measuring stations, monitored by the Department of Water Affairs (DWA) of MEWD. These data are in principal the average of past 10 years (Oct. 1996-Sep. 2006), though many measuring stations have missing periods more or less. 4 stations (marked with * in the table) have no data at all during this period, thus they are substituted by the river flow data during 1963- 1992, which are found in the study report of the National Water Resources Master Plan in the Republic of Zambia, 1995, by JICA. The locations of these stations are plotted in Figure 8-1.

Table 8-2 River Flow Data (Oct.1996 – Sep.2006)

Station Number	Name of Station	East Longitude	South Latitude	Catchment Area [km^2]	Monthly Mean discharge [m^3/s]												Flow Regime [m^3/s]			Anunual Runoff [mil m^3]
					Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Max.	Min.	Ave.	
ZAMBEZI RIVER																				
1105	Chavuma Pump House	13: 5	22:41	75,967	434	439	463	538	652	720	729	577	505	476	455	442	974	423	530	16,729
1150	Zambezi Pump House	13:33	23: 6	87,275	46	50	91	290	658	1818	1762	538	322	174	91	61	2976	35	726	22,910
1650	Kabompo Boma	13:36	24:13	42,740	141	152	198	286	350	394	401	252	204	182	168	154	518	108	216	6,814
1950	Watopa Pontoon	14: 1	23:36	67,261	62	65	110	257	351	510	412	167	122	104	87	69	882	42	195	6,162
2030	Lukulu	14:23	23:14	206,531	183	190	310	717	1569	1943	1915	982	479	348	277	222	2727	134	829	26,157
2250	Kalabo	11:50	28:44	123,072	10	7.5	7.5	11	30	88	95	98	77	46	33	17	165	5.1	38	1,205
2400	Senanga	16: 7	23:15	284,538	236	245	341	583	1029	1822	2293	2123	1177	608	404	300	2941	163	902	28,441
KAFUE RIVER																				
4050	Raglan Farm	12:25	27:44	5,775	3.1	2.8	9.4	41	79	112	98	25	15	10	6.5	3.9	474	0.5	34	1,085
4120	Mwambashi	12:43	28:13	827	3.1	1.3	4.2	16	19	21	13	4.6	2.8	2.2	1.5	1.1	48	0.1	8.3	262
4130	Smith Bridge	12:45	28:14	8,914	14	14	41	95	166	171	129	77	34	26	21	15	284	6.8	81	2,553
4200	Mpatamato	13:15	28: 8	12,001	9.4	14	60	174	261	253	163	66	41	31	22	15	430	5.8	91	2,862
4280	Machiya Ferry	13:39	27:37	23,065	16	17	53	159	233	248	195	97	58	60	50	22	485	11	90	2,851
4350	* Chilenga	14: 6	27:25	34,451	29	32	77	199	347	479	445	260	121	77	56	39	571	92	179	5,650
4450	Lubungu	14:34	26:27	55,962	23	23	72	206	338	444	327	275	105	63	46	34	790	5.8	160	5,043
4560	Chifumpa Pontoon	13:59	26:21	20,999	29	28	44	112	129	189	159	71	50	47	40	34	417	17	83	2,632
4669	Hook Bridge	14:56	25:55	96,239	32	28	64	238	442	651	528	290	131	90	71	53	1614	12	219	6,922
LUANGWA RIVER																				
5650	* Mfuwe	13: 6	31:46	73,422	55	56	185	487	813	800	469	212	133	100	80	64	1610	34	181	8,894
5800	* Ndevu Camp	14:23	30:28	55,488	21	31	208	638	1232	888	446	165	83	56	37	24	3329	11	327	10,270
5940	Great East Rd. Bridge	*15:00*	*30:12*	140,922	43	42	200	1098	784	1084	768	266	154	107	76	55	3240	12	471	14,864
CHAMBESHI RIVER																				
6289	Chambeshi Pontoon	10:57	31: 4	34,745	20	18	46	118	207	268	253	178	109	65	43	30	847	4.6	113	3,549
6350	Kasama Luwingu Rd. Bridge	10:11	30:58	6,504	22	26	50	87	98	110	110	59	42	36	29	27	310	10	59	1,860
6670	Chembe Ferry	11:50	28:44	123,072	257	241	366	410	537	598	665	667	604	471	431	331	1660	9.5	466	14,699
6785	* Kashiba	10:23	28:38	161,275	237	195	265	536	1068	1758	1741	1295	931	712	488	323	2012	174	741	26,044

Source: DWA

Note: Data of the stations with asterisk (*) during the said period was not available thus was substituted with 1963-1992 data from the Study Report on the National Water Resources Master Plan in the Republic of Zambia (JICA, 1995)

8.2.3. Hydropower Potential for Electrification

Table 8-3 shows the list of unelectrified RGCs in the priority list that may have a waterfall in the neighbourhood, and the distance to the waterfall. This information was obtained from District Planners through the Rural Electrification Workshop held in each Provincial centre. There are two main conditions to determine the existence of hydropower potential, namely the certain volume of water flow and the effective elevation gain of waterfall thus the information regarding the existence of waterfall around the unelectrified RGCs indicates the possibility of electrification through micro-hydropower. This table suggests that North-western, Northern, and Luapula Province may have a lot of Micro-hydropower potential sites.

Table 8-3 Distance from Unelectrified RGCs to the Nearest Waterfall

Province	District	Name of RGC	Distance [km]
North-western	Chavuma	Chivombo	30
		Sanjongo	3
		Lukolwe	11
		Chinwandumba	17
		Kalombo	15
		Kakhoma	9
		Kamisamba	19
		Kambuya	18
		Mandalo	1
		Chambi	2
		Mukelangombe	28
	Mwinilunga	Ntambu	7
		Ikelenge	0
		Nyakaseya	7
		Kanyama	15
		Chisengi	20
		Kanongesha	7
		Jimbe	24
		Saluj	27
		Samteba	10
		Kafweku	15
		Lwakela	5
		Kawiku	20
	Zambezi	Chitokoloki	26
		Mpidi	15
		Dipalata	5
		Ishima	2
		Katontu	5
		Lukunyi	5
		Kayenge	0.5
		Milomboyi	4
		Mwange	10
		Matondo	3
		Likungu	2
North-western	Zambezi	Liyovu	0.5
		Chinyingi	0.4
		Muyembe	1
		Kashona	1
Northern	Isoka	Kafwimbi	30
	Kasama	Lukulu North	5
		Namakwi	1
		Chilubula	1.7
		Chishimba	0.05
	Mporokoso	Mukupakaoma	1
		Chiwala	10
		Chishamwamba	6
	Mungwi	Kayambi	2
		Kalulu	2
		Nsampa	2
		Chisau	2
		C/Weyaya	2
	Nakonde	Chilolwa	0.5
Luapula	Kawambwa	Chibote	20
		Mukuma	10
		Kalamba	11.2
		Township	18.2
	Milenge	Musolo	5
	Mwense	Chama	20
		Mubamba	2
Lusaka	Kafue	Tukunka	0
Southern	Choma	Kanchomba	2
	Livingstone	Mulala	8
		Majeledi	7
		Simwizi	9
		Sakurita	4
Western	Kaoma	Mangango	1
	Shang'ombo	Sioma	10

Source: Information obtained from District Planners through Provincial Workshop, November 2006

8.3. Review of Existing Hydropower Development Plans

8.3.1. On-grid Hydropower Development Plans

Existing plans of on-grid HPP projects are listed in Table 8-4 and the location of these sites is plotted in Figure 8-2. The numbering in the table corresponds to that in the map.

Table 8-4 Planned On-grid HPP Projects

No.	Name of Site	Province	Output [MW]	Estimated Cost [million US$]	Expected Construction Period
1	Kabompo Gorge	North-western	34	78	2009-2012
2	Itezhi-Tezhi	Southern	120	150	2009-2013
3	Batoka Gorge	Southern	1600	3,000	
4	Devil's Gorge	Southern	1600	3,000	
5	Kariba North (Extension)	Southern	1080(+360)	255	2008-2010
6	Kafue Gorge Lower	Southern	750	740	2010-2014
7	Mumbotuta Falls	Luapula	301	483	
8	Mambilima Falls	Luapula	326	674	
9	Kalungwishi	Northern	218	570	2009-2013
10	Lusiwasi (Extension)	Central	62(+50)	80	
11	Musonda Falls (Extension)	Luapula	7.5(+2.5)	10	
12	Chishimba Falls (Extension)	Northern	9.6(+3.6)	15	
13	Lunzua Falls (Extension)	Northern	10(+9.25)	23	

Source: ZESCO

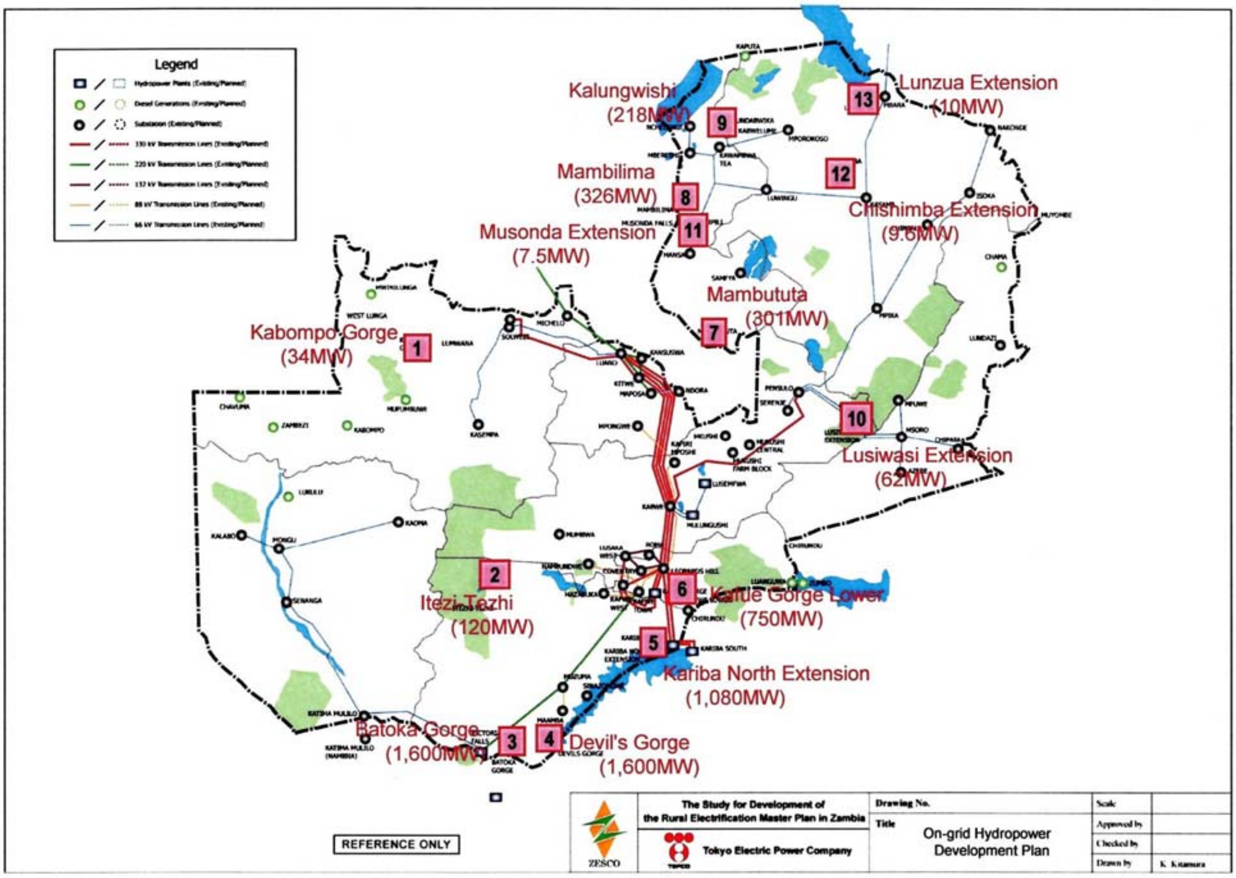


Figure 8-2 Location of On-grid HPP Project Sites

The outline of projects in the list is as follows:

(1) Kabompo Gorge Project

Kabompo Gorge site is located in south of Mwinilunga District, North-western Province, and the project is a development of 34MW hydropower plant on Kabompo River. NORPLAN, a Norwegian consultant, implemented pre-feasibility study in 2000 in collaboration with ZESCO. OPPPI wants to finish the bid for feasibility study and construction works up to end of November 2007. Then it is expected to complete the feasibility study in 2008, to implement the construction works from 2009 to 2012.

(2) Itezi-Tezhi Project

The existing Itezhi-Tezhi dam is located on the Kafue River, about 350 km west of Lusaka. The project consists of installing 2 units of 60MW generators, and the estimated cost is about 150 million US$. This Hydropower plant will be connected to the national grid at Muzuma substation in Southern Province via 330 kV transmission lines. To carry out this development, ZESCO and TATA Africa Holdings signed on a Memorandum of Understanding on Nov. 2006 and they will form a special purpose vehicle company called Itezhi-Tezhi Power Corporation Limited. This new plant was originally planed to supply electricity from the end of 2009, but the project has not made great progress yet, and now it is still on the detail design and financing stage. Based on the latest information from OPPPI, the construction works will be implemented from 2009 to 2013.

(3) Batoka Gorge Project

Batoka Gorge site is located on the border with Zimbabwe, Southern Province, and the project is 1,600MW hydropower plant scheme using the rich water of Zambezi River. Feasibility study was executed in 1993 by ZESCO and ZESA, power utility of Zimbabwe. Because of the site location on the international border, both Zambian and Zimbabwean Government plans to develop this potential in collaboration, and the 1,600MW of generation capacity will be shared in halves by them, which gives additional 800MW generation capacity to Zambian national grid. Zambezi River Authority possesses the right for the development of this site, but the there is no remarkable progress after the feasibility study.

(4) Devil's Gorge Project

Devil's Gorge site on Zambezi River is located about 100km downstream of Batoka Gorge site. The site also has 1,600MW of generation capacity, which will be shared in halves by Zambian and Zimbabwean Government. Zambezi River Authority also possesses the right for the development of this site, but any study has not been done, and the schedule of the development has been left vacant.

(5) Kariba North Bank Project

ZESCO plans to expand existing 600MW Kariba North Bank hydropower plant (the total capacity after ongoing rehabilitation would be 720MW). The scope of the project is to add two more turbine-generator units with 180MW each. Then KNB-HP will have six unit of 180MW and its total capacity will be 1,080MW. This construction works are expected to start 2008, and to be finished by 2010 funded by Chinese Government.

(6) Kafue Gorge Lower Project

The site of Kafue Gorge Lower project is located on 65 km upstream of the confluence of Kafue River and Zambezi River, and 2 km away from the existing KG-PS. The feasibility study of this project was completed in 1995 by Harza Engineering Company. This study report suggested the installation of 4 units of 150MW turbine-generators, but ZESCO later upgraded this to 5 units of 150MW. Now the candidate site of the development has been changed from the site reported in the feasibility study, OPPPI plans to hire a consultant and to start feasibility study for the new site in early 2008 supported by IFC, International Finance Cooperation.

(7) Mumbotuta Falls Project

Mumbotuta Falls site is located in the south end of Luapula Province on the border with Republic of Congo. This is the project to develop 301MW hydropower plant on Luapla River. HARZA implemented pre-feasibility study in 2001, but there is no progress after the study. Figure 8-3 shows a picture of Mumbotuta Falls.

Figure 8-3 Picture of Mumbotuta Falls

(8) Mambilima Falls Project

Mambilima Falls site on Luapula River is located at about 110km northwest of Mansa District centre, the capital of Luapula Province, on the border with Republic of Congo. Along with Mumbotuta Falls Project, HARZA implemented pre-feasibility study in 2001, but there is no progress after the study. Two sites are introduced in this study report. Their potentials of power generation are evaluated at 124MW and 202MW, and the costs for developments are estimated at 174 million US$ and 500 million US$ respectively. The total potential and project cost of these two sites are indicated on Table 8-4.

(9) Kalungwishi Project

Kalungwishi project consists of 135MW Kundabwika Falls site and 83MW Kabwelume Falls site, which are located on Kalungwishi River in northwest of Mporokoso District, and the total potential of hydropower generation is 218MW. Feasibility study was conducted by HARZA in 2000, which reported that total potential of these two sites was 163MW. OPPPI revised the study recently and upgraded the potential up to 218MW with 570 million US$ of project cost including 170 million US$ of transmission line cost. Now the project is getting forward by Luzua Power Authority, Zambian private company. They are planning to start the construction works from 2009 and to complete the works by 2013.

(10) Upgrade of ZESCO's Four Small Hydropower Plants

ZESCO owns four small hydropower plants, which are described in Chapter 3.3.1(2), and ZESCO has plans to upgrade all of them. Pre-investment study for these extension/renovation projects was implemented in 1997 by Knight Piesold, and ZESCO is planning to update this study in early 2008. In this study report, some options for each hydropower plant are indicated, and Table 8-5 shows the summery of these options.

Table 8-5 Existing Plan of Extension/Renovation of Four Small Hydropower Plants

Name	Lusiwasi	Musonda	Chishimba	Lunzua
Existing Capacity	12MW	5MW	6MW	0.75MW
Number of Unit	3MW x 4	1MW x 5	A: 1.2MW x 4 B: 0.3MW x 4	0.25MW x 3
Option 1	Installation of 20MW x 2 units to existing plant	Upgrade of existing units up to 1.25MW x 5 units, and installation of additional 1.25MW x 1 unit	Installation of 0.3MW x 1 unit to B station	Installation of 0.25MW x 1 unit to existing plant
Cost [million US$]	60.5	10.1	3.9	1.3
Option 2	Development of upper site, installing 5MW x 2units		Replacing 0.3MW x 4units of A station with 0.75MW x 2 units, plus existing B station	Replacing existing 0.25MW x 3 units with 1MW x 1 unit
Cost [million US$]	19.5		4.7	1.6
Option 3			Abolition of A station and reconstruction with 2.4MW x 2 units, plus existing B station	Abolition of existing plant and reconstruction with 5MW x 2 units
Cost [million US$]			15.0	23.0
Upgraded Capacity (Maximum Case)	62MW (Option 1+2)	7.5MW (Option 1)	9.6MW (Option 3)	10MW (Option 3)

Source: ZESCO

8.3.2. Off-grid Hydropower Development Plans

Existing plans of off-grid HPP projects are listed in Table 8-6, and the location of these sites is plotted in Figure 8-4. The numbering in the table corresponds to that in the map.

Table 8-6 Planned Off-grid HPP Projects

No.	Name of Site	Province	District	Output [MW]	Estimated Cost [million US$]
1	Chavuma Falls	North-western	Chavuma	15	20.0
2	Chikata Falls	Northwestern	Kabompo	3.5	13.1
3	West Lunga	Northwestern	Mwinilunga	2.0	5.8
				2.5	7.2
4	Mwinilunga	Northwestern	Mwinilunga	1.5	Site1: 7.0 Site2: 4.5
5	Chitokoloki Mission	Northwestern	Zambezi	0.15	0.3
6	Shiwang'andu	Northern	Chinsali	1.0	1.4

Source: DoE, ZESCO, and Mwinilunga Ventures Ltd.

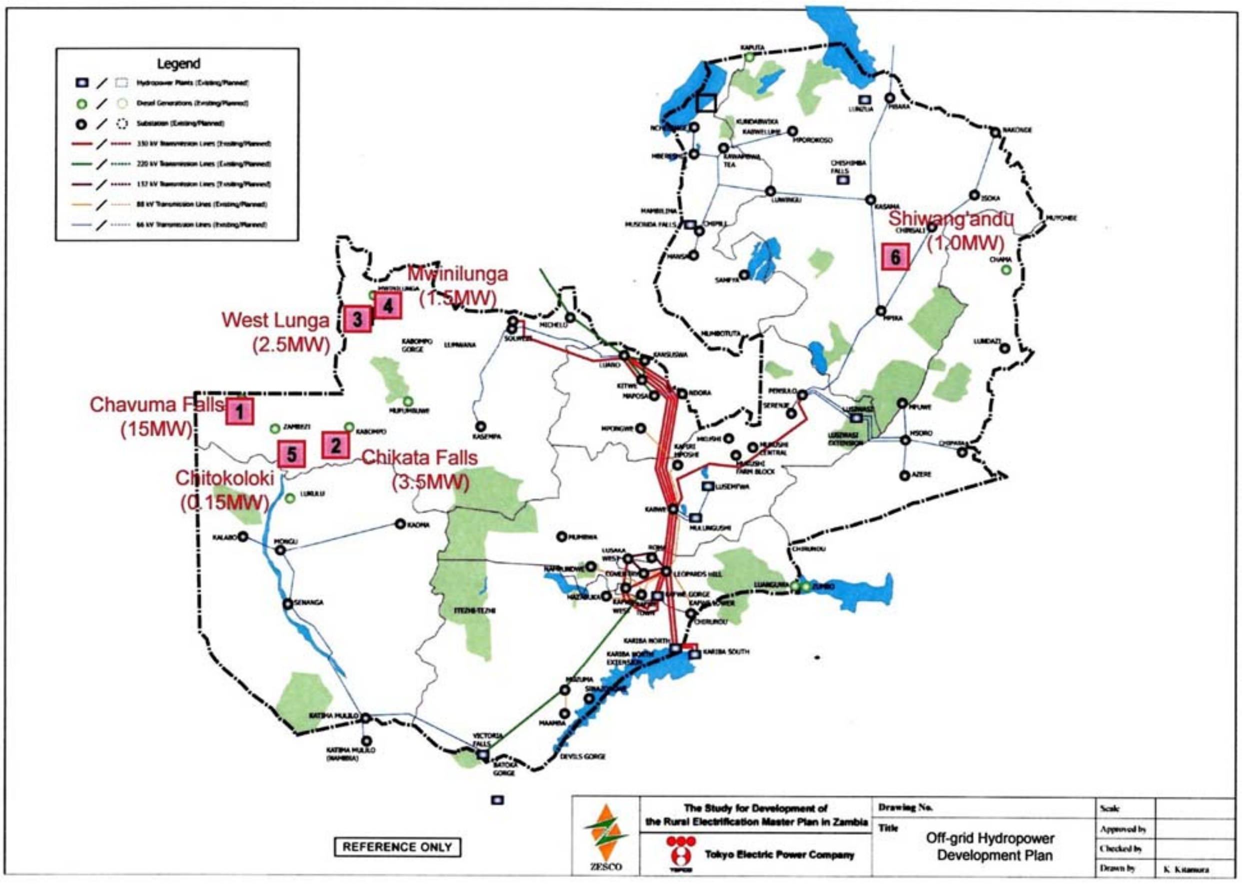


Figure 8-4 Locations of Off-grid HPP Project Sites

The outline of some projects in the list is as follows:

(1) Chavuma Falls Project

The potential generation capacity and the cost on Table 8-6 were provided by ZESCO, but no further information was not given. Yet, this project site was visited in October 2007 by Mr. Charles Rea who is an independent consultant in Mwinilunga hired by the Study Team for hydropower potential survey and also a developer of existing Zengamina Hydropower Plant. The following information was provided by him.

There are two possible sites, namely Chanda Falls and Chavuma Falls. Chanda Falls has a head of 13.5m, which gives 2 to 3MW in the wet season with rich river flow of 10 to 20 m^3/s. The existing diesel generator could supplement the shortage of output in the dry season. Additional development of Chavuma Falls site has a possibility to be an alternative to this backup diesel generator. Chavuma Falls site has a river flow of about $50m^3/s$ even in the dry season, and the head of 7m is available with 5m-height weir, which gives 3MW in the dry season. But the length of the weir would be about 200m and it cost about 2.5 million US$, which would raise the total project cost. The problem is that the tail water level rises leaving only about 2m net head during 2 month in the wet season. Therefore, both two sites should be developed and supplement each other during each low generation period. Figure 8-5 shows a picture of Chavuma Falls.

Figure 8-5 Picture of Chavuma Falls

(2) Chikata Falls Project

Chikata Falls is located on Kabompo River about 5km north of Kabompo District centre. NORPLAN, a Norwegian consultant, implemented pre-investment study in 2000 in collaboration with ZESCO, and SMEC, Australia's consulting engineering firms, carried out pre-feasibility study in 2007. This is a 3.5MW run-of-river type hydropower project, and the project cost was reported 12 million US$. This project is expected to be the alternative to the existing diesel power plant in Kabompo District centre. Figure 8-6 shows a picture of the site.

Figure 8-6 Picture of Chikata Falls

(3) West Lunga Project

West Lunga Project is considered as the best alternative to existing diesel power plant supplying electricity to Mwinilunga District centre. The site is located about 7.5km downstream from the Mwinilunga Road Bridge on West Lunga River. NORPLAN also implemented pre-investment study in 2000 for low-head run-of-river scheme in collaboration with ZESCO. Two alternatives with separate dam site are reported in this study: one has 2.0MW of generation capacity with 5.8 million US$ of construction cost, and the other has 2.5MW with 7.2 million US$.

(4) Mwinilunga Project

This is a 1.5 MW hydropower scheme near the Mwinilunga Boma, and is expected to help reducing the area’s dependence on diesel generation. Enprima Ltd., Finnish consultant, conducted the feasibility study in 2004. There are 2 possible sites for this project, one is Kanyikomboshi and the other is Kakobakani, which are respectively at the distance of 6.5km and 15 km downstream from the road bridge in Mwinilunga town. The estimated project costs of Kanyikomboshi and Kakibakani are 7.2 million US$ and 4.5 million US$ respectively.

(5) Chitokoloki Mission Project

Chitokiloki Mission Hospital is situated on the east bank of Zambezi River, 40km south of Zambezi. Since ZESCO’s distribution lines have not reached this Mission Hospital yet, the hospital is operating its own 105kW diesel generator only in the limited time, from 11:00 to12:00 and from 18:00 to 21:30, for pumping up water and working medical device such as X-ray. The hospital plans to install 2 units of water turbines (100-150kW) by UEK Corporation, USA, in order to reduce the fuel cost and make electricity available 24 hours. Chitokoloki Mission and UEK Corporation prepared the proposal of this project and submitted to DoE, which was taken over to REA and was selected as one of REF release projects (K100 million) in 2006.

(6) Shiwang’andu Project

Shiwang’andu is located 120km north of Mpika. The plan of installing mini-hydro pilot plant is a part of the project named “Renewable Energy Based Electricity Generation for Isolated Mini-Grids”, which is implemented by United Nations Industrial Development Organization (UNIDO) and Global Environment Facility (GEF) and consists of 3 pilot plants powered by mini-hydro, solar and biomass. The total cost is estimated at 7.5 million US$ (out of which 1.4 million US$ is budgeted for the hydropower plant). For financing this cost, however, 2.75 million US$ of co-financing from private investors is requested, which might be the highest barrier to actualise the project. The generation capacity of the hydropower plant is designed as 1,000 kW, considering the water flow of 11m^3/sec and the gross elevation gain of 12m. Figure 8-7 shows pictures of Shiwang’andu Project site.

Figure 8-7 Pictures of Shiwang’andu Project Site

8.4. Hydropower Potential Survey

The purpose of the Hydropower Potential Survey is to estimate the amount of hydropower generation potential and the development cost. Hydropower potential surveys were mainly implemented in North-western, Northern and Luapla Provinces, where the national grid has not been developed enough and also where is relatively rich difference of elevation. Since Western Provincial Planner submitted the information of some small falls, the Study Team conducted the additional survey in Western Province following the information.

The surveys were implemented separately in two phases; the first survey was for North-western and Western Provinces, and the second survey was for Northern and Luapula Provinces. The targets of potential site are determined based on the information from Counterparts, Local Government and Local Consultants in addition to the map study on the 1:50,000 scale topographic map.

8.4.1. Method of Hydropower Potential Estimation

(1) Water Head Measurement

Hydropower potential is in proportion of the water head, therefore, measuring the gross water head is one of the main issue of this survey. The study team decide the place of intake and tailrace, and measure the elevation along the river with total station to estimate the gross head of the site. Here, effective head, which is used to hydropower potential calculation, is set at 90% of gross head.

(2) Design Discharge Estimation

Water discharge is another component of hydropower potential. To design the generation capacity, it is quite essential to figure out the average water flow amount in the dry season. However, the site does not have any flow gauging equipment. Therefore, the study team estimates the river flow of the site by the following method.

i) Obtain the river flow data at the nearest gauging station located downstream of the site [River flow A].

ii) Acquire the catchment area of the gauging station [Catchment area A], which are usually included by the database of gauging station itself.

iii) Figure out the catchment area of the actual site [Catchment area B] using 1:50,000 topographic maps.

iv) Calculate the waterflow at the site [River flow B] by the following equation;

[River flow A]: [River flow B]= [Catchment area A]: [Catchment area B],

Therefore, [River flow B]= [River flow A] [Catchment area B]/ [Catchment area A*]

After conversion of the existing river flow data into the discharge of the actual site, the study team draws a duration curve for each site, figures water flow of 80% availability (more than 80% days in a year, water flow is more than this amount), and makes it the design discharge for the site.

(3) Hydropower Potential Estimation

Hydropower potential can be calculated by the following equation;

$$P=9.8*Q*H*\eta_T*\eta_G$$

Here, P: Generating Power [kW]

Q: Water Discharge [m^3/s]

H: Effective Head [m]

η_T: Turbine Efficiency

η_G: Generator Efficiency

In this potential estimation, the study team fixes the turbine efficiency and generator efficiency at 85% and 95% respectively, which are considered as a reasonable figure given the present technical circumstances.

(4) Construction Cost Estimation

The study them roughly designs the general layout for good hydropower potential sites and estimates the length of weir, channel, penstock, tailrace, spillway and distribution line. Based on this basic design, the construction cost is calculated. Design conditions are as follows:

- Civil facilities are mainly structured by stone masonry
- Ratios of common excavation and rock excavation are 20% and 80%, respectively
- Turbine and generator are Cross-flow turbine manufactured in Europe, which are frequently adopted to existing small hydropower plant in Zambia
- Voltage of distribution line is thirty-three (33) kV

Table 8-7 shows the unit price of each item, which is based on the actual price in the Zengamina Mini-hydropower Project in Mwinilunga, and information from ZESCO and REA. The costs of 33kV distribution line and 33kV/400V Transformer are following the costs determined in Table 7-3, Chapter 7.

Table 8-7 Unit Price

Item	Unit Price
Access Road	US$ 30,000 /km
Road maintenance	US$ 3,000
Masonry	US$ 150 /m^3
Concrete	US$ 600 /m^3
Rebar	US$ 1,400 /t
Tunnel boring	US$ 1,000 /m
Common Excavation	US$ 10 /m^3
Rock Excavation	US$ 60 /m^3
Steel structure	US$ 2,800 /t
33kV distribution line	US$ 36,000 /km
33kV/400V Transformer (100MVA)	US$ 13,700 /unit

After calculation of direct cost for construction, engineering service cost, overhead cost and Profit margin are tacked on the direct cost at 8%, 25% and 20% of direct cost respectively. These percentages are decided following the discussion with REA.

8.4.2. Results of Hydropower Potential Survey

(1) North-western Province

The hydropower potential survey in North-western Province was carried out from 24th May to 30th May. The study team found out nine (9) hydropower potential sites. The locations of the surveyed hydropower potential sites are shown in Figure 8-8. The results of the survey are described as follows.

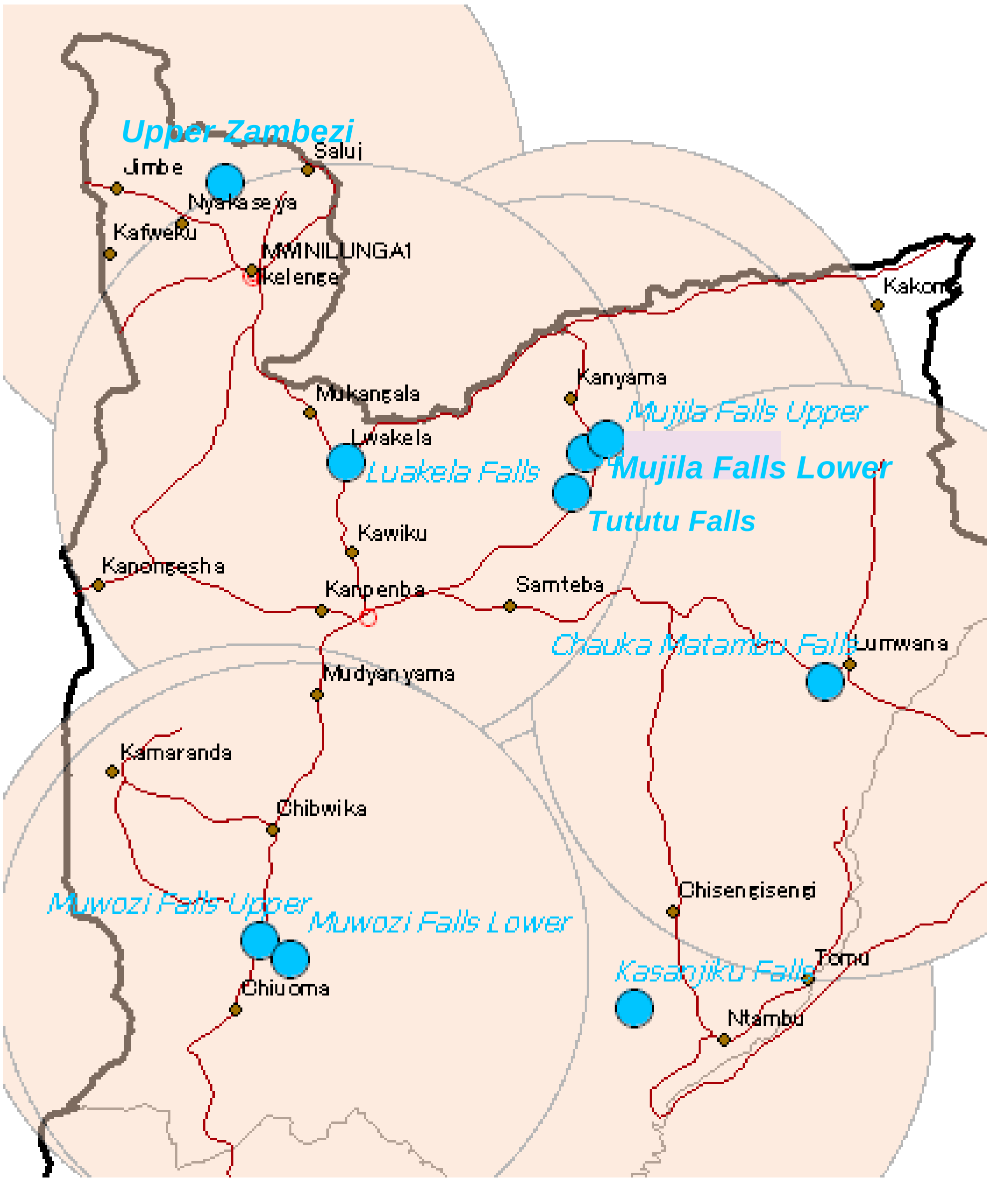


Figure 8-8 Location of Hydropower Potential Site in Northwestern Province

(a) Upper Zambezi Site

Upper Zambezi Site is located about 75 km north of the centre of Mwinilunga District, on the uppermost stream of Zambezi River. There is Zengamina Hydropower Plant (700kW, here after Zengamina HP) at only 4.5km downstream of this site. The survey was implemented on 24th May 2007, and the water flow was about 10m^3/s with 9m gross head. Since the water flow at 80% availability is 6.44m^3/s on the flow duration curve (Figure 8-9), which was edited by the Study Team, the designed discharge should be 6.0m^3/s and then the potential generation capacity is estimated at 380kW. Figure 8-10 shows pictures of this site.

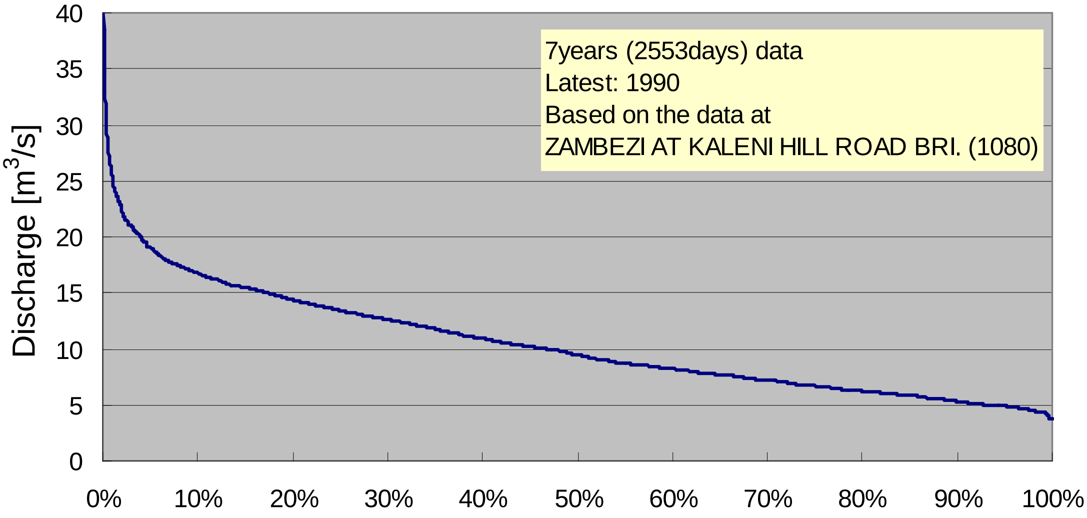


Figure 8-9 Flow Duration Curve at Upper Zambezi Site

a) Main falls

b) Water channel on the right bank

c) View from head tank to powerhouse

Figure 8-10 Pictures of Upper Zambezi Site

Zengamina Power Company, which owns the Zengamina HP, has already been planning to develop this site with a dam of 10m height. Thanks to this additional height of dam, they estimated that the potential generation capacity of this site is 1,000kW with 18m effective head and 8.0m^3/s designed discharge and the project cost is about USD 3.0 million. Furthermore, since they will be able to use water more effectively due to this planned dam, they also want to install another 700 kW unit to existing Zengamina HP and to expand its total capacity up to 1,400kW.

Existing Zengamina HP supplies electricity to Ikelenge RGC (potential demand: 1,995kW), which is located 4.5km south of Zengamina HP and Nyakaseya RGC (potential demand: 483kW), which is located 14km northwest of Ikelenge RGC via 33kV distribution line. However, due to the large potential demand of these areas, it is quite possible that electricity consumption there exceeds the 700kW capacity of Zengamina HP in the near future. Therefore, it is really effective option to develop Upper Zambezi Site and to connect to Zengamina HP. There is no household and firms in influenced area by construction works, so the environmental issue would not be a barrier of the development. The Study Team estimated development cost of this potential as a run-of-river type, 380kW hydropower plant. Table 8-8 shows the summery of this site.

Table 8-8 Project Summery of Upper Zambezi Site

[Design Result]

Province	Northwestern
District	Mwinilunga
Name of the Site	Upper Zambezi
Name of the River	Zambezi River
Latitude	S11:06:18
Longitude	E24:13:41
Catchment Area	698 km^2
80% available discharge	6.44 m^3/s
Design Discharge	6.0 m^3/s
Gross Head	9.0 m
Effective Head	8.0 m
Generation Capacity	380 kW
Volume of Powerhouse	362 m^3
Volume of Weir	216 m^3
Length of Channel	142 m
Length of Penstock	47 m
Length of Tailrace	30 m
Length of Spillway	60 m
Length of Distribution Line	4.5 km

[Electrified Area]

Ikelenge RGC	1995 kW
Nyakaseya RGC	483 kW

[Project Cost Estimation]

I. Construction Cost	1,496,720 US$
i) Temporary Works	224,360 US$
ii) Civil Engineering	677,860 US$
iii) Turbine, Gen and Main Transformer	364,000 US$
iv) Distribution Line & Transformer	230,500 US$
II. Engineering Service Cost	119,738 US$
III. Overhead Cost	374,180 US$
IV. Profit Margine	299,344 US$
Grand Total	2,289,982 US$

(b) Mujila Falls Lower Site

Mujila Falls Lower (hereafter MFL) Site is on Mujila River, which is a tributary to West Lunga River and is located 45km northeast of Mwinilunga District centre. The water flow as of 25th May 2007 was about 15m^3/s. The river has several falls within a span of 400m stream, therefore 18m gross head will be available including the height of 5m weir. The upstream of the planned weir is depression contour, so this could be a natural reservoir after the construction of the weir. Therefore, though its water flow at 80% availability at the site is 9.21m^3/s from the flow duration curve (Figure 8-11), designed discharge can be set at 10.0m^3/s. Due to this head and discharge, maximum generation capacity of 1,400kW will be achieved.

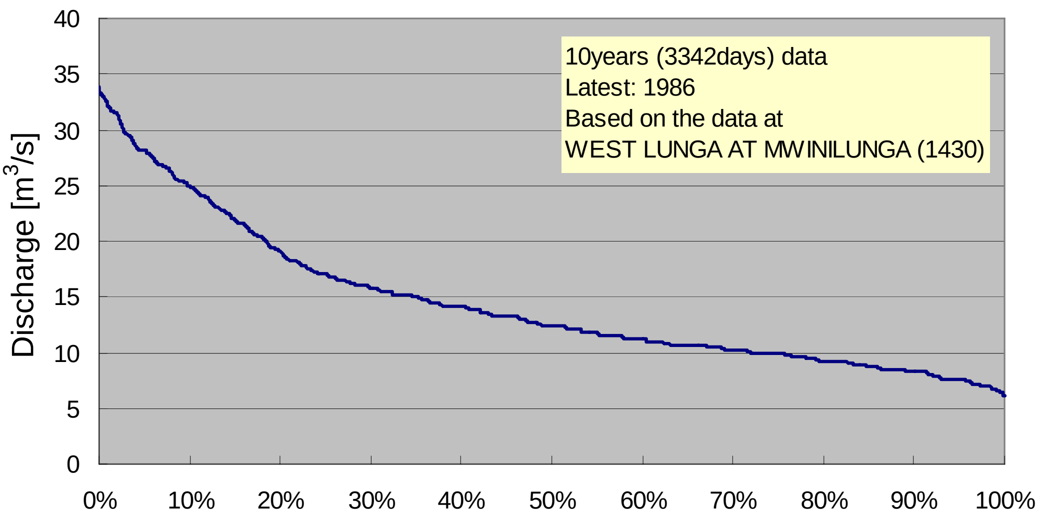


Figure 8-11 Flow Duration Curve at Mujila Falls Lower Site

Figure 8-12 shows pictures of MFL site. As Mujila River is bending to the left toward downstream after the weir, so direct distance from the weir to the end of the rapids on the left bank is only about 270m. However, since the left bank of the river is a steep hill, it is recommended to make a non-pressure tunnel conduit from intake to head tank. Due to this effort, the length of penstock will become shorter and the project cost will be smaller.

a) Mujila falls lower

b) Overview of the site

c) Depression contour for natural reservoir

Figure 8-12 Pictures of Mujila Falls Lower Site

Possible demand sites are Kanyama RGC (potential demand: 598kW) at about 10km north of MFL site and Kakoma RGC (potential demand: 350kW), located near the border with Congo, 60km east from Kanyama RGC. The potential of MFL site is too much for only these two RGCs. But there are two important villages along the main road within catchment area of Kanyama RGC. One is Mujila Village, located on the way from the falls to Kanyama RGC. This village has about 200 households and the Mujila Falls Agriculture Centre, whose potential demand is 234kW. The other is Kapundu Village, located about 10km south from the falls. This village also have 200 households, an elementary school, and a clinic, whose potential demand is 233kW. The total demand of these two RGCs and two villages is 1,415kW, which is nearly equal to the potential of generation capacity. Therefore, to maximize the benefit of MFL site development, these two villages should be included in the electrified area.

The site is located in the valley, and there is no household and firms to be influenced by the development. The left bank of the river would be opened up to create water tunnel and a powerhouse, so the trees in the hill of left bank must be cut off. Nevertheless, the environmental issue would not be a barrier of the development. The Study Team estimated development cost of this potential. Table 8-9 shows the summery of this site.

Table 8-9 Project Summery of Mujila Falls Lower Site

[Design Result]

Province	Northwestern
District	Mwinilunga
Name of the Site	Mujila Falls Lower
Name of the River	Mujila River
Latitude	S11:30:52
Longitude	E24:46:24
Catchment Area	1,146 km^2
80% available discharge	9.21 m^3/s
Design Discharge	10.0 m^3/s
Gross Head	18.0 m
Effective Head	17.1 m
Generation Capacity	1,400 kW
Volume of Powerhouse	596 m^3
Volume of Weir	450 m^3
Length of Channel	210 m
Length of Penstock	23 m
Length of Tailrace	20 m
Length of Spillway	36 m
Length of Distribution Line	98 km

[Electrified Area]

Kanyama RGC	598 kW
Kakoma RGC	350 kW
Mujila Village	234 kW
Kapundu Village	233 kW

[Project Cost Estimation]

I. Construction Cost	6,393,200 US$
i) Temporary Works	404,070 US$
ii) Civil Engineering	1,070,230 US$
iii) Turbine, Gen and Main Transformer	1,158,000 US$
iv) Distribution Line & Transformer	3,760,900 US$
II. Engineering Service Cost	511,456 US$
III. Overhead Cost	1,598,300 US$
IV. Profit Margine	1,278,640 US$
Grand Total	9,781,596 US$

(c) Mujila Falls Upper Site

Mujila Falls Upper (hereafter MFU) Site is located 4.4km upstream of MFL site (shown above) on Mujila River. The water flow as of 25th May 2007 was about 8m^3/s. There are several falls within a span of 100m stream, which gives in total 14m gross head including steep downstream and the weir to be installed. The flow duration curve at this site (Figure 8-13) indicates that its water flow at 80% availability is 4.14m^3/s, and the potential generation capacity of this site is estimated at 420kW assuming that the designed discharge is 4.0m^3/s. Figure 8-14 shows pictures of MFU site.

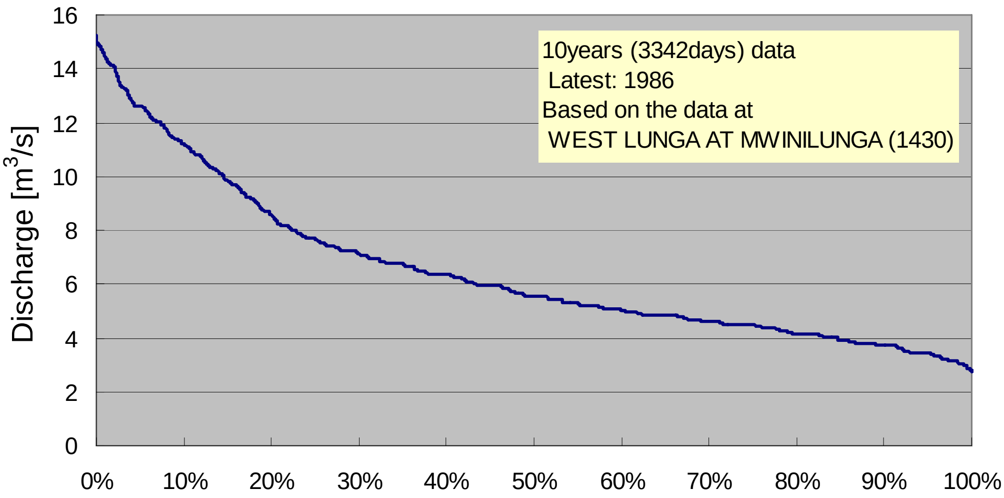


Figure 8-13　Flow Duration Curve at Mujila Falls Upper Site

a) Mujila falls upper

b) Upstream of the falls

Figure 8-14　Pictres of Mujila Falls Upper Site

MFU site, with its rich hydropower potential and ease of construction, appears to be highly suitable for hydropower development. However, possible demand sites to be electrified with MFU site, which will be Kanyama and Kakoma RGCs, will overlap with those for MFL site.

Furthermore, since the potential generation capacity of MFL site is much more than that of MFU site and only developing MFL site is enough to supply electricity to these two RGCs, the development of MFU site is less prioritized than MFL site. The development of MFU site might be considered in case the total power demand of this area exceeds the generation capacity of MFL site in the future.

There are five households and their livestock farm beside the site. The structures of hydropower plant will not affect their lives but the access road and the noise of construction work will influence them. But these issues will not discourage against the development because they are ambitious of using electricity to enhance the efficiency of their firm management. The Study Team estimated development cost of this potential. Table 8-10 shows the summery of this site.

Table 8-10 Project Summery of Mujila Falls Upper Site

[Design Result]

Province	Northwestern
District	Mwinilunga
Name of the Site	Mujila Falls Upper
Name of the River	Mujila River
Latitude	S11:29:32
Longitude	E24:48:25
Catchment Area	515 km^2
80% available discharge	4.14 m^3/s
Design Discharge	4.0 m^3/s
Gross Head	14.0 m
Effective Head	13.2 m
Generation Capacity	420 kW
Volume of Powerhouse	393 m^3
Volume of Weir	180 m^3
Length of Channel	78 m
Length of Penstock	36 m
Length of Tailrace	19 m
Length of Spillway	47 m
Length of Distribution Line	11 km

[Electrified Area]

Kanyama RGC	598 kW

[Project Cost Estimation]

I. Construction Cost	1,479,720 US$
i) Temporary Works	157,900 US$
ii) Civil Engineering	466,320 US$
iii) Turbine, Gen and Main Transformer	391,000 US$
iv) Distribution Line & Transformer	464,500 US$
II. Engineering Service Cost	118,378 US$
III. Overhead Cost	369,930 US$
IV. Profit Margine	295,944 US$
Grand Total	2,263,972 US$

(d) Tututu Falls Site

Tututu Falls Site is located at 7km south of MFL site on Kapundu River that is a tributary to Mujila River. The water flow as of 25th May 2007 was only about 1.5m^3/s, so designed discharge should be 1.0m^3/s at most. And as gross head there is 4.0m, potential generation capacity would be only 30kW. Figure 8-15 shows a picture of this site.

Kapundu village, which is one of surrounding villages of Kanyama RGC, exists beside Tututu Falls Site. These villages are out of the scope of this Rural Electrification Master Plan, but to electrify Kapundu village would be significant because it has about 200 households, an elementary school and a clinic. However, it is unnecessary to develop this site because the potential demand of this village can be easily covered by the potential generation capacity of MFL site

Figure 8-15 Picture of Tututu Falls Site

(e) Kasanjiku Falls Site

Kasanjiku Falls Site is located about 80km southeast of Mwinilunga District centre on Kasanjiku River, which is a tributary to Kabompo River. The water flow as of 26th May 2007 was 10m^3/s and its gross head is 10m including 4m height of weir to be installed. The flow duration curve at this site (Figure 8-16) indicates that its water flow at 80% availability is 4.63m^3/s. Therefore, the potential generation capacity of this site is estimated at 320kW assuming that the designed discharge is 4.5m^3/s. Figure 8-17 shows pictures of Kasanjiku Falls Site. The banks of the river are covered by bushes, which must be cut off in construction stage. But there are no household and firms to be influenced by the development of the site.

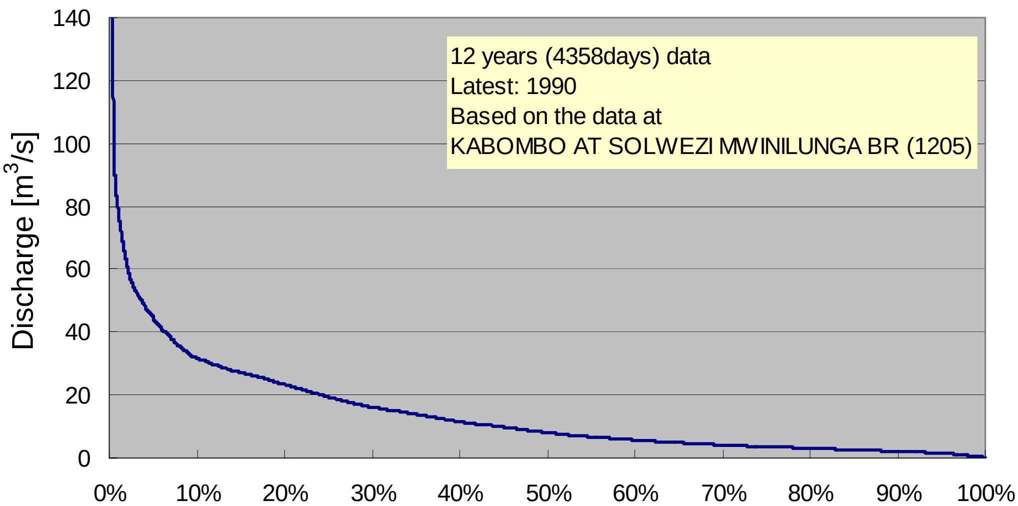


Figure 8-16 Flow Duration Curve at Kasanjiku Falls Site

a) Kasanjiku falls

b) Upstream of the falls

c) Downstream of the falls

Figure 8-17 Pictures of Kasanjiku Falls Site

Possible demand site to be electrified is Ntanbu RGC (potential demand: 532kW), which is located at 15km southeast from this site. Ntanbu RGC has the new Luwi Hospital, which was funded by Korean government, and was ranked as the first priority on the Mwinilunga RGC list for the willingness to be electrified. The potential generation capacity of Kasanjiku Falls Site will not fully satisfy the potential demand of Ntanbu RGC, but it is enough to satisfy the present potential demand. Additionally, Ntanbu RGC is located quite far from District centre where 66kV transmission line will be extended by ZESCO in the future. Those are the reason why the hydropower potential of Kasanjiku Falls Site is still attractive to be developed. The Study Team estimated the construction cost and Table 8-11 shows the summery of the project.

Table 8-11 Project Summery of Kasanjiku Falls Site

[Design Result]

Province	Northwestern
District	Mwinilunga
Name of the Site	Kasanjiku Falls
Name of the River	Kasanjiku River
Latitude	S12:21:10
Longitude	E24:50:55
Catchment Area	1,605 km^2
80% available discharge	4.63 m^3/s
Design Discharge	4.5 m^3/s
Gross Head	10.0 m
Effective Head	9.0 m
Generation Capacity	320 kW
Volume of Powerhouse	314 m^3
Volume of Weir	180 m^3
Length of Channel	231 m
Length of Penstock	44 m
Length of Tailrace	10 m
Length of Spillway	69 m
Length of Distribution Line	22 km

[Electrified Area]

Ntambu RGC	532 kW

[Project Cost Estimation]

I. Construction Cost	2,301,150 US$
i) Temporary Works	470,850 US$
ii) Civil Engineering	659,500 US$
iii) Turbine, Gen and Main Transformer	324,000 US$
iv) Distribution Line & Transformer	846,800 US$
II. Engineering Service Cost	184,092 US$
III. Overhead Cost	575,288 US$
IV. Profit Margine	460,230 US$
Grand Total	3,520,760 US$

(f) Chauka Matambu Falls Site

Chauka Matambu Falls Site is located 80km east of Mwinilunga District centre on West Lumuwana River, which is a tributary to Kabompo River. The accessibility of the site is very good because the site is situated only 3km south from Solwezi-Mwinilunga main road. The main falls has 6m drop and another fall on 200m downstream has 3m drop, which gives 11m of gross head including the height of low weir. The water flow as of 28th May 2007 was 4m^3/s, and the flow duration curve at this site (Figure 8-18) indicates that its water flow at 80% availability is 2.64m^3/s. Therefore, the potential generation capacity would be estimated at 180kW assuming 2.5m^3/s of designed discharge. Figure 8-19 shows pictures of Chauka Matambu Falls Site. The bushes on the left bank must be opened due to the construction works, and there is a Filicales firm on the left bank near the proposed place for powerhouse. In addition, access road for the site will cross the Lumuwana RGC. Therefore, the environmental impact of the development should be discussed before the site is developed.

Possible potential site is Lumuwana RGC (potential demand: 370kW), which is situated just beside the main road and has greatly grown recently due to pineapple plantations. Though its potential demand in 2030 will exceed the potential generation capacity, the potential of Chauka Matambu Falls Site can satisfy the current potential demand and is situated close to the demand site. Therefore, to develop this hydropower potential and to electrify only the plantations and public facilities can accelerate the further growth of this area. The Study Team estimated the project cost and Table 8-12 shows the summery of the project.

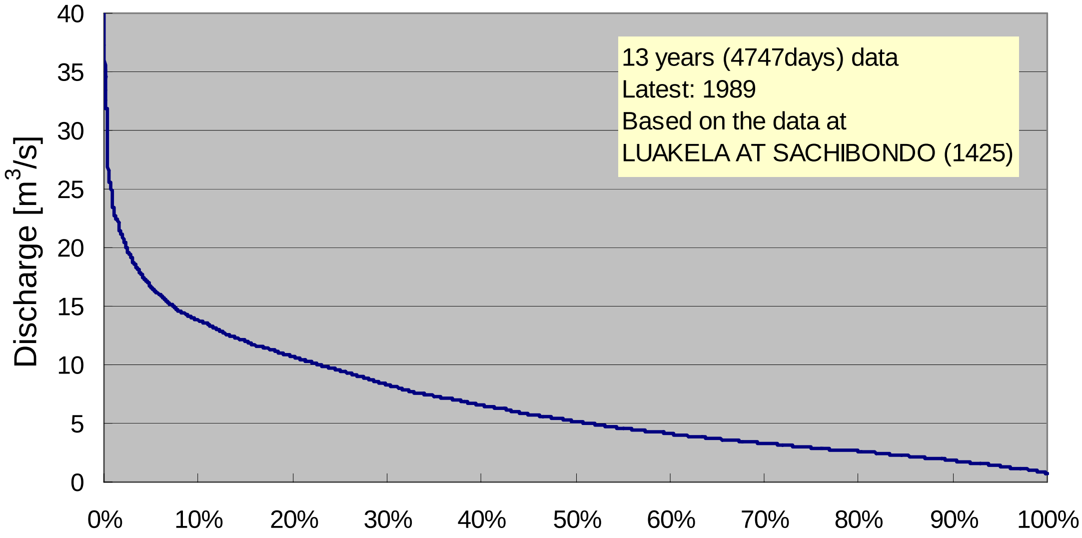


Figure 8-18　Flow Duration Curve at Chauka Matambu Falls Site

a) Main falls

b) Lower falls

Figure 8-19　Pictures of Chauka Matambu Falls Site

Table 8-12 Project Summery of Chauka Matambu Falls Site

[Design Result]

Province	Northwestern
District	Mwinilunga
Name of the Site	Chauka Matambu Falls
Name of the River	West Lumuwana River
Latitude	S11:51:34
Longitude	E25:08:13
Catchment Area	537 km^2
80% available discharge	2.64 m^3/s
Design Discharge	2.5 m^3/s
Gross Head	11.0 m
Effective Head	9.1 m
Generation Capacity	180 kW
Volume of Powerhouse	197 m^3
Volume of Weir	600 m^3
Length of Channel	175 m
Length of Penstock	235 m
Length of Tailrace	25 m
Length of Spillway	40 m
Length of Distribution Line	6 km

[Electrified Area]

Lumwana RGC	371 kW

[Project Cost Estimation]

I. Construction Cost	1,306,780 US$
i) Temporary Works	269,930 US$
ii) Civil Engineering	549,750 US$
iii) Turbine, Gen and Main Transformer	230,000 US$
iv) Distribution Line & Transformer	257,100 US$
II. Engineering Service Cost	104,543 US$
III. Overhead Cost	326,695 US$
IV. Profit Margine	261,356 US$
Grand Total	1,999,374 US$

(g) Lwakela Falls Site

Luakela Falls Site is located about 25km north of Mwinilunga District centre on Luakela River, which is a tributary to West Lunga River. The water flow as of 28th May 2007 was 5m^3/s and the gross head is 7m with a simple low weir. The flow duration curve at this site (Figure 8-20) indicates that its water flow at 80% availability is 2.14m^3/s. Therefore, the potential generation capacity of this site is estimated at 100kW assuming that the designed discharge is 2.0m^3/s. Figure 8-21 shows a picture of Lwakela Falls Site.

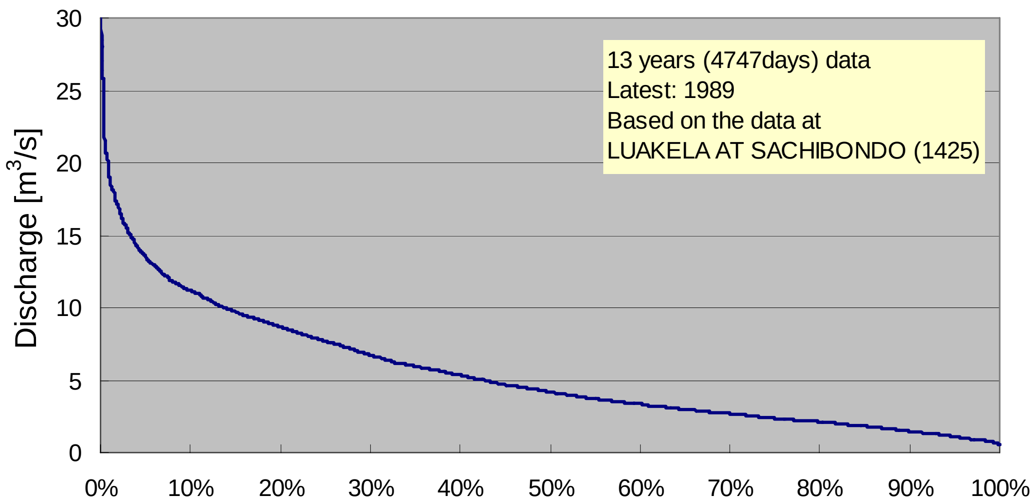


Figure 8-20 Flow Duration Curve at Luakela Falls Site

Figure 8-21　Picture of Lwakela Falls Site

There is Lwakela RGC (potential demand: 257kW) only 0.5km northwest of this site. The potential generation capacity is much less than the potential demand, and this RGC can be cheaply connected to the national grid after ZESCO realize the plan of transmission line extension to Mwinilunga District centre. Therefore, there is no necessity to develop this site.

(h) Muwozi Falls Upper Site

Muwozi Falls Upper Site is located about 60km south of Mwinilunga District centre on Muwozi River that is a tributary to West Lunga River. Its gross head is 4m and the discharge as of 29th May 2007 was only $1.5m^3/s$. The discharge would be designed at most $1.0m^3/s$ considering the low flow in the dry season, and the potential generation discharge would be estimated at 30kW. Figure 8-22 shows a picture of Muwozi Falls Upper Site.

Chiwoma RGC (potential demand: 418kW) is located 6km south of the falls. The potential generation capacity is much less than the demand and the effectiveness of the hydropower development is extremely low.

Figure 8-22　Picture of Muwozi Falls Upper Site

(i) Muwozi Falls Lower Site

Muwozi Falls Lower Site is located about 6km downstream of Muwozi Falls Upper Site. Its gross head is 5m and the discharge as of 29th May 2007 was only 1.5m^3/s. The discharge would be designed at most 1.0m^3/s considering the low flow in the dry season, and the potential generation discharge would be estimated at 35kW. Figure 8-23 shows a picture of Muwozi Falls Lower Site.

Nearest demand site is also Chiwoma RGC (potential demand: 418kW). The potential generation capacity is too small compared with the demand and there is no reason to develop this site.

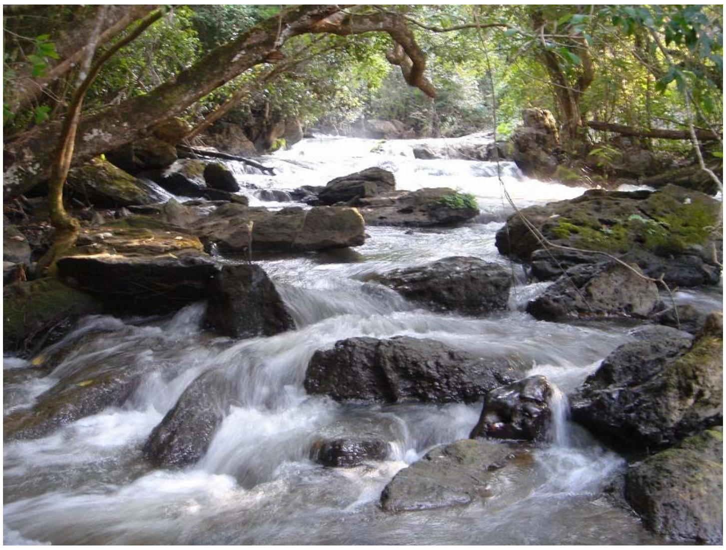


Figure 8-23 Picture of Muwozi Falls Lower Site

(2) Northern and Luapula Provinces

The hydropower potential survey in Northern and Luapula Provinces was carried out from 4th August to 11th August 2007. The study team found out eleven hydropower potential sites during this period. The locations of the surveyed hydropower potential sites are shown in Figure 8-24. The results of the survey for each site are described as follows.

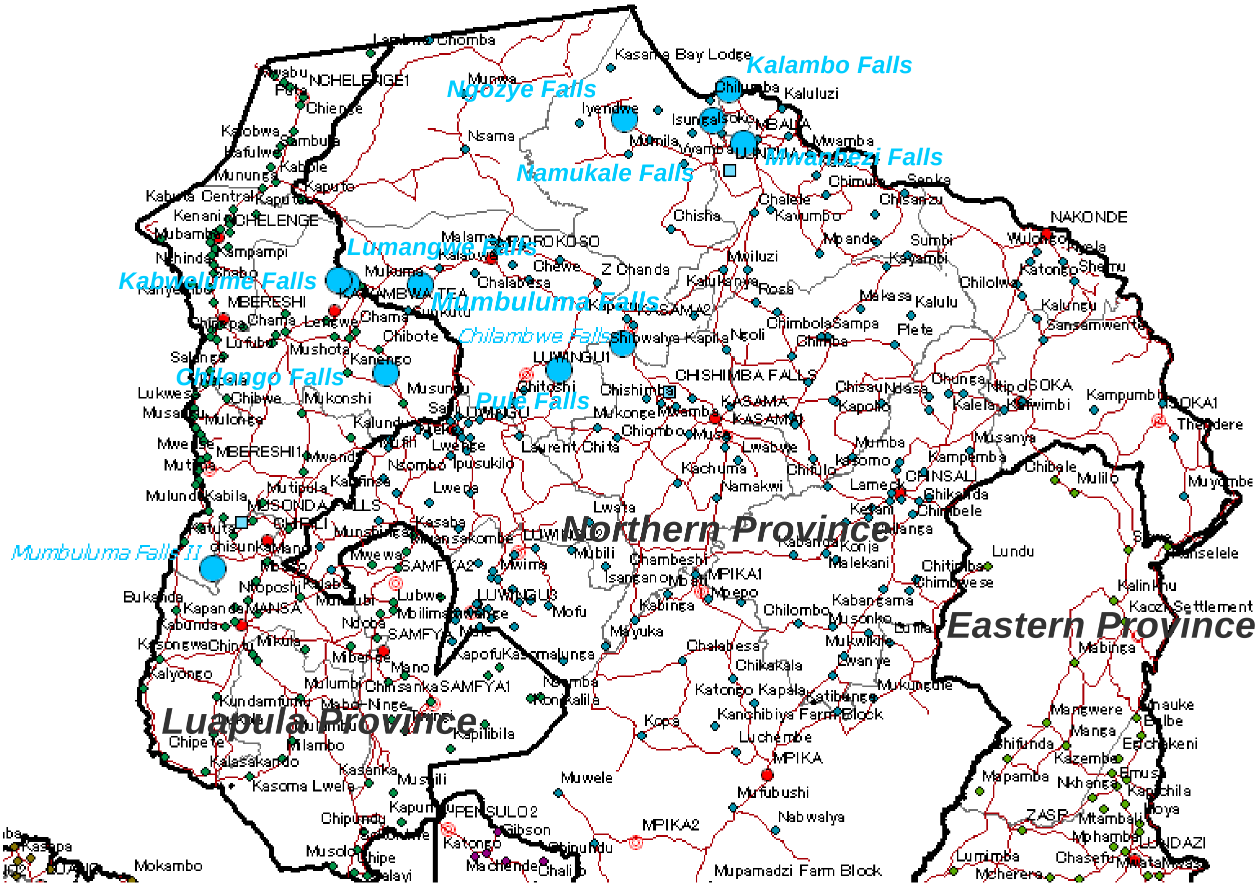


Figure 8-24 Location of Hydropower Potential Site in Northern and Luapula Provinces

(a) Kalambo Falls Site (Northern Province)

Kalambo Falls Site is located at the north end of Mbala District on Kalambo River running along the border with Tanzania and into the Lake Tanganyika. The fall has the second highest drop in the nation and is certified as a national monument. The water flow as of 4th August 2007 was 1.5m^3/s, and it will decrease around 1m^3/s in the dry season. The water is falling plumb down and topographic survey could not be executed owing to the safety aspect. The potential generation capacity is estimated at 1,650kW assuming 1.0m^3/s of designed discharge and 231m of gross head which is said in the official guidance. Figure 8-25 shows pictures of the site.

a) Kalambo falls (side view)

b) Kalambo falls (from top of a waterfall)

c) Landscape from the top of a waterfall

Figure 8-25 Pictures of Kalambo Falls Site

Possible demand site for this hydropower potential will Mbala District centre, which is located about 35km south of the falls. Mbala District centre is out of the scope of rural electrification because Mbala District centre has already been electrified by the national grid via 66kV transmission line from Kasama substation, but as Mbala is branched at very end of the grid and has problem of quality of electricity, to settle a power plant here will be quite effective to enhance the stability of electricity. Nearest RGC from the falls is Kaluluzi (potential demand: 53kW), but since the distance from Kaluluzi to Mbala substation is only 22km. Therefore, this RGC can easily connected to the grid from Mbala substation and this is much more cost-effective than developing Kalambo Falls Site.

The falls can be accessed by car from the left bank without any difficulties. However, it is required to dig the bedrock more than depth of 200m perpendicularly, which is costly and works with a lot of difficulty. In addition, there must be several problems to be solved because the falls are located on the national border and are registered as a national monument. As stated above, Kalambo Falls Site is not attractive for the purpose of rural electrification in spite of its rich hydropower potential.

(b) Mwanbezi Falls Site (Northern Province)

Mwanbezi Falls Site is located about 8km southwest of Mbala District centre on Mwanbezi River. The water flow as of 4th August 2007 was about 1.0m^3/s, which would decrease at about 0.7m^3/s in the dry season, and the gross head is 3m. Figure 8-26 shows the picture of the site. The land condition around the site is smooth and the construction works of 10kW micro hydropower plant will be simple, however, the potential generation capacity is too small and there is no necessity of development.

Figure 8-26 Picture of Mwanbezi Falls Site

(c) Namukale Falls Site (Northern Province)

Namukale Falls Site is located about 6km east of Mpulungu District centre on Lunzua River. The distance from the falls to Lake Tanganyika is about 1.5km and Lunzua Falls HP, owned by ZESCO, exists on upstream. The water flow as of 5th August 2007 was 4m^3/s. Since flow duration curve at this site (Figure 8-27) indicates that the water flow at 80% availability is 2.37m^3/s, designed discharge should be settled at 2.3m^3/s. This site has two falls with 4m drop and 10m drop in a row, and 16m gross head in total is available including the drop of steep flow on up the first fall and the low weir to be installed, hence the potential generation capacity is estimated at 270kW. Figure 8-28 shows pictures of this site.

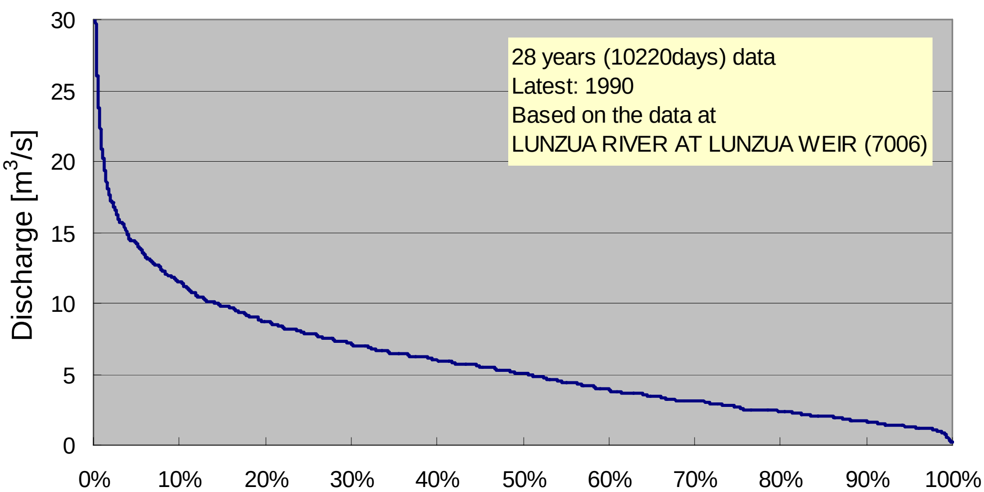


Figure 8-27 Flow Duration Curve at Namukale Falls Site

a) Lakeside village of Lake Tanganyika near Namukale Falls

b) Namukale Falls

c) Overview of the site

Figure 8-28 Pictures of Namukale Falls Site

Possible demand site is Mpulungu Central RGC (potential demand: 2,201kW), which is ranked first on our priority list of 1,217 unelectrified RGCs. The problems are the lack of the potential generation capacity for the large potential demand and poor accessibility. There was no road approaching this falls, so the Study Team had to travel by boat on Lake Tanganyika and walk to the falls from the right bank of the river. Nevertheless, the development of this hydropower potential is considerable. As preparations of the development, construction of a land route approaching the falls and also a bridge to the left bank, which arrows to develop a hydropower plant on the left bank and makes the works easier, are required. The left bank is completely covered with bushes, and it seems that there is no living area within the influenced area by the proposed hydropower plant. The Study Team estimated the project cost and Table 8-13 shows the summery of the site.

Table 8-13 Project Summery of Namukale Falls Site

[Design Result]

Province	Northern
District	Mpulungu
Name of the Site	Namukale Falls
Name of the River	Lunzua River
Latitude	S8:45:02
Longitude	E31:09:47
Catchment Area	791 km^2
80% available discharge	2.37 m^3/s
Design Discharge	2.3 m^3/s
Gross Head	16.0 m
Effective Head	15.0 m
Generation Capacity	270 kW
Volume of Powerhouse	274 m^3
Volume of Weir	90 m^3
Length of Channel	200 m
Length of Penstock	45 m
Length of Tailrace	15 m
Length of Spillway	70 m
Length of Distribution Line	6 km

[Electrified Area]

Mpulungu Central RGC	2201 kW

[Project Cost Estimation]

I. Construction Cost	1,351,220 US$
i) Temporary Works	338,560 US$
ii) Civil Engineering	451,860 US$
iii) Turbine, Gen and Main Transformer	290,000 US$
iv) Distribution Line & Transformer	270,800 US$
II. Engineering Service Cost	108,098 US$
III. Overhead Cost	337,805 US$
IV. Profit Margine	270,244 US$
Grand Total	2,067,367 US$

(d) Ngozye Falls Site (Northern Province)

Ngozye Falls Site is located about 70km west of Mbala District centre on Ngozye River. The water flow as of 6^{th} August 2007 was only 0.1m^3/s, so it can hardly be expected to get stable water to produce certain amount of electricity in dry season. In spite of its rich head drop of 100m, the potential generation capacity is estimated at only 35kW assuming 0.05m^3/s of designed discharge. Figure 8-29 shows the picture of the site. Because the falls is situated on the cliff, it is expected that the construction works of civil facilities are quite difficult. Due to the small potential and difficulty of the development, the necessity of this potential development is extremely low.

Figure 8-29 Picture of Ngozye Falls Site

(e) Chilambwe Falls Site (Northern Province)

Chilambwe Falls Site is located about 70km northeast of Kasama, Capital of Northern Province, on Kafubu River, which is a tributary to Luombe River. The water flow as of 7th August 2007 was 1.5m^3/s and its gross head was 40m. Since flow duration curve at this site (Figure 8-30) indicates that the water flow at 80% availability is 0.85m^3/s. Figure 8-31 shows pictures of this site.

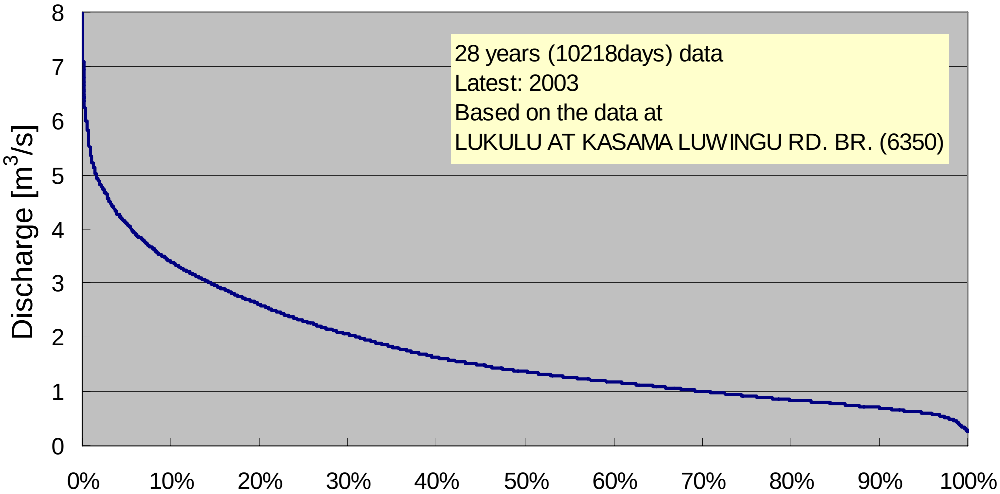


Figure 8-30 Flow Duration Curve at Chilambwe Falls Site

a) Chilambwe Falls

b) Upstream of the falls

c) Downstream of the falls

Figure 8-31 Pictures of Chilambwe Falls Site

The upstream of the falls is very flat with potential for a long low weir to take off the water to the canal. Head tank should be installed on the upper edge of the steep fall via water canal of which length will be about 150m. Short penstock should be installed to lead the water to turbine on the steep slope of the left bank. Down the falls, there is a wide flat for powerhouse to be built. There are no firm and household, hence the environmental issue would not be a barrier for the development.

This falls is about 3km off the Kasama-Mporokoso main road and it is easy to access the site by vehicle. Possible demand site would be Kapatu RGC (potential demand: 610kW) or Sibwalya Kapila RGC (potential demand: 4,013kW), which are both 16km apart from the falls. The potential generation capacity cannot fulfil huge demands of these RGCs. Each RGC has clinic, schools, large firms, etc. so the requirement of electrification is strong. However, this Kasama-Mporokoso road is situated in the pocket of well-developed 66kV transmission line in Northern Province because Kasama has been connected from south and Mporokoso has been connected from west. Therefore, it is highly beneficial to develop this hydropower potential to supply electricity only to these public facilities and business entities. In order to fulfil the current potential demand of Kapatu RGC, or potential demand of public facilities and business entities in Kapatu and Sibwalya Kapila RGCs, it is necessary for the site to be developed with 300kW generation capacity, which requires 1.0m^3/s of designed discharge. This discharge is a bit more than the water flow at 80% availability, but the Study Team decided the designed discharge at 1.0m^3/s and estimated the project cost of Chilambwe Falls development as a 300kW hydropower plant. Table 8-14 shows the summery of the project.

Table 8-14 Project Summery of Chilambwe Falls Site

[Design Result]

Province	Northern
District	Moporokoso
Name of the Site	Chilambwe Falls
Name of the River	Kafubu River
Latitude	S9:49:58
Longitude	E30:43:26
Catchment Area	175 km^2
80% available discharge	0.85 m^3/s
Design Discharge	1.0 m^3/s
Gross Head	39.5 m
Effective Head	37.8 m
Generation Capacity	300 kW
Volume of Powerhouse	298 m^3
Volume of Weir	48 m^3
Length of Channel	138 m
Length of Penstock	192 m
Length of Tailrace	50 m
Length of Spillway	30 m
Length of Distribution Line	41 km

[Electrified Area]

Kapatu RGC	610 kW
Sibwalya Kapila RGC	4013 kW

[Project Cost Estimation]

I. Construction Cost	2,355,510 US$
i) Temporary Works	190,320 US$
ii) Civil Engineering	324,390 US$
iii) Turbine, Gen and Main Transformer	310,000 US$
iv) Distribution Line & Transformer	1,530,800 US$
II. Engineering Service Cost	188,441 US$
III. Overhead Cost	588,878 US$
IV. Profit Margine	471,102 US$
Grand Total	3,603,931 US$

(f) Mumbuluma Falls Site (Northern Province)

Mumbuluma Falls Site is located about 47km west of Mporokoso District centre on Luangwa River that is a tributary to Kalungwishi River. The head drop of the falls is 6m and there are steep rapids upstream for about 400m and downstream for about 200m, which gives a total gross head measured at 18m. Its water flow as of 8th August 2007 was about 30m^3/s, and the flow duration curve at the site (Figure 8-32) gives 14.35m^3/s of the water flow at 80% availability. Then the maximum potential generation capacity is estimated at 1,630kW assuming designed flow at 13.5m^3/s. Figure 8-33 shows a picture of the site. The right bank to be developed is covered with shrubs, and there is no household and firm within the area to be opened up due to the construction works of the hydropower plant.

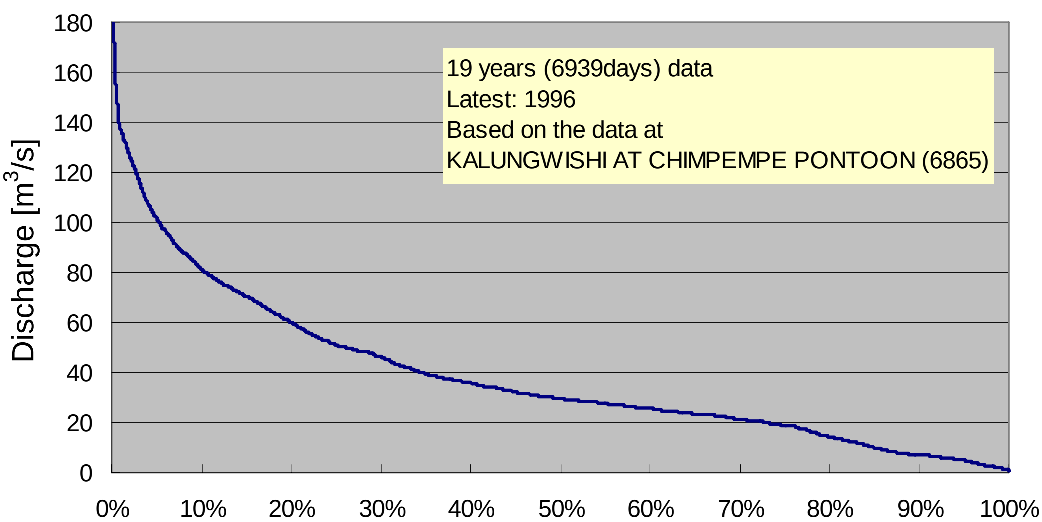


Figure 8-32 Flow Duration Curve at Mumbuluma Falls Site

Figure 8-33 Picture of Mumbuluma Falls Site

Possible demand sites would be Sunkutu RGC (potential demand: 386kW) located 15km south of the site and Kalabwe RGC (potential demand: 472kW) located 13km north of the site. The potential generation capacity is much bigger than the total potential demand of these two RGCs. So there is another option to develop at suitable capacity to for these two RGCs. The Study Team designed the plant at 930kW with lower gross head of 14m and discharge of 9.0m^3/s, which reduce the length of water channel, and estimated the project cost, shown in Table 8-15.

Table 8-15 Project Summery of Mambuluma Falls Site

[Design Result]

Province	Northern
District	Moporokoso
Name of the Site	Mambuluma Falls
Name of the River	Luanguwa River
Latitude	S9:32:53
Longitude	E29:44:47
Catchment Area	4,848 km^2
80% available discharge	14.35 m^3/s
Design Discharge	9.0 m^3/s
Gross Head	14.0 m
Effective Head	13.0 m
Generation Capacity	930 kW
Volume of Powerhouse	751 m^3
Volume of Weir	576 m^3
Length of Channel	140 m
Length of Penstock	65 m
Length of Tailrace	25 m
Length of Spillway	88 m
Length of Distribution Line	32 km

[Electrified Area]

Kalabwe RGC	471 kW
Sunkutu RGC	386 kW

[Project Cost Estimation]

I. Construction Cost	3,597,360 US$
i) Temporary Works	454,770 US$
ii) Civil Engineering	1,105,890 US$
iii) Turbine, Gen and Main Transformer	734,000 US$
iv) Distribution Line & Transformer	1,302,700 US$
II. Engineering Service Cost	287,789 US$
III. Overhead Cost	899,340 US$
IV. Profit Margine	719,472 US$
Grand Total	5,503,961 US$

(g) Lumangwe Falls Site (Northern Province)

Lumangwe Falls Site is located 80km west of Mporokoso District centre and 46km northeast of Kawambwa District centre of Luapula Province. It is identified as a national monument and a popular scenic site. Figure 8-34 shows a picture of the falls. The falls, which has 30m head drop, are situated on Kalungwishi River and its water flow as of 8th August was estimated more than 100m^3/s. These figure gives about 15,000kW of potential generation capacity assuming 70m^3/s designed discharge if it is developed as run-of –river type hydropower station without high dam.

This site has already been studied and well known as a Kalungwishi Project (listed on Table 8-4) with 218MW potential generation capacity including Kabwelme Falls Site, which will be mentioned next. Therefore, this site is described here just as a record of our survey and should not be handled on this Rural Electrification Master Plan.

Figure 8-34 Picture of Lumangwe Falls Site

(h) Kabwelme Falls Site (Northern Province)

Kabwelme Falls Site, which is also identified as a National Monument, is located only 4km downstream of Lumangwe Falls Site described above. Figure 8-35 shows a picture of the falls. The falls, which has 20m head drop, has more than 100m^3/s water flow on 8th August 2007, and its potential generation capacity can be estimated at about 10,000kW assuming 70m^3/s designed discharge if it is developed as run-of –river type hydropower station without high dam. But this potential has also been registered on large hydro development list as Kalungwishi Project and should not be handled here in this Master Plan.

Figure 8-35 Picture of Kabwelme Falls Site

(i) Pule Falls Site (Northern Province)

Pule Falls Site on Kasanshi River, which is a tributary to Lukulu River, is located about 50km north off Chitoshi RGC on the midmost of Kasama-Luwing main road. The falls have 35m head drop and the steep rapids give some addition, then in total 48m gross head can be expected. The water flow as of 10th August 2007 was only 0.3m^3/s, and the flow duration curve (Figure 8-36) indicates that the water flow at 80% availability is only 0.14m^3/s. This low discharge gives only 50kW of potential generation capacity. Figure 8-37 shows pictures of the site.

Mukupa Kaoma RGC (potential demand: 2,177kW) is situated only 1.5km apart from the falls. Because this large RGC has more than 100km distance from existing substation, dispersed power source with isolated grid exactly suits. Nevertheless, the potential generation capacity of Pule Falls Site would be too much smaller than the potential demand.

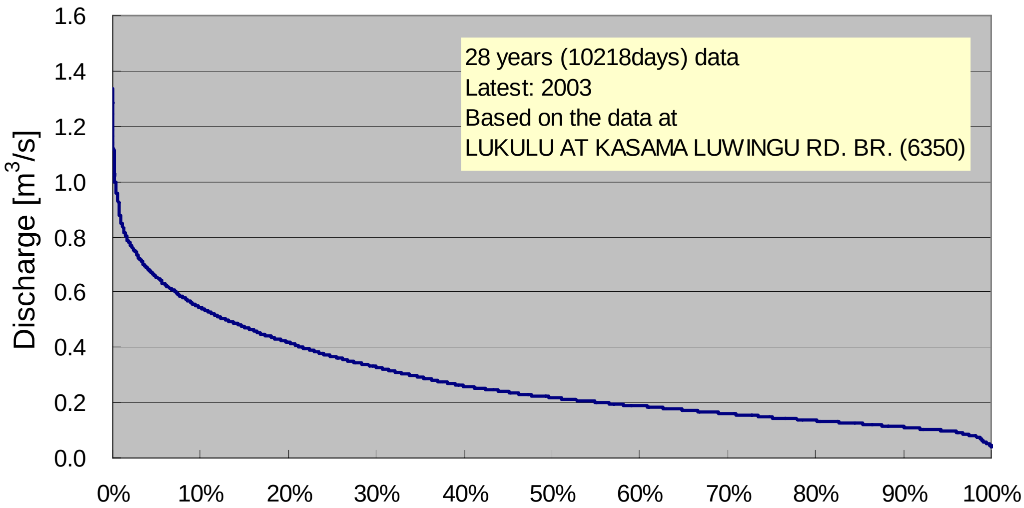


Figure 8-36 Flow Duration Curve at Pule Falls Site

a) Pule Falls

b) Downstream of the falls

Figure 8-37 Pictures of Pule Falls Site

(j) Chilongo Falls Site (Luapula Province)

Chilongo Falls Site on Lufubu River, which is a tributary to Kalungwishi River, is located about 60km southeast of Kawambwa District centre. The rich drop of the falls gives 40m of gross head, and the water flow as of 9th August 2007 was 3.6m^3/s. The flow duration curve (Figure 8-38) shows 1.83m^3/s for its water flow at 80% availability, so the potential generation capacity is estimated at 500kW assuming that the designed discharge is 1.7m^3/s. Figure 8-39 shows pictures of the site.

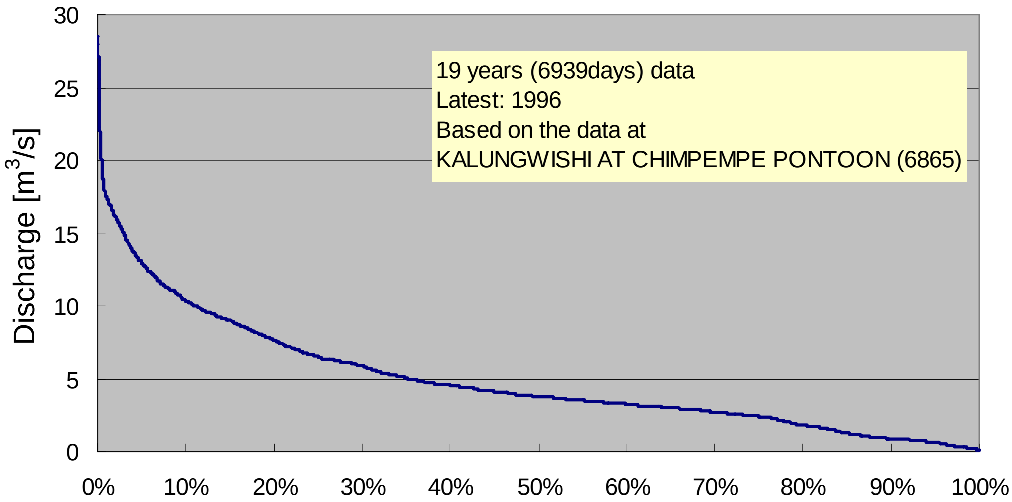


Figure 8-38 Flow Duration Curve at Chilongo Falls Site

a) Chilongo Falls

b) Upstream of the falls

c) Downstream of the falls

Figure 8-39 Pictures of Chilongo Falls Site

There are some firms and small community around the path to the falls though it is not very close to the falls. But the access road for the proposed power plant should be designed not to disturb their live activities.

The possible demand site would be Kanengo RGC (potential demand: 79kW) located 29km west of the falls and Chibote RGC (potential demand: 133kW) located 18km north of the falls. The total demand of 212kW is about 300kW less than the potential generation capacity. There are three more RGCs, Chama (potential demand: 355kW), Mushota (potential demand: 588kW), and Lengwe (potential demand: 178kW), which are located very closely one another in the middle of the falls and existing Kawambwa Tea substation. The length of 33kV distribution line to be extended from Chilongo Falls Siteis to these 3RGCs is about 33km, which 11km shorter than that from Kawambwa Tea substation. If the hydropower potential were large enough to supply 1,333kW of electricity in total of all these five RGCs, the development of this hydropower potential could be the most effective. Actually the potential generation capacity of the site is less than half of the total demand, so these three RGCs should be connected to the national grid in the end. Here, the Study Team estimated the project cost at 500kW generation capacity, and Table 8-16 shows the summery of the project.

Table 8-16 Project Summery of Chilongo Falls Site

[Design Result]

Province	Luapula
District	Kawambwa
Name of the Site	Chilongo Falls
Name of the River	Lufubu River
Latitude	S9:58:25
Longitude	E29:34:41
Catchment Area	618 km^2
80% available discharge	1.83 m^3/s
Design Discharge	1.7 m^3/s
Gross Head	40.0 m
Effective Head	37.2 m
Generation Capacity	500 kW
Volume of Powerhouse	453 m^3
Volume of Weir	105 m^3
Length of Channel	300 m
Length of Penstock	390 m
Length of Tailrace	50 m
Length of Spillway	250 m
Length of Distribution Line	49 km

[Electrified Area]

Kanengo RGC	79 kW
Chibote RGC	133 kW

[Project Cost Estimation]

I. Construction Cost	3,766,250 US$
i) Temporary Works	619,630 US$
ii) Civil Engineering	855,420 US$
iii) Turbine, Gen and Main Transformer	445,000 US$
iv) Distribution Line & Transformer	1,846,200 US$
II. Engineering Service Cost	301,300 US$
III. Overhead Cost	941,563 US$
IV. Profit Margine	753,250 US$
Grand Total	5,762,363 US$

(l) Mumbuluma Falls II Site (Luapula Province)

Mumbuluma Falls II Site is located about 34km northwest of Mansa District centre on Luamfumu River, that is a tributary to Luapula River. Since the name of the falls is as same as Mumbuluma falls in Northern Province, the Study Team renamed this falls 'Mumbuluma Falls II' on this report. Figure 8-40 shows the picture of the site. Existing two small falls in a row gives 12m gross head. The water flow as of 10th August 2007 was about 1.5m^3/s, then its potential generation capacity will be 70kW with 0.8m^3/s designed discharge considering the low water flow in dry season. This falls could be regarded as a quite suitable hydropower potential site if it is evaluated from the view of ease of construction and accessibility, but the potential generation capacity is too low to be invested.

a) Upper Falls

b) Lower Falls

Figure 8-40 Pictures of Mumbuluma Falls II Site

(3) Western Province

The hydropower potential survey in Western Province was carried out from 4th June to 6th June 2007. At first, the survey would be carried out only in North-western, Northern and Luapula Provinces, but Western Provincial Planner reported the existence of some falls for small hydropower development to DoE, so the Study Team additionally implemented the survey at the recommended falls. Figure 8-41 shows the location of surveyed sites.

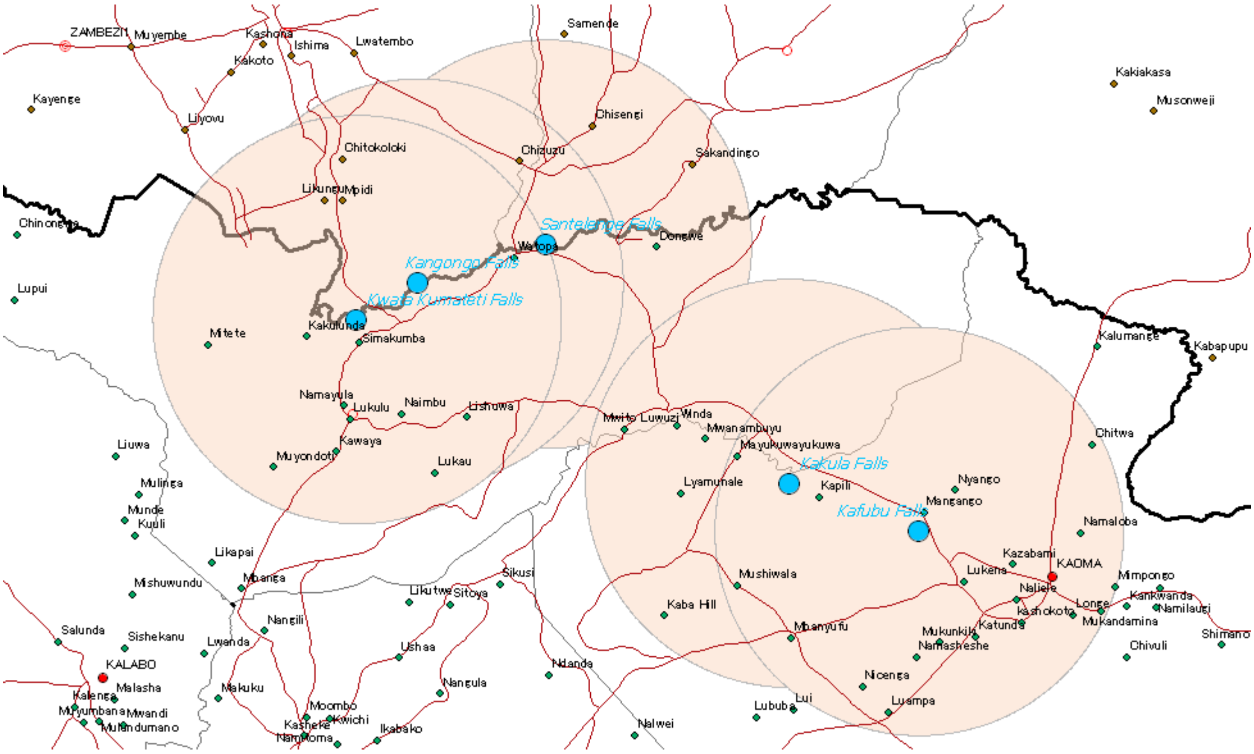


Figure 8-41 Location of the Hydropower Potential Site in Western Province

Table 8-17 indicates the summery of five surveyed sites, and Figure 8-42 shows the pictures of them. It is clear on the pictures that these five sites have rich amount of water flow but are located on quite flat land, therefore, it is difficult to earn high head drop without high-dam or quite long water channel, which are not suitable for rural electrification by small hydropower plant. Hence these sites are introduced here as our survey records, but the hydropower potentials are not discussed.

Table 8-17 Summery of Surveyed Site in Western Province

Name of Site	District	Latitude	Longitude	Name of River	Date of Visit
Santelenge Falls	Lukulu	S14:01:29	E23:41:44	Kabompo	04-June-2007
Kangongo Falls	Lukulu	S14:06:38	E23:24:47	Kabompo	04-June-2007
Kwata Kumateti Falls	Kaoma	S14:11:27	E23:16:38	Luena	05-June-2007
Kakula Falls	Kaoma	S14:33:06	E24:13:45	Luena	06-June-2007
Kafubu Falls	Kaoma	S14:39:28	E24:30:51	Luena	07-June-2007

a) Santelenge Falls on Kabompo River

b) Kangongo Falls on Kabompo River

c) Kwata Kumateti Falls on Luena River

d) Kakula Falls on Luena River

e) Kafubu Falls on Luena River

Figure 8-42 Pictures of Surveyed Sites in Western Province

(4) Summery of Hydropower Potential Survey

The Study Team visited twenty-five hydropower potential sites, nine sites in North-western Province, nine sites in Northern Province, two sites in Luapula Province, and five sites in Western Province.

In North-western Province, there are lot of District centres, which have not been electrified by national grid, so small hydropower generation with isolated grid is a significant method of rural electrification. Five hydropower potential sites, Upper Zambezi, Mujila Falls Lower, Mujila Falls Upper, Kasanjiku Falls, and Chauka Matambu Falls, were evaluated to be reasonable site for Rural Electrification. Table 8-18 shows the summery table of the hydropower potential site in North-western Province.

The falls in Northern and Luapula Province have relatively high head drops, and four hydropower potential sites out of eleven sites, Namukale Falls, Chilambwe Falls, Mambuluma Falls, and Chilongo Falls, have a suitable potential to be discussed in the Master Plan. Table 8-19 shows the summery table of the hydropower potential site in Northern and Luapula Provinces.

Additionally, the national grid has been already extended to almost all the District centres in Northern and Luapula Provinces, then the necessity of small hydropower plant with micro-grid is not so high.

However, as this area is located quite far from Zambian power source in Southern Province, the stability of electricity is low. Therefore, it is important to develop large hydropower plants such as Kalungwishi Site, which will help to enhance the quality of electricity on the national grid.

Table 8-18 Summery of the Hydropower Potential Survey in Northwestern Province

Name of the Site	Upper Zambezi	Mujila Falls Lower	Mujila Falls Upper	Tututu Falls	Kasanjiku Falls	Chauka Matambu Falls	Luakela Falls	Muwozi Falls Upper	Muwozi Falls Lower
Date of Survey	24-May-07	25-May-07	25-May-07	25-May-07	26-May-07	28-May-07	28-May-07	29-May-07	29-May-07
Province	Northwestern	Northwestern	Northwestern	Northwestern	Northwestern	Northwestern	Northwestern	Northwestern	Northwestern
District	Mwinilunga	Mwinilunga	Mwinilunga	Mwinilunga	Mwinilunga	Mwinilunga	Mwinilunga	Mwinilunga	Mwinilunga
Latitude	S11:06:18	S11:30:52	S11:29:32	S11:34:27	S12:21:10	S11:51:34	S11:31:38	S12:15:04	S12:16:45
Longitude	E24:13:41	E24:46:24	E24:48:25	E24:45:14	E24:50:55	E25:08:13	E24:24:44	E24:16:54	E24:19:33
Name of the River	Zambezi	Mujila	Mujila	Kapunda	Kasanjiku	West Lumuwana	Luakela	Muwozi	Muwozi
Effective Head [m]	8.0	17.1	13.2	3.6	9.0	9.1	6.3	3.6	4.5
Designed Dischirge [m^3/s]	6.0	10.0	4.0	1.0	4.5	2.5	2.0	1.0	1.0
Potential [kW]	380	1400	420	30	320	180	100	30	35
Electrified RGC 1	Ikelenge	Kanyama (incl. 2 villages)	Kanyama	Kanyama	Ntambu	Lumuwana	Luakela	Chiwoma	Chiwoma
Length of the Power Line [km]	Existing	13	10.5	19	21	4	0.5	6.5	7.5
Connected from	Zengamina HP	Mujila Falls Lower	Mujila Falls Upper	Tututu Falls	Kasanjiku Falls	Chauka Matambu Falls	Luakela Falls	Muwozi Falls Upper	Muwozi Falls Upper
Number of Households in 2006	1763	921	521	521	416	310	216	361	361
Potential Demand in 2030 [kW]	1995	1065	598	598	532	371	257	418	418
Priority Order	57	671	671	671	322	526	660	497	497
Priority in the District	2	4	4	4	1	5	18	14	14
Electrified RGC 2	Nyakaseya	Kakoma							
Length of the Power Line [km]	Existing	60							
Connected from	Ikelenge RGC	Kanyama RGC							
Number of Households in 2006	400	301							
Potential Demand in 2030 [kW]	483	350							
Priority Order	445	551							
Priority in the District	3	17							
Cost Estimation [thousand US$]	2,290	9,782	2,264	-	3,521	2,000	-	-	-

Table 8-19 Summery of the Hydropower Potential Survey in Northern and Luapula Provinces

Name of the Site	Kalambo Falls	Mwanbezi Falls	Namukale Falls	Ngozye Falls	Chilambwe Falls	Mumbuluma Falls	Lumangwe Falls	Kabwelume Falls	Pule Falls	Chilongo Falls	Mumbuluma Falls II
Date of Survey	04-Aug-07	04-Aug-07	05-Aug-07	06-Aug-07	07-Aug-07	08-Aug-07	08-Aug-07	08-Aug-07	10-Aug-07	09-Aug-07	10-Aug-07
Province	Northern	Northern	Northern	Northern	Northern	Northern	Northern	Northern	Northern	Luapula	Luapula
District	Mbala	Mbala	Mpulungu	Mpulungu	Mporokoso	Mporokoso	Mporokoso	Mporokoso	Mporokoso	Kawambwa	Mwense
Latitude	S8:35:40	S8:51:41	S8:45:02	S8:44:14	S9:49:58	S9:32:53	S9:32:24	S9:31:22	S9:57:47	S9:58:25	S10:55:42
Longitude	E31:14:22	E31:18:31	E31:09:47	E30:44:09	E30:43:26	E29:44:47	E29:23:16	E29:21:06	E30:25:08	E29:34:41	E28:44:09
Name of the River	Kalambo	Mwanbezi	Lunzua	Ngozye River	Kafubu	Luangwa	Kalungwish	Kalungwish	Kasanshi	Lufubu	Luamfumu
Effective Head [m]	207.9	2.7	15.0	90.0	37.8	13.0	-	-	43.2	37.2	10.8
Designed Dischirge [m^3/s]	1.0	0.7	2.3	0.05	1.0	9.0	-	-	0.14	1.7	0.8
Potential [kW]	1650	10	270	35	300	930	-	-	50	500	70
Electrified RGC 1	Mbala BOMA	-	Mpulungu Central	Iyendwe	Kapatu	Kalabwe	-	-	Mukupa Kaoma	Kanengo	Chibondo
Length of the Power Line [km]	34		6	22	17	16.5			1.5	29	24
Connected from	Kalambo Falls		Namukale Falls	Ngozye Falls	Chilambwe Falls	Mumbuluma Falls			Pule Falls	Chilongo Falls	Mumbuluma Falls II
Number of Households in 2006	-		2000	200	512	425			1974	60	286
Potential Demand in 2030 [kW]	-		2201	231	610	471			2177	79	331
Priority Order	Electrified		1	728	95	453			50	1029	567
Priority in the District	-		4	7	14	10			1	3	6
Electrified RGC 2					Sibwalya Kapila	Sunkutu				Chibote	
Length of the Power Line [km]					6	15.5				17	
Connected from					Kapatu	Mumbuluma Falls				Chilongo Falls	
Number of Households in 2006					3646	350				90	
Potential Demand in 2030 [kW]					4013	386				133	
Priority Order					13	512				907	
Priority in the District					2	8				4	
Cost Estimation [thousand US$]	-	-	2,068	-	3,604	5,504	-	-	-	5,763	-

Chapter 9

Solar Power Planning

Chapter 9. Solar Power Planning

9.1. Current Status of Solar Power

9.1.1. Renewable Energy Possibilities for Rural Electrification in Zambia

The most favourable way of electrifying villages is to extend the existing national distribution network all over the country. Grid extension has an advantage that it highly satisfies demand-side needs from the aspects not only of quantity (24-hour available) but also of quality (voltage and frequency stability). However, from the geographic and demographic points of view, such as location and population density, grid extension to some areas that are too remote from the existing lines, which requires high construction cost for limited potential power, may not be economically viable. In short, grid extension may not always be the panacea for enhancing rural electrification.

Utilization of renewable energy to create onsite electricity supply system is considered to be realistically the most effective mode of electrifying the above mentioned remote areas even if it would be inferior to national grid extension in quantity and quality. Another problem regarding onsite electrification using renewable energy is that in many countries there’s no specific policy, regulation or official guideline regarding the selection of sites and electrification mode, and even technical standards are not necessarily specified systematically.

The 1944 National Energy Policy (NEP), which among other goals was to accelerate rural electrification through the formulation of guidelines regarding renewable energy and the establishment of Rural Electrification Fund (REF) was expected to support the promotion of renewable energy. In 2003, the Zambian Government passed the Rural Electrification Act establishing the Rural Electrification Authority (REA) with the intention of expanding electrification-related services targeting impoverished rural areas. With the arrangements regarding policies and organizations gradually completed, we consider that the spread of rural electrification using renewable energy will be widely promoted, once the government proceeds with a concrete implementation plan.

9.1.2. Current Status of Solar Power Electrification

At the moment, the solar energy’s contribution to improving the electrification rate in Zambia is quite minor since the pilot projects regarding solar power have only just begun a few years ago.

Presently pilot projects are funded by SIDA and are operated by private companies called Energy Service Companies (ESCOs). ZAMSIF has also provided solar system for schools and health centres for the Ministries of Education and Health. Recently, several distributors have been set up in Lusaka that are responsible for designing, installing and maintaining solar power facilities. Their business is not just limited to supplying equipment and services, but also extending to the sales of solar panels and their accessories to end-users.

(1) Solar Power Projects through ESCO

ESCOs, the first commercial energy suppliers using solar home system (SHS), started their business with the financial support from Swedish International Development Agency (SIDA), which is inline with the Zambian Government's policy to reduce poverty in rural areas through electricity supply by making use of resources of private sector.

The first pilot project for rural electrification began in 1998, and a total of 400 systems were targeted for installation in ordinary homes in three towns (Nyimba, Chipata and Lundazi) in Eastern Province. NESCO was established in Nyimba in 2000, and until early 2001, and CHESCO in Chipata and LESCO in Lundazi were also established. Taking into consideration the current situation of insufficient skills of business operations, their office is located in each District Centre, not onsite, respectively, and daily maintenance and servicing of facilities are carried out by four or five employees consisting of a supervisor, a manager, a reporter and two experts. Table 9-1 shows the number of houses that these 3 ESCOs supply electricity with SHS and Figure 9-1 shows the organization chart of CHESCO.

Each service company is responsible for leasing SHS to customers. The service company also maintains the equipment and collects monthly electricity tariff from customers. Table 9-2 shows the standard equipment supplied by ESCOs. The basic facilities for ordinary household consist of four fluorescent lights and a 12v socket. These are used for lighting, TV/Video and radio and rarely used for refrigerator to keep medicine for livestock. The consumers are upper-middle class people such as schoolteachers, police officers and government employees and farmers who account for only 12 to 17%. Figure 9-2 shows the typical daily load curve. Figure 9-3 and Figure 9-4 present the examples of houses using SHS in Chipata.

The needs for solar power generation in remote area are increasing, and in Nyimba district for example, 350 households are waiting for installation of SHS. It is necessary to improve the technical criteria, operation and maintenance, operation of organization and market development.

Table 9-1 SIDA-funded ESCOs

Company Name	Installations	Site Location
NESCO (Nyimba Energy Service Company)	100	Nyimba
CHESCO (Chipata Energy Service Company)	150	Chipata
LESCO (Lundazi Energy Service Company)	150	Lundazi

Table 9-2 Standard Equipment of SIDA-Funded SHS

Equipment	Specifications	Notes
PV Panel	55Wp (rating) 20A	In some cases, such as clinics, two panels are installed.
Battery	12V, 105Ah	Normal Capacity of 4 days
Regulator	Pre-Paid Meter	Electricity charges are pre-paid on a monthly basis.

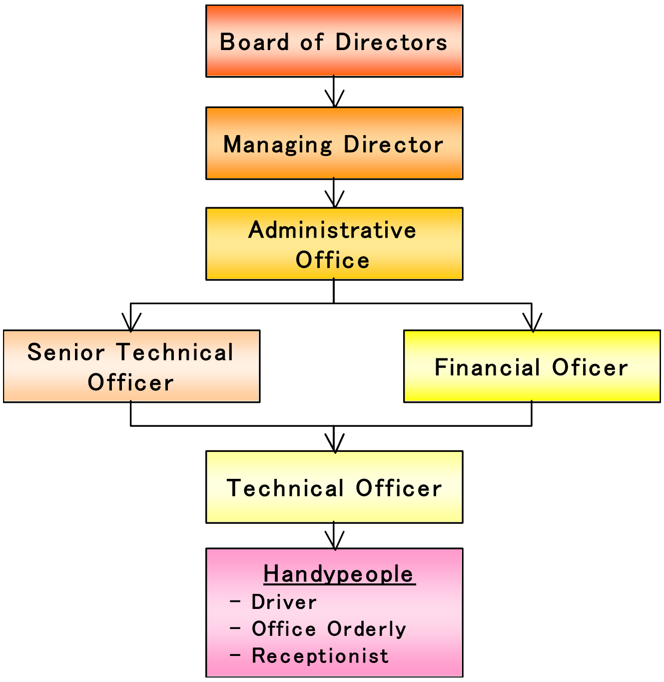


Figure 9-1 Organaization Structure of Chesco

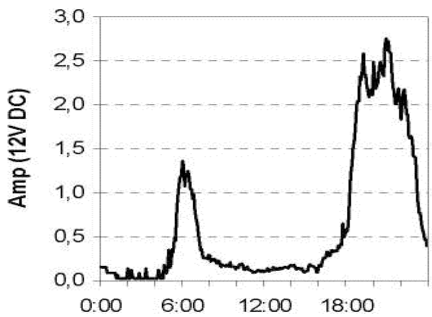


Figure 9-2 Average Daily Load Curve over 21 Days

Figure 9-3 A House Equipped with a Solar Home System in Chipata

Figure 9-4 A House Equipped with a Solar Home System in Chipata

(2) Solar Power Projects by the Government

(a) ZAMSIF-funded Projects

Zambia Social Investment Fund (ZAMSIF) was established and started its business operation in 1993 using funds from the World Bank. The projects started from facilities such as schools and hospitals in un-electrified areas of Northern Province, and SHSs with various scales were installed in a total of 750 sites by 2001.

Before 2006, SHS installation sites funded by ZAMSIF were mainly in places such as schools, health centre, and staff houses for teachers and health workers. Table 9-3 lists the standard equipment used by ZAMSIF for the installation of SHS. A rough estimate of the number and capacity of ZAMSIF-installed SHS by area is shown in XXTable 9-4.

Table 9-3 Standard Equipment of ZAMSIF-funded SHS

Equipment	Specifications	Notes
PV Panel	75Wp	
Battery	12V, 96-300Ah	Normal capacity of 4 days
Controller	12V, 15A	Charge controller
Lighting Fixtures	11W×4, 9W×4	Lighting in 8 places
Switch		Supplied with 5 switches

Table 9-4 ZAMSIF-installed SHS

	Town/Village	Capacity (Wp)		Town/Village	(Wp)
Central Province	Chibombo	6,640	Northern Province	Chilubi	960
	Kabwe	(N.A.)		Chinsali	5,520
	Kapiri–Mposhi	3,680		Isoka	5,200
	Mkushi	1,680		Kaputa	1440
	Mumbwa	4,640		Kasama	5,040
	Serenje	8,160		Luwingu	3,920
		24,800		Mbala	4,240
Copperbelt Province	Chililabombwe	(N.A.)		Mpika	10,000
	Chingola	(N.A.)		Mporokoso	6,080
	Kalulushi	(N.A.)		Mpulungu	2,000
	Kitwe	4320			**44,400**
	Luanshya	(N.A.)	North-Western Province	Chavuma	1,200
	Lumfwanya	2560		Kabompo	2,320
	Mufulira	1440		Kasempa	3,200
	Ndola	1520		Mufumbwe	1,680
		9,840		Mwinilunga	6,640
Eastern Province	Chadiza	4,480		Solwezi	4,880
	Chama	4,480		Zambezi	1,200
	Chipata	12,800			**21,120**
	Katete	8,480	Southern Province	Choma	6,640
	Lundazi	15,040		Gwembe	2,800
	Mambwe	2,320		Itezhi-tezhi	1,440
	Nyimba	5,200		Kalomo	11,280
	Petauke	9,920		Kazungula	3,520
		62,720		Livingstone	2,160
Luapula Province	Chiengi	9,440		Mazabuka	3,040
	Kawambwa	960		Monze	6,240
	Mansa	3,280		Namwala	720
	Milenge	1,360		Siavonga	(N.A.)
	Mwense	1,920		Sinazongwe	3,920
	Nchelenge	1,680			**41,760**
	Samfya	11,600	Western Province	Kalabo	9,440
		30,240		Kaoma	10,480
Lusaka Province	Chongwe	4,720		Lukulu	4,320
	Kafue	1,200		Mongu	5,520
	Luangwa	1,920		Senanga	13,680
	Lusaka	(N.A.)		Sesheke	4,560
				Shang'ombo	4,000
		7,840			**52,000**
Total					**294,720**

Source: ZAMSIF, as of June 2007

(b) GRZ-funded Projects

In 2005 the Zambian Government carried out the installation of 75/80Wp SHS in 207 locations, which include 165 residences of local leaders and 42 schools, using Rural Electricity Fund (REF) and solar-funds from the Department of Energy. In May 2005, 8 schools in Senanga and Mongu in Western Province were targeted. The funds were used to cover the cost of solar power generation equipment and installation. However, funds that were required to carry out operation and maintenance, and capacity building were not included. Table 9-5 is the specifications that GRZ (DoE) set when procuring SHS equipment to be installed on chief's palace.

Figure 9-5 A house equipped with a Solar Home System in Lundazi

Table 9-5 Specifications of SHS Equipment procured by GRZ (Residential Use)

Technical Specification	
1.0	**Components for Solar Home Systems to be Supplied**
1.1	Providing 75 Wp Solar Panel
1.2	96-300 Ah 12V DC Battery
1.3	12 – 15A Charge/Discharge Controller
1.4	8 Light Units (4 X 11W & 4 X 9W)
1.5	Provision of 5 Switches
2.0	**Standards for Components and Workmanship**
2.1	Crystalline Silicon Photovoltaic Module
2.2	Batteries, with minimum 300 cycles to 80% depth of discharge at 25^{0}C
2.3	Battery Charge regulators capable of disconnecting load at full charge
2.4	Minimum Warranties of 2 years on all Components
2.5	Photovoltaic Modules covered by warranty of 10 Years
2.6	Batteries covered by warranty of 2 Years against defects or degradation
2.7	Provision of Lockable Box for Battery and Charge Controller

Source: DoE "Evaluation Report on the Tender for the Supply, Delivery and Installation of Solar Home Systems to Chief's Palaces", January 2005

(c) GRZ/UNIDO/GEF Projects

The program for renewable energy supported by GRZ/UNIDO/GEF was initially aimed at biomass energy, and then the solar power system program was built onto the project.

Site location and evaluation of the solar power system programme in Chinsanka in Samfa District, Luapula Province, were completed in 2002, and presently arrangement of coordination between agencies concerned and fund procurement were in progress. Chinsanka was the largest commercial centre in the area consisting of 875 houses and 70 stores in an area of about 2km radius.

Expansion of the grid is difficult in Zambia due to the low population density. Off-grid diesel electric power generation is very costly because the fuel is imported from abroad. To solve the issues, GRZ/UNIDO/GEF is promoting the use of renewable energy and projects to support solar power is expected to expand in the future.

9.2. Data Collection

9.2.1. Solar Power Generation Potential

(1) Climatic Overview

Zambia is located at longitude of 8°S - 17°S and latitude of 23°E - 34°E and has an area of 752,600 km^2. The most of the county is highland plateau of 1,000 – 1,350m and has a tropical climate.

A cool, dry season lasts from May to August during which the morning and evening temperatures in May and June range from 4°C to 5°C. A hot, dry season lasts from September to November and a hot, rainy season from December to April.

Regarding the characteristics of annual rainfall observed in Lusaka, the rainy season usually begins from mid-November and lasts until March, whereas there is virtually no rainfall from August to October. The average annual rainfall in northern part of the country is relatively high (about1400mm p.a.), compared to that in southern part (about 500mm p.a.).

(2) Solar radiation and the potential for solar energy

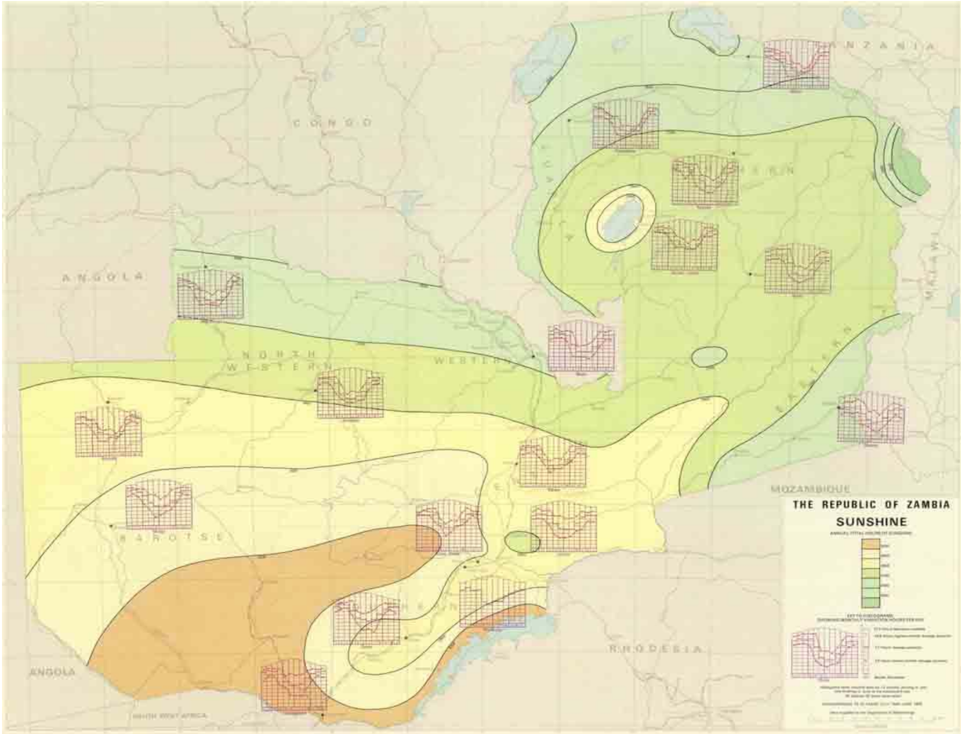
According to data from Zambia Meteorological Department (ZMD), which is under the Ministry of Communication and Transport, the average annual solar radiation in Zambia is 15.66MJ/m^2/day (or 4.35kWh/m2/day in electricity conversion). Zambia's average annual solar radiation is 1.3 times higher than that of Japan (Tokyo)'s 12MJ/m^2/day (or 3.34 kWh/m^2/day). Figure 9-6 shows the solar radiation map of Zambia, and Table 9-6 shows the annual average global solar radiation by region. There is not much inequality among regions in annual solar radiation, which is recorded relatively high and stable between 6,600 and 7,700MJ/m^2 p.a., which means that Zambia has potential for the solar energy all over the country. Table 9-7 shows the average daily solar generation in each region, which is 4.35kWh/m^2/day.

The potential solar generation can be estimated as follows. First, we assume that 1m^2 solar panel (approximately L=1.2m x B=0.8m) is installed on all of households in rural area (1,288,064 households in rural area as of 2004, source: CSO). An area of 1.3km^2 is used for solar generation in total, which is equivalent to 0.00017% of Zambia's national land area (752,610 km^2). And when we assume that the conversion efficiency of solar panels is 0.1, about 200GWh can be generated in a year. This generation is also equivalent to 30MW scale power plant with 80% operating rate.

The electricity generation and capacity scale are equal to about 6% of Zambia's electricity consumption (3,516GWh in 2006, excluding bulk sales to mining industry and export) and about 1.6% of total installed capacity of power plants in Zambia (about 1,800MW) respectively. As these figures indicate, utilization of highly potential solar generation is one of effective measures for rural electrification in Zambia.

Potential Electricity Generation from Solar Power (kWh/year)
= Average Solar Radiation (kWh/ m^2/day) × Land Area (km^2) ×365 (day/year) × 10^6
× Conversion Efficiency

- Average Solar Radiation: 4.35 kWh/m^2/day
- Land Area: 1.3km^2
- Conversion Efficiency: 0.1
- Unit Measurement: 1MJ/m^2 =23.89cal/cm^2=238.9kcal/m^2=0.2778kWh/m^2



Note: STANDARDIZED to 20years July1945-Jun1965
Source: Department of Meteorology

Figure 9-6 Solar Radiation Map of Zambia

Table 9-6 Annual Global Solar Radiation by Region

	(MJ/m²・Year)
Lusaka	6,832
Livingstone	7,677
Ndola	6,646
Mansa	7,422
Mongu	7,187
Kawambwa	6,999
Mwinilunga	7,093
Kasama	7,571
Mpika	7,613
Zambezi	6,868
Kasempa	6,756
Kabompo	6,743
Solwezi	7,318
Kafironda	6,981
Chipata	6,941
Kafue Polder	7,701
Kabwe	7,002
Mount Makulu	6,795
Choma	6,981

Table 9-7 Average Daily Solar Power Generation (2002-2005)

	(kWh/m²/day)
Chipep	4.12
Kabwe	3.32
Livingstone	3.69
Lundazi	3.89
Lusaka01	8.37
Lusaka02	8.51
Magoye	3.84
Mbala	3.75
Mfuwe	2.45
'Misamf	4.43
Mongu	6.31
Mumbwa	3.53
Petauke	3.68
Solwezi	2.87
Zambezi	2.56
Average	**4.35**

Source: Zambia Meteorological Department

9.3. Review of Existing Solar Power Development Plans

9.3.1. Possibilities and Challenges of the Solar Power Development

The average population density in Zambia is 13.1 people/km^2, and the population density is relatively high in urban area such as Lusaka (63.5 people /km^2) and Copperbelt (50.5 people/km^2), while it is very low in rural areas such as North-Western Province (4.6 people/km^2), Western Province (6.1 people/km^2) and Northern Province (8.5 people/km^2).

Taking into account the low population density and the limited power demand in rural areas, extending the national grid throughout the country may be inefficient in some remote areas in that the expected revenue may not be enough to cover the initial investment and the operation/maintenance costs. Installation of SHS on each premise as a kind of distributed onsite energy resources can be expected for increasing and improving electrification rate in remote areas for contributing to poverty reduction and for correcting the gap in economic levels among regions. However, it also has a number of issues to be tackled for practically using renewable energy such as a high initial investment, the necessity of securing a stable and long-term revenue source to sustain its business, and technical follow-up.

The challenges found so far in the course of implementation of solar power generation pilot projects are as follows:

- Lack of knowledge and consciousness regarding solar power generation technology,
- High equipment and operational costs against low ability to pay of households in rural area,
- Lack of guidelines for promoting solar energy as a substitute of electrification through the national grid,
- Lack of customers' understanding of their obligation to pay electricity tariff, which causes gradually worsening tariff collection
- Lack of customers' understanding of appropriate use of equipment, which causes its frequent breakdown that could have been prevented
- Chronic shortage of technical experts and lack of organizations and training for the development of technical experts, and
- Establishment of equipment and material supply systems and maintenance techniques.

9.3.2. Lessons Learned from ESCO Projects

Since ESCO solar power generation projects were first introduced in Zambia they have been limited to the Eastern Province. However, the demand for the services in unelectrified households and commercial sector has increased in other parts of the country.

However, installation costs of the ESCO projects depends on how much subsidy would be offered, and the electricity tariff only covers the running costs (staff costs and maintenance costs), i.e. it is not enough to cover the initial investment. Therefore the current ESCOs cannot afford reinvesting in new solar panels to expand their business. In addition, there is no other prominent candidate to start the same kind of ESCO business without subsidy though the potential demand for this kind of project electrification may also exist in other areas.

Main issues to be solved are as follows:

- Lowering costs of operation and maintenance through the improvement of management
- Formulation of technical standard, and
- Enlightenment of customers for their obligation to pay and the correct use of equipment.

It is recommended that ESCOs shall develop manuals regarding the operations of its organization, the operation and maintenance of equipment and the collection of electricity tariff, so that they can improve the sustainability of its business and can expand the size of business in the future without subsidies.

9.3.3. Lessons Learned from GRZ Projects

Installation of SHS funded by REF is implemented as the Government initiated project mostly for schools and public facilities as well as for individual users a relatively high income; individuals such as traditional leaders and middle-income earners in rural areas.

Based on the knowledge gained from the projects being implemented, the future measures and policies can be summarized as stated below.

- Formulation of off-grid solar electrification programme with a view to long term planning
- Setting guidelines for selecting target areas, demand estimation and standardization of solar electrification and equipment
- Formulation of manuals and implementation of training programme in operation and maintenance to enhance sustainability
- Taking efficiency and rationalization into consideration, securing stable income by setting payment and collection methods of electricity tariff, and expansion of the business by increased investment by controlling costs
- Development of markets for the SHS

9.4. Local In-country Survey and Assessment of Existing Solar Power Generation Systems

9.4.1. Solar Energy Resource and Current Status in Zambia

The purpose of rural electrification using solar power generation in Zambia is to reduce the dependency to charcoal, kerosene and other resources which are generally procured and used in that country, and to increase access to electricity services by applying solar power generation technology, in order to contribute to poverty reduction by improving productivity and quality of life. The average annual amount of global solar radiation in Zambia is 6,600-7,700MJ/M2 per year, and especially Central Province, Southern Province, Eastern Province, Western Province, Northern Province and North-Western Province are rich in this energy with each of their average annual amount of global solar radiation is more than 7,000MJ/M2 per year, where it is expected that even a 50Wp solar power generation system (household system) can generate about 70kWh electricity annually. However, currently solar power generation systems have been introduced only in small part of the country by the support of foreign donors and the government, and the approach to increase the number of electrified houses is in its early stages to be encouraged in the future.

9.4.2. Assessment of Previous Solar Power Generation Projects

In Zambia several organizations have completed pilot projects for the use of solar power generation systems. Electrification projects using solar power generation were implemented as ESCO projects, including fund raising and operation, establishment of a framework, and administration of projects for electrification. Electricity supply by solar power generation in unelectrified areas is welcomed by users / potential users because of the positive results of previous projects, and the increased number of applicants for installation of these systems, which realize electrification relatively easily, indicates the large expectation for electrification. However, as the nature of electrification using solar power generation, (1) The capacity is smaller than the case of electrification using grids, (2) There are limitations to facility usage, (3) It is difficult to expect the same benefit as the case of electrification using grids which can leverage motors, (4) Significant productivity improvement has not yet achieved. In addition, there are several issues in technical business skills to ensure the sustainability, and in the coordination among donors, and because of their disparities in electrification purposes, individual organizations and government authorities, although they are organized as the ESCO project framework.

In general households, solar power generation is used for lights, TVs, DVD players and CD players with radio. Among them electricity supply to lights and TVs are most appreciated, and recently the electricity use for media such as battery charge is added to them, reflecting the popularization of mobile phones. In future rural electrification, increased aspirations for accesses to information can not be ignored.

School buildings and other related facilities in this country use adobe bricks for their walls, and they have only a few windows because of their structure. Inside these buildings it is dark even during daytime hours, and darker in rainy seasons and cloudy days. Even in fine days similar phenomenon occurs in evenings. Learning efficiency, which remains low in such circumstances, will significantly be improved by lightening after electrification. The results of previous projects prove that learning hours and motivation for learning have been increased by lightning in classrooms, raising the expectation to introduce electrification to more schools.

The benefit of lightening in clinics is that since they can use microscopes, for example, in sample test of malaria, the consultation quality of doctors has been improved. In addition, since medicines can be stored in refrigerators, various kinds / larger quantity of officinal drugs can be stocked there. Before electrification, it was dark inside clinics even during daytime hours, which gave a negative image to patients and clinics were not places where patients were willing to go. These benefits show that electrification has significantly changed and contributed to the improvement of medical technologies.

9.4.3. Current Local Procurement Status of Solar Power Generation Systems

In Zambia solar power generation systems for general households are procured from several agents (suppliers) in Lusaka, the capital of the country, and systems for ESCO projects of each donor and for government projects are supplied via bidding among these suppliers, but the criteria are not clearly defined. Existing facilities except for those in ESCO projects were sold as maintenance-free systems, and buyers should bear the responsibility for operation maintenance including the case when any trouble occurs, however, these systems have issues in technological sustainability. According the market survey in 2007 in Lusaka, the procurement of solar power generation facilities fully relies on imports. Major suppliers of facilities in previous projects are described below, and these facilities are imported mainly via South Africa.

Table 9-8 Results of Market Survey on Solar Power Generation Facilities in Zambia

Company	**Supply Country**	**Item**
Kyosera	Japan	Solar Modules
Xantrex	USA	Inverter
Edwards	Australia	Solar Hot System
Steca	Germany	Charge regulators
Deltec	France	High Deep Cycle Batteries
Surrette	Canada	Deep Cycle Batteries
Mingle	Germany	Torches, Telephone Chargers
Sollatek	UK	Glowstar Protection Power promotion
Logic Electronics	Netherlands	Solar lantern

Source; JICA Study team

9.4.4. Essential Agendas for Systematic and Rational Implementation of Solar Power Generation Projects

Considering the rural electrification rate (3% in 2007), and because electrification promotion is a long term project, it is important to develop an off-grid electrification program using solar power, including a long term plan based on electrification policies of the government. Government authorities should lead the initiative while reflecting opinions of each province, to develop selection criteria of subject areas, expect demands, and standardize electrification methods using solar power. Also a framework should be established that defines responsibilities and alignment in logistics, construction, materials / equipment ownership, maintenance, education / training, fund collection and other related tasks.

9.4.5. Standardization of Implementation Plans, Applied Technologies and Equipment Specifications, and Development of Technical Manuals

Unification of technical standards, standardization of solar power generation technologies which align with local characteristics regarding design and installation items, etc., and technical manuals are needed for installation, implementation and operation maintenance. Currently the procurement of solar power generation facilities mainly relies on imports, but in order to promote the future utilization of parts manufactured in the country, costs and quality of these products should achieve an international level, requiring the establishment of technical standards, quality improvement, and technological advancement for cost reduction, of solar power generation facilities.

9.4.6. Establishment of a System and Framework for Operation, Maintenance and Management of Facilities / Services

In previous ESCO projects using solar power generation in Zambia, systems are not purchased by users, but they are installed in users' houses. The electricity generated from these systems is supplied to users and the electricity charge is collected from the users. Facilities are owned by the government and maintained by operating organizations. However, with limited supply quantity and similarly limited revenue of these projects, these organizations can not afford activities other than ongoing administration of themselves, nor to start an economic cycle of initial investment - revenue increase - productivity increase (electricity rate increase). In these ESCO projects, a mechanism to transfer the ownership from the government should be defined. Solar power generation facilities in Zambia are not purchased by users, but they are installed in users' houses. The electricity generated from these systems is supplied to users and then the electricity charge is collected from the users. Previous experiences in ESCO projects indicate that it is difficult to collect invested funds within a short period, and operating organizations need stable management foundation. Based on these insights, it is recommended that organizations which can obtain supports from central authorities while being located in rural areas should be established and operated by themselves. Especially if future rural electrification by solar power generation expands across the country, it may be difficult for traditional ESCO projects to sustain operations because of regional characteristics and gaps, requiring a single organization to administer electrification projects in the future.

It is recommended to develop engineers and standardize operation maintenance method under a maintenance system which can reflect opinions from the government and stakeholders. In order to focus on sustainability and regional characteristics, projects need (1) Low cost operation and maintenance, (2) Establishment a framework to realize them, (3) Development of a market for solar power generation facilities, (4) Formulation of technical standards including selection criteria.

9.4.7. Policy for Rural Electrification Framework Using Solar Power Generation

(1) The Rural Electrification Authority (REA), the relevant government authority, should unify organizations, because this system uses the Rural Electrification Fund (REF).

(2) A framework for capacity building of REA, provinces, districts and rural residents should be established.

(3) Since rural electrification extends to a broad range of areas, initiatives and independence of individual provinces and residents should be reinforced to promote responsibilities of residents

to share facility costs and participation in O&M.

(4) Participation of private sectors should be encouraged to strengthen alignment between the government and private sectors.

Table 9-9 Stakeholders of Electrification by Solar Power Generation and Their Roles / Responsibilities

Level	Role
Government	・Plays a leading role in rural electrification and is responsible for planning, expansion and decision making. ・Engages in the upstream of rural electrification including fund raising, planning, defining technical standards, and capacity building of government - province - district - organization related to electrification projects.
Province District	・Working with REA, develops annual targets for the electrification plan, approves projects, and verifies their quality when completed, etc. ・Regularly monitors projects, and reports their status to REA. ・Gives instructions and advices regarding operation maintenance to resolve regional technical gaps.
Organization	・RGC or each household is responsible for the management and operation of their systems. ・Develops engineers for each area after implementing systems. ・Transfers technologies to enable users to manage their systems.

9.4.8. Human Resource Development

Issues for human resources and technologies based on the insights from the experiences in previous electrification projects using solar power generation in Zambia are listed below.

(1) Lack of knowledge and low awareness of solar power generation technologies.

(2) Damages to facilities caused by low understanding of end users on how to use the facilities.

(3) Chronic shortage of professional engineers.

(4) Lack of organizations and trainings to develop engineers.

(5) Establishment of a system to supply materials / equipment, and maintenance methods for them.

For the sustainability of the framework, resolution of these issues is the most prioritized critical agenda. If these issues are not resolved, low understanding of end users on their responsibility to pay their bills may deteriorate the bill collection rate, resulting in a risk to the organizational sustainability. Therefore developing manuals for operation and maintenance, and providing trainings are critical for the sustainability of the framework. It is recommended that a system for this framework which can start working at the implementation of facilities should be established.

9.4.9. Technical Training Plan

(1) Establishing technical standards and developing standard O&M curriculum.

(2) Founding a centralized training centre to develop technical instructors using the defined technical standards and standard O&M curriculum.

(3) Developing technical instructors at each province or district level to maintain solar power generation facilities on regional basis.

9.4.10. Significance of Solar Power Generation and Conclusion

Electrification by solar power generation will significantly contribute to poverty reduction and resolution of economic gaps which are major issues in Zambia, because it will create social benefits, and develop regional areas and even peripheral areas.

Economically, electrification still needs public financial assistance, although the project will request users to share the cost as much as possible. It may be difficult to quantify most of the expected benefits from rural electrification in low income areas, but it will contribute to the infrastructure building which achieves rural electrification, social and economical stability, and benefits. Solar power generation is sure to play a major role in the increase of electrification rate in remote areas, where there are limited sources for power supply and distribution lines.

9.5. Design and Specification of Solar Power Generation Systems

9.5.1. Design of Solar Power Generation Facilities

The subjects of electrification are RGCs which are centers for rural economical activities. Systems are installed in (1) public facilities (schools, clinics and community halls), (2) other public facilities (markets), and (3) private houses.

Major components of solar power generation facilities are solar power modules, mountings, controllers, inverters, fuses, batteries, switches, fluorescent lights and plugs. In Zambia solar panels available in the market have a capacity of about 20Wp to 125Wp, and the selection will be made among them. The output power capacity for a private house is designed to be about 100W, a capacity of one to three about 8-10W lights plus two or three hours use of a radio or TV depending on each of the output power capacity, and this capacity is defined as the standard specification. For schools, it is important to define the number of classrooms and teachers' rooms to be electrified for lighting and other purposes, and the standard electrification will be implemented to equipment including lights, TVs and communication devices in three classrooms and two teachers' rooms. For clinics standard electrification will be implemented to equipment including lights, TVs, communication devices, refrigerators and sterilizers in consultation rooms.

9.5.2. Standard Specification of Solar Power Generation Systems

Based on results of pilot projects for solar power generation facilities in Zambia and availability of procurement, the specifications are defined as follows.

Table 9-10 Specification of Solar Power Generation Systems (Schools)

[School]			
Solar Equipment	Specification	Unit	Amount
Solar Modules	85Wp	Piece	1
Battery	105Ah	Unit	1
Charge controller	12A	〃	1
Solar fluorescent.	c/w switch 8W	〃	10
Rip cord	4.0mm^2	m	8
Cable	2.5mm	m	50
Roof model frame		rack	1

Table 9-11 Specification of Solar Power Generation Systems (Private Houses)

[Private House]			
Solar Equipment	Specification	Unit	Amount
Solar Modules	60Wp	Piece	1
Battery	105Ah	Unit	1
Charge controller	6.6A	〃	1
Solar fluorescent.	c/w switch 10W	〃	6
Rip cord	4.0mm^2	m	8
Cable	2.5mm	m	30
Roof model frame		rack	1

Table 9-12 Specification of Solar Power Generation Systems (Markets)

[Market]			
Solar Equipment	Specification	Unit	Amount
Solar Modules	70Wp	Piece	1
Battery	105Ah	Unit	1
Charge controller	8.8A	〃	1
Solar fluorescent.	c/w switch 10W	〃	7
Rip cord	4.0mm^2	m	8
Cable	2.5mm	m	35
Roof model frame		rack	1

9.6. Cost Assessment Method for Solar Power Generation System

The cost assessment of Solar power generation facilities is made based on the relation between the total cost including hardware and installation costs at the implementation, and operation maintenance cost, and their lifetime. The hardware cost should be minimized or reduced by deciding standard specifications based on the defined technical standards, and by introducing biddings or other arrangements for lot purchases of a certain expected quantity. The installation cost of facilities should be unified using technical standards and installation manuals while ensuring the quality by skilled engineers. For installation local companies are employed in the early stages, but in the future it is recommended that a system in which users install the facilities by themselves should be established. To maintain and enhance projects in unelectrified areas while sustainably controlling cost, it is also recommended to develop manuals for organizational management and operation maintenance of facilities, as well as for bill collection, to improve operational quality. In addition, government-led fund raising plans and cost assessments which cover whole fund flow including cost sharing by users, are required. It will be critical to enhance projects by investment increase, control costs including hardware and operation costs, and maintain users' ability to pay, by ensuring stable revenue through setting electricity tariffs, establishing bill collecting system and other arrangements, and reducing expenditures through improving efficiency and encouraging rationalization.

Chapter 10

Other Renewable Energies Planning

Chapter 10. Other Renewable Energies Planning

10.1. Current Status of Other Renewable Energies

10.1.1. Renewable Energy in Zambia

There are various kinds of alternative renewable energy sources that could be used besides micro-hydro and solar power, namely biomass, geothermal, and wind-power. Zambia is said to have some potential of the said renewable energy sources, and the Zambian Government has been keen to expand the use of renewable energy, which is considered to be effective in addressing the following concerns, (though, in fact, the current utilization of renewable energy still contributes very little to the nation's energy supply).

- Diversifying energy sources,
- Increasing the electrification rate in rural areas since renewable energy is an on-site energy source and it is generally available in rural areas, and
- Improving the living standards of residents in impoverished rural areas, improving their health and educational level, and reducing endemic diseases such as HIV/AIDS.

Table 10-1 shows the availability and potential for the use of renewable energy in Zambia.

Table 10-1 Availability and Potential for Utilization of Renewable of Energy Resources and Technologies in Zambia

Renewable Energy	Opportunities/Use	Resource Availability	Potential Energy Output
PV	Thermal (water heating), Electricity (water pumping, lighting, refrigeration)	6-8 sunshine hours	5.5 kWh/m^2/day (modest potential especially for limited irrigation)
Wind	Electricity Mechanical (water pumping)	Average 3m/s	Good potential, especially for irrigation
Micro-hydro	Small grids for electricity supply	Reasonably extensive	Requires elaboration and quantification
Biomass (Combustion and Gasification)	Electricity generation	Agro wastes Forest wastes Sawmill wastes	Requires elaboration and quantification
Biomass (biomethanation)	Electricity generation Heating and cooking	Animal waste Agro- and industrial waste Waste water	Potential requires elaboration
Biomass (extraction, processing for transport)	Ethanol for blending with gasoline to replace lead as octane enhancer Biodiesel for stationary engines	Sugarcane Sweet sorghum Jatropha	15,000 ha to meet current demand
Biomass (for household energy)	Improved charcoal production Improved biomass stove	Sawmill wastes and indigenous trees from sustainable forest management	Reasonably extensive

Source: Centre for Energy, Environment, and Engineering (Z) Limited, 2004 National Energy Policy (MEWD), 2006

However, many issues remain to be solved to expand the use of renewable energy, such as:

- Support from Government/donors for subsidising private sector investment to cover very high initial investment,
- Improvement of technical capacity to operate and maintain photovoltaic systems,

- Development of organization and management for sustainable business enterprises;
- Promoting the establishment of the market for equipment and materials.

At the time of writing, the Government provided only policy guidelines regarding the utilization of renewable energies and there was no specific program.

10.2. Data Collection

10.2.1. Wind-power Potential

Wind-power has the characteristic that it is strongly affected by the climate, land features and surrounding environment. Zambia is a landlocked country surrounded by 8 countries. The distance from the eastern border to the Indian Ocean is 700km and the western border to Atlantic Ocean 1,000km. The elevation of the country ranges between 1,000m and 1,350m. Gently sloped plateau is savanna, which is covered with grass and shrubs.

The Zambia Meteorological Department (ZMD) has 18 observatories in the country (limited to the sites where reliable data are available), which are record wind velocities at a height of 10m from the ground. Table 10-2 shows the annual average wind velocity in Zambia.

The data reported by the Zambia Meteorological Department show the monthly average wind velocity from 2002 to 2005 at each observatory. The country’s annual average wind velocity is about 3.2m/second.

Table 10-2 Annual Average Wind Velocity in Zambia (2002-2005)

Chipep	Kabwe	Livingstone	Lundaz	*Lusaka01*
4.1	3.3	3.7	3.9	*N.A.*
Lusaka02	Magoye	Mbala	Mfuwe	'Misamf
N.A.	3.84	4.1	2.6	4.4
Mongu	Mumbwa	Petauke	Solwezi	Zambezi
6.3	3.5	3.7	2.9	2.6
Kafiro	Mwinil	Mumbwa	Kaoma	Kabomp
1.7	1.6	3.5	1.14	1.1
Average	**3.2**（m/s）			

Source: Zambia Meteorological Department

10.2.2. Biomass Potential

Promotion of biomass energy development in Zambia is in line with the Government policy to promote fair share of sustainable renewable resources in the energy supply. The Government has been developing the guidelines to improve institutional and legal frameworks for the promotion of biomass energy development in the future.

In Zambia, wood fuel as forest resource has been consumed as firewood and charcoal. Forests are estimated to cover an area of 50million ha, or 66% of the national land. Most households use firewood and charcoal for cooking and heating, and this accounts for over 70% of the energy consumption in Zambia (2004). This type of energy consumption is projected to continue in the future, as the statistics show that the percentage of using firewood for cooking is 60.9%, using charcoal 24.3%, while electricity accounts for only 13.8% (Draft National Energy Policy, October 2006). Meanwhile, as the population grows and the demand for energy increases the cutting of timber exceeds the rate of reforestation, forests are destroyed and the consequential negative environmental effects such as desertification become serious concerns.

Zambian Government has a strong interest in the utilization of bio-fuels. Use of bio-fuels in the transport sector has been discussed. In general, bio-fuel is classified into bio-ethanol and bio-diesel. The bio-ethanol is produced by fermentation of residue of agricultural products such as oats, rice and sugarcane. The fuel is used by mixing ethanol of with 3 to 10%. Actually the history of automobiles shows that initially bio-ethanol was used as the fuel; but it was gradually replaced by gasoline because of the lower costs. Bio-diesel is produced from crop material such as casaba, jatropha curcas, canola oil and soybeans. Methanol is added to the bio-diesel to initiate a chemical reaction to lower the viscosity for practical use.

Although the expansion of renewable energies utilization is called for, there are no examples of electrification projects using biomass in Zambia.

Table 10-3 shows residue of major crops for biomass energy in Zambia.

Table 10-3 Residue of Some Major Crops Grown in Zambia

Crop	Type of residue	Average Annual crop production10^3t (1987-1999)	Average Residue Annual availability 10^3t
Maize	Stalk+cobs	1,143.0	2,857.5
Sorghum	Stalk	29.5	59.0
Millet	Stalk	49.4	98.8
Paddy Rice	Straw+ husks	11.7	34.0
Sugar cone	Bagasse (50%wet)	1,313.3	459.7
Cotton	Stalk Gin trash	42.0	147.0 126.0
Groundnuts	Shell, Stalk	39.9	19.95 115.7
Soya beans	Straw	24.8	62.0
Sunflower	Stalk	13.2	23.1
Irrigated Wheat	Straw	58.6	102.5
Cashew nuts	Shell	2.5	5.0
Coffee	Kernel	1.4	0.7
Castor oil	Stick	0.2	0.7
Irish potato	Straw	11.1	3.3
Sweet potato	Straw	5.0	2.0
Mixed beans	Straws/peels	19.0	43.7
Cassava	Stalks/peels	122.3	89.5
Cashew nuts	Shell	2.7	5.5

Source: Annual Report of Department Agriculture 2001

Among the residue of major crops produced in Zambia, the proportion of stems of sugarcane and maize are relatively large. In case these materials are planned to use for biomass generation, it is carefully noted that the procurement of raw material significantly affects the power generation potential.

There are three commercial sugar factories in Zambia namely Zambia Sugar Factory in Mazabuka (Southern Province), Kafue Sugar Factory in Kafue (Lusaka Province), and Kalungwishi Sugar Factory in Kasama (Northern Province). The Government expects that these sugar factories would contribute to the production of bio-fuels. Table 10-4 shows rough outline of the production of the three sugar factories.

Table 10-4 Rough Outline of Production in the Major Sugar Factories in Zambia

Sugar factory	Cultivated acreage	Quantity of production (Sugar)	Quantity of production (Molasses)	Yield
Zambia Factory	15,800ha	233,765t	52,000t	111,178t
Kafue Factory	4,200ha	6,500t	15,000t	N.A.
Kalungwishi Factory	3,000ha	4,000t	800t	38,000t

Source: Final Concept Paper by The renewable Energy committee 2004

10.3. Review of Existing Other Renewable Energies Development Plans

10.3.1. Wind-power

(1) About Wind-Power Generation

Conditions suitable for wind-power generation are high average wind velocity, stable wind direction and small turbulence.

Selection of suitable areas for wind-power generation takes the following steps: first, select areas where annual average wind velocity is over 5m/s, preferably 6m/s at a height of 30m from the ground[26], and then select areas among them where the high velocity conditions covers a wide area.

Although annual average wind velocity in country of Zambia is 3.2m/s, in some sites the annual average wind velocity of 5m/s or more is observed. Table 10-5 shows the classification of windmills by size.

Table 10-5 Classification of Windmills by Size

Classification		Capacity
Micro windmill		Less than 1kW
Small sized windmill		1 - below 50kW
Medium sized windmill	I	50 - below 500kW
	II	500 - below 1,000kW
Large sized windmill		Over 1,000kw

Source: International Electro technical Commission (IEC)

[26] In Japan the criterion for determining the possibility of wind-power generation business is that annual average wind velocity is preferably over 6m/s at a height of 30m from the ground (Wind-power Generation Introduction Guidebook, NEDO, 2005).

(2) Past Projects of Wind-Power Generation in Zambia

Zambian Government has no wind-power generation project at the moment. Micro windmills are sometimes used by private sector, but full-fledged utilization of wind power is rare.

Figure 10-1 Shiwang'andu – Chinsali District in Northern Province – Wind Power Generation

10.3.2. Biomass

A biomass project in Zambia has been implemented in Kaputa, Northern Province, financed by the grant aid from Global Environment Facility (GEF), which is under United Nations Industrial Development Organization (UNIDO). The project's objective is to provide electricity to mini-grid from biomass gasification system.

Various methods of biomass energy utilization are discussed and planned for the future expansion, but at the time of the Study actual project plans had not materialized.

No technical standards had been developed either.

10.3.3. Others

Geologically, Zambia is covered with sedimentary rocks and on contrary to the general observation that in the lands like Zambia hot springs are scarcely available compared to the lands that are dominated by igneous rocks, hot springs are found in over 80 sites in areas with intrusive rocks formed through the geological process.

Two sets of 120kW turbine were established as pilot sites in Kapisya Hot Spring in mid-1980s under the initiative of the Italian Government. Due to the absence of a nearby load the facility was not used. The Zambian Government planned to revive geothermal development projects in other sites though their potential for electricity generation was not known.

Chapter 11

Environmental
and
Social Considerations

Chapter 11. Environmental and Social Considerations

11.1. National Environmental Strategies and Legislation

11.1.1. National Policy on Environment

In 2006, the Ministry of Tourism, Environment and Natural Resources finalized a Draft Policy on Environment that recognizes the requirements set out in the national constitution and acknowledges the responsibility of civil society and all citizens to protect and conserve the environment. The Policy calls for the importance of managing the environment in partnership with the private sector, non-governmental organizations (NGOs) and the local people for the benefit of the present and the future generations. The planning and executing agency for the Policy is the Ministry of Tourism, Environment and Natural Resources (MTENR).

11.1.2. The Environmental Protection and Pollution Control Act, 1990

The Environmental Protection and Pollution Control Act (EPPCA), the supreme environmental law in Zambia, was passed in 1990. The Act established the Environmental Council of Zambia (ECZ), which assumes sole responsibility to protect the environment and control pollution so as to ensure the health and welfare of people and wildlife in Zambia.

EPPCA specifies the functions and authority of the ECZ. Membership of the board for ECZ is drawn from specified stakeholders regarding the protection of the environment and natural resource use. The MTENR appoints the Chairperson of the board. The board appoints the Director, who is the Chief Executive Officer. The Director executes the policies and directives of the board.

ECZ is empowered;

- to identify projects or types of projects, plans and policies for which environmental impact assessment are necessary and to undertake or request others to undertake such assessments for consideration by ECZ;
- to monitor trends in the use of natural resources and their impact on the environment;
- to request information on projects proposed, planned or in progress by any person anywhere in Zambia;
- to request information on the quantity, quality and management methods of natural resources and environmental conditions from any individual or organization anywhere in Zambia; and
- to consider and to advise the GRZ on all major development projects at an initial stage and on the effects of any sociological or economic development on environment.

11.1.3. The EIA Regulations, 1997

The Environmental Impact Assessment Regulations were set out in 1997. The EIA regulations in conjunction with the EPPCA of 1990 provide a sound legal framework for the process and requirements for environmental clearance in Zambia. The EIA Regulations articulate specific procedures that anyone who takes on development activities listed in the regulations must follow. Authorization licenses granted by ECZ under the EIA Regulations remain valid for three years from date of issue. The EIA Regulations also provide a framework for post-assessment environmental audits as well as an appeal procedure for any party aggrieved by the decision of ECZ.

11.1.4. Other Regulations

In addition to the above environmental legislation, there are other pieces of legislation administered by various Government Departments that project developers need to take into consideration, such as the;

- Public Health Act, 1930
- Water Act, 1949
- Noxious weeds Acts, 1953
- Agricultural Lands Act, 1960
- Factories Act, 1967
- Natural Resources Conservation Act, 1970
- Zambezi River Authority Act, 1987
- National Heritage Conservation Commission Act, 1989
- Local Government Act, 1991
- Town and Country Planning Act, 1995
- Electricity Act, 1995 and Energy Regulation Act, 1995
- Lands Act, 1995 and Lands Acquisition Act, 1995
- Fisheries Act, 1998
- Zambia Wildlife Authority Act, 1999
- Forestry Act, 1999
- Rural Electrification Act, 2003
- Project developers also need to consider other International and Regional Conventions such as;
  - Convention on the Protection of World Cultural and Natural Heritage
  - Convention on Wetlands of International Importance, especially as waterfowl habitat
  - Statutes for the International Union for the Conservation of Nature and Natural Resources
  - Convention on the African Migratory Locust
  - SADC Protocol on the Environment
  - SADC revised Water Protocol
  - African Convention on the Conservation of Nature and Natural Resources
  - Convention on International Trade in Endangered Species of Wild Fauna and Flora
  - Vienna Convention for the Protection of the Ozone Layer
  - Montreal Protocol on Substances that Deplete the Ozone Layer
  - Agreement on the Action Plan for the Environmentally Sound Management of the Common Zambezi River System
  - Convention on Biological Diversity
  - United Nations Framework on Climate Change
  - United Nations Convention to Combat Desertification
  - Bonn Convention

11.2. Environmental Process and Regulations Relating to Rural Electrification

11.2.1. Environmental Clearance Process

The purpose of the environmental clearance process is to determine whether development projects are likely to have potential adverse environmental and social impacts, to determine appropriate mitigating measures for those impacts, to ensure that those mitigation measures be incorporated into the project design, and to monitor social and environmental indicators during implementation and operation. The level of the environmental assessment required depends on the nature of projects. ECZ provides EIA Guidelines with a checklist and project classification categories.

Section 3 (1) of Statutory Instrument No. 28 of 1997 of the Environmental Protection and Pollution

Control Act No. 12 of 1990, namely, the EIA Regulations stipulate that "A developer shall not implement a project for which a project brief or environmental impact statement is required under these Regulations, unless the project brief or an environmental impact statement has been concluded in accordance with these regulations and the ECZ has issued a decision letter."[27] An EPB is the first stage of the environmental and social impact assessment process and is supposed to cover the results of preliminary investigations on the impacts of the project on both society and environment.

The items to be described in an EPB constitute the followings:

- Environment of the project site/area
- Objectives of alternatives to the project
- Main activities to be conducted in the preparation, construction, and operation phases
- Raw materials in the project
- Products, by-products, including solid, liquid and gaseous wastes
- Noise level, heat, and radioactive wastes in normal/emergency operation states
- Socio-economic impacts expected in the project, number of people who would be directly forced to resettle or those who would be employed in construction /operation phases of the project
- Anticipated impacts on environment by implementation of the project taking into consideration the above
- Biodiversity, nature, geographical resources, and land/water area affected in terms of time and space
- Mitigation measures and monitoring plan to be implemented

[27] The EIA Regulations apply to specific projects and not to a Master Plan. However, it would be appropriate for the Master Plan to be subjected to a Strategic Environmental Assessment (SEA) once it is finalized. The SEA enable a proponent or planner to overview the environmental aspects and comprehensive impacts of the Master Plan. The present EIA Regulations do not provide for approval of the Strategic Environmental Assessment. The SEA would be very useful for formulation of a whole Master Plan, thus providing useful information for decision making.

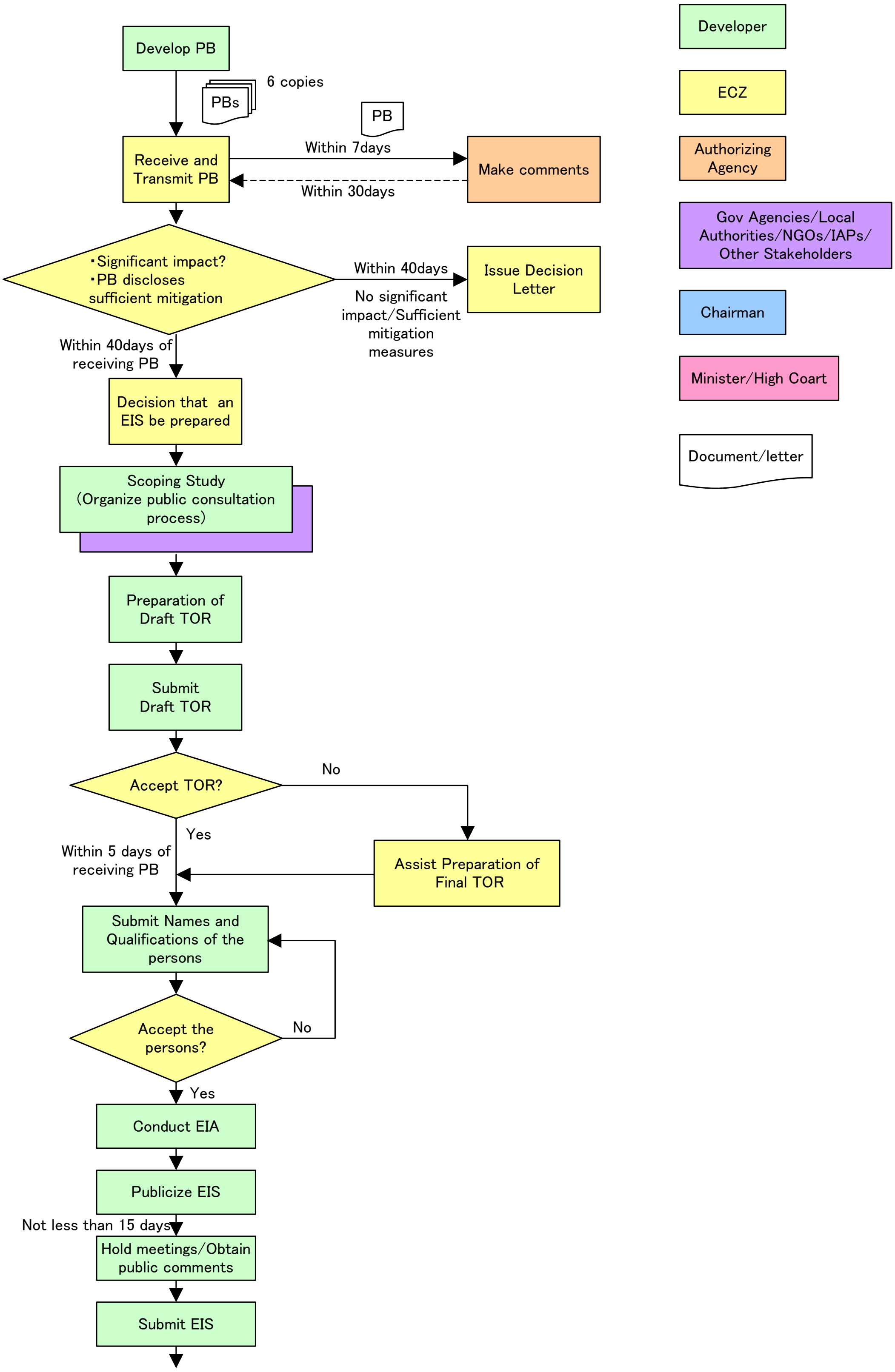


Figure 11-1 Environmental Clearance Process in Zambia

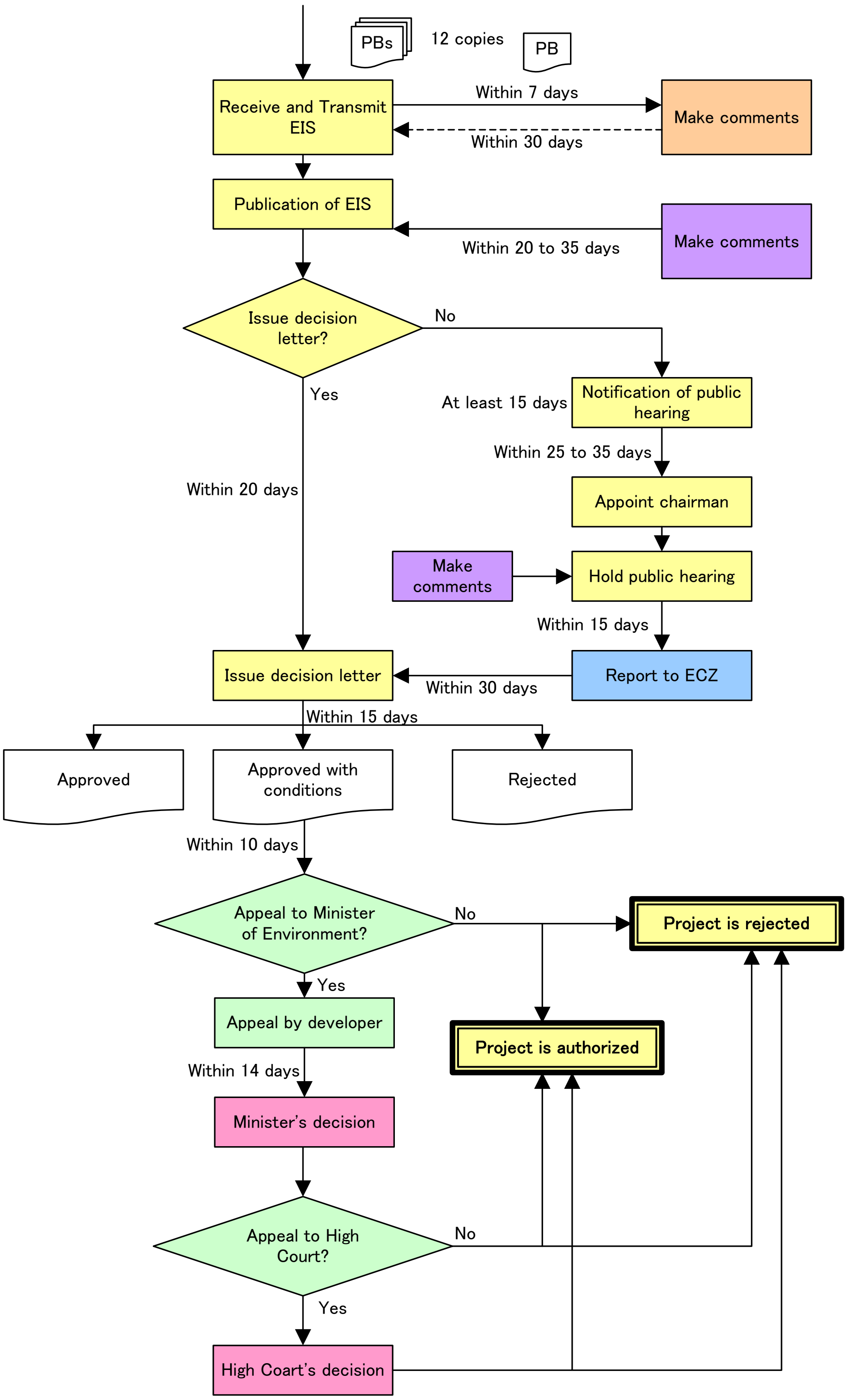


Figure 11-1 Environmental Clearance Process in Zambia (Cont.)

After receiving an EPB[28] submitted by a developer, ECZ makes a reference to the authorizing agency, and then carefully review the EPB taking into account the reference results. If ECZ concluded that no significant impact on environment is anticipated by the project, it suggests approval and issues a decision letter, in other words, development permission. If certain negative impacts of the project are identified, ECZ proceeds to review of the impact mitigation measures. When ECZ recognize that the PB in question shows sufficient mitigation measures, it authorizes the project implementation and issues the decision letter as same as it does for the first case. In case where ECZ regards the project's adverse impacts on environment as significant, it decides to either reject the project or recommend further in-depth environmental assessment.

In case ECZ sees the need for further assessments, the developer is then directed to undertake detailed social and environmental impact assessment studies. The developer starts from scoping then prepares the draft terms of reference (TOR). In determining the scope of works, the developer is obliged to engage in public hearing with government agencies, local authorities, NGOs, civil society, and a variety of stakeholders. The developer submits the TOR's including the names and qualifications of the persons who will conduct the EIA study and prepare the EIS. The draft TOR is then scrutinized by ECZ and the developer is then advised whether to go ahead with the EIA study or improve on the study team composition and terms of reference before doing so. Following approval of the TOR's and study team composition, the developer commences with the EIA study. Upon completion of the study, the developer submits the draft Environment Impact Statement (EIS) report to the ECZ for review and comment. The developer incorporates the comments received from the ECZ and submits the final report. Upon receiving the final EIS, ECZ sends the EIS to relevant ministries, government departments, local governments, parastatals, NGOs, and the Interested and Affected Parties (IAPs) for their review and comments. ECZ makes the EIS available for public at public buildings in the vicinity of the proposed project site to obtain public comments. Public meetings may be held in the vicinity of the proposed project site if ECZ considers it necessary. Based on the all comments it has received, ECZ scrutinizes the EIS, examining whether the proposed measures are appropriate as well as adequate. Upon completion of the procedures, ECZ makes a decision whether it authorizes project implementation with conditions, without conditions, or rejects the project.

Therefore, the administration of the environmental clearance process in Zambia involves a variety of stakeholders. Project developers, sectoral agencies, and environmental authority (namely ECZ) assume respective responsibility.

As was mentioned in the previous section, a project developer kicks off the environmental clearance process when a certain project materializes. After screening, the project developer prepares necessary documents such as EPB and EIS, conducts environmental impact assessments complies with management and monitoring requirements resulting from the assessment and the public recommendations. The project developer has to collect and disclose information regarding the scope of the project, its socio-environmental impacts, and management- and mitigation measures and monitoring programs.

ECZ and Sectoral agency or related authorities collaborate on behalf of the public to ensure that ecological, cultural, social, and economic issues are properly addressed in line with government policy and legislation. The sectoral agency retains responsibility to ensure that the proposed project meets all the sectoral requirements for which the agency is mandated.

11.2.2. Projects which require Environmental Project Briefs

Below are the types of projects that require the preparation of Environmental Project Briefs. The

[28] According to MTENR, only sub-projects in the Rural Electrification Master Plan require submission of EPBs and ECZ's approval when these projects are actually decided to be implemented, basically, these do not fall into the project category which requires EIA.

Environmental Regulations have a long list of types of projects that require the preparation of Environmental Project Briefs, but only those projects, which relate to the operations of power development, are highlighted as follows[29]:

- Hydropower schemes
- Transmission lines development
- Distribution line construction of more than one 1 km long
- Projects affecting wetlands
- Projects affecting natural forests
- Flood control schemes
- Diesel powered generating plants
- Pumped water storage plants
- Resettlement schemes
- Hospitals, clinics, health centres, schools, colleges and universities
- Housing schemes
- Recreations facilities, hotels, restaurants and lodges
- Renovations or expansions to all the above infrastructure

11.2.3. Projects that require Environmental Impact Statement (EIS)

The Environmental Regulations have a long list of the types of projects that require the preparation of EIAs, but only those projects, which relate to power development, are highlighted as follows:

- Electricity generation stations
- Transmission line development more than 1 km long
- Access roads along transmission lines for more than 1 km
- Dams and barrages covering a total of 25 hectares for irrigation, water supply or generation of electricity
- Sewerage disposal sites with a capacity of 15,000 litres or more a day
- Sites for solid wastes disposal with 1,000 tonnes and above a day
- Sites for hazardous waste disposal
- Major road construction and large scale improvements to existing roads of over 10 km or 1 km if it passes through a national park or forest reserve
- Clearance of forests in sensitive areas such as watershed areas for agricultural, industrial and other uses

11.2.4. Review Fees

According the Environmental Protection and Pollution Control Act (Environmental Impact Assessment) (Amendment) Regulations of 1998, the project proponent is required to pay specified amount of money to Environmental Council of Zambia (ECZ) for reviewing (reading through the report to give approval) the Environmental Impact Assessment (EIA) reports and Environmental Project Briefs. Currently for Environmental Project Briefs, the project proponent is required to pay K7,799,940. The amount to be paid for the review of EIA reports depends on the value (total investment cost) of the project and ranges between K7,799,940 and K584,995,500. These fees are subject to periodic review.

[29] According to MTENR, none of the rural electrification projects will fall into the category of those projects that require full environmental impact assessment. However, there are some examples of rural electrification projects that were required to conduct EIA by ECZ. Even for the rural electrification projects, full EIA could be required depending on the scale of the project and degree of adverse impacts on environments.

Table 11-1 Review Fee Tariff

Project Cost	Fee (K)	US$ Equivalent
Review of project brief	7,799,940.00	1,950
Less than US $100,000	7,799,940.00	1,950
US $100,000 – 500,000	38,999,700.00	9,750
US $500,000 – 1,000,000	97,499,160.00	24,375
US $1,000,000 – 10,000,000	194,998,320.00	48,750
US $10,000,000 – 50,000,000	389,997,000.00	97,499
US $50,000,000 or more	584,995,500.00	146,249

Note: Exchange rate of 1US$ = K4,000 was applied for currency conversion

11.2.5. ZESCO's Environmental Management

ZESCO, a key national power sector operator in Zambia, has developed an environmental policy in line with the provisions of the Environmental Protection and Pollution Control Act of 1990. The policy is also in conformity with international standards and public expectations in environmental management. The ZESCO Environmental Policy is presented as follows;

- ZESCO's ambition is to satisfy customers' demand for efficient, safe and environmentally friendly supply of electric energy.
- The natural resources on which our operations depend shall be harnessed with utmost possible care.
- In our effort to achieve environmental excellence in our operations, we shall continuously train and motivate all employees to perform their duties in an environmentally responsible manner.
- Facing our responsibility to enhance environmental protection, we shall take the interest of future generations into consideration when carrying out our development projects.
- In openness and with commitment to environmental issues related to power development, we shall endeavour to create and enjoy the confidence of our customers and other stakeholders in our actions and operations.

The Environment and Social Affairs Unit (ESU) was established in June 1996 under Engineering Development Directorate of ZESCO. The Unit was tasked to handle environmental and socio-economic issues pertaining to the operations of ZESCO.

The main function of ESU is to ensure that ZESCO operates within the provisions of the environmental regulations. Specifically, the major functions of ESU are:

- to ensure that ZESCO operates in accordance with Zambian environmental regulations;
- to develop environmental guidelines and environmental operational plans for ZESCO on various aspects;
- to advise engineering and other ZESCO staff on environmental and social issues;
- to train ZESCO staff in environmental and social issues;
- to represent ZESCO on environmental and social issues in national and international form;
- to liaise with Government ministries and other institutions responsible for management of water, land and other natural resources, environmental regulation and socio-economic affairs;
- to develop baseline environmental and socio-economic database for catchment areas where ZESCO operates;
- to conduct environmental impact assessments for ZESCO projects to identify the impacts, recommend mitigation measures and monitoring implementation of recommended mitigation measures;

- to supervise consultants hired to do environmental work for ZESCO projects pertaining to power generation, transmission and distribution;
- to manage land acquisition, resettlement programmes and compensation related to implementation of ZESCO projects; and
- to conduct public meetings in project areas to ensure that the public understands the projects being undertaken by ZESCO and to get their input on various aspects of each project.

The ESU of ZESCO comprised sixteen officers, namely, the ESU Manager, Chief Environmental Scientist, a Principal Soil Scientist, Information Specialist, Ecologist, Hydrologist, four Way-Leave Officers, an Environmental Assistant, Environmental Technologist (Ecologist), Environmental Technologist (Geophysist), and Environmental Technician (Hydrology). Throughout extensive project experience, ESU has built its capacity on environmental impact assessment studies. For donor-assisted projects, ESU has conducted EIA studies in association with international and national leading environmental consultants, meeting international social and environmental requirements.

11.2.6. REA's Environmental Management

The Rural Electrification Authority (REA) is a new statutory body established in April 2004 and now expanding its operational capacity. The REA structure includes the position of environmental specialist reporting to the Senior Manager, Planning and Projects. As part of its environmental management system, the REA prepares EPB's and EIS's for its rural electrification projects. This helps in meeting legal obligations under the EPPCA as the REA undertakes its projects. In future, the REA may also play a role of making comments on EPBs and EISs submitted by developers and transmitted to the REA by ECZ in the environmental clearance process and to categorize power generation projects based on generation and supply capacity.

ZESCO, which has cumulative project experience, may actively assist REA in developing social and environmental assessment capacity, for example, by involving REA personnel in ZESCO's EIA study team and by giving lectures and workshops on EIA techniques.

11.3. Environmental and Social Considerations to Rural Electrification Master Plan

11.3.1. Environmental and Social Impact of Master Plan

There is no direct environmental and social impact in the master plan stage. However, in implementing specific components to be proposed in the Master Plan may involve some social and environmental considerations. Therefore, The concept of the Strategic Environmental Assessment (SEA) should be taken into consideration to prepare appropriate Rural Electrification Master Plan in view of environmental and social aspects.

Two proposed mini-hydropower project sites were selected by the field survey conducted in June and August 2007. The JICA Study Team in collaboration with the Zambian Counterpart team conducted preliminary environmental impact assessment activities and prepared EPBs, for capacity development purposes.

The following Table 11-2 shows the revised scoping of social and environmental considerations in the Rural Electrification Master Plan.

Table 11-2 Scoping of Social and Environmental Considerations

	No.	Item	Rating											Remarks
			Master Plan Stage	D/L		Minihydro		PV		Wind		Biomass		
				Construction	Operation	Construction	Operation	Construction	Operation	Construction	Operation	Construction	Operation	
Social Environment	1	Involuntary Resettlement	D	D	D	B	C	D	D	B	C	D	D	
	2	Local economy such as employment and livelihood, etc.	D	D	D	B	B	D	D	D	D	D	C	
	3	Land use and utilization of local resources	D	B	D	B	B	D	D	D	D	B	B	
	4	Social institutions such as social infrastructure and local decision-making institutions	D	C	D	C	D	D	D	D	D	D	D	
	5	Existing social infrastructures and services	D	B	B	B	B	B	B	B	B	B	B	
	6	The poor, indigenous and ethnic people	D	D	D	D	D	D	D	D	D	D	D	
	7	Misdistribution of benefit and damege	D	D	B	D	B	D	B	D	B	D	B	
	8	Cultural heritage	D	B	D	B	D	D	D	B	D	B	D	
	9	Local conflict of interests	D	D	D	D	D	D	D	D	D	D	D	
	10	Water Usage or Water Rights and Rights of Common	D	D	D	B	B	D	D	D	D	D	D	
	11	Sanitation	D	D	D	D	D	D	D	D	D	D	C	
	12	Hazards (Risk)/Infectious diseases such as HIV/AIDS	D	B	D	B	D	B	D	B	D	B	D	
Natural Environment	13	Topography and Geological features	D	C	C	B	B	D	D	C	C	D	D	
	14	Groundwater	D	D	D	D	D	D	D	D	D	D	D	
	15	Soil Erosion	D	B	B	B	B	D	D	C	C	D	D	
	16	Hydrological Situation	D	D	D	B	B	D	D	D	D	D	D	
	17	Coastal Zone	D	D	D	D	D	D	D	D	D	D	D	
	18	Flora, Fauna and Biodiversity	D	C	C	C	C	C	C	C	C	C	C	
	19	Meteorology	D	D	D	D	D	D	D	D	D	D	D	
	20	Landscape	D	B	B	B	B	B	B	B	B	B	B	
	21	Global Warming	D	D	D	D	D	D	D	D	D	D	D	
Pollution	22	Air Pollution	D	B	D	B	D	B	D	B	D	B	B	
	23	Water Pollution	D	C	D	C	D	C	D	C	D	C	D	
	24	Soil Contamination	D	D	D	D	D	D	D	D	D	D	D	
	25	Waste	D	B	D	B	D	B	D	B	D	B	D	
	26	Noise and Vibration	D	B	D	B	D	B	D	B	D	B	C	
	27	Ground Subsidence	D	D	D	D	D	D	D	D	D	D	D	
	28	Offensive Odour	D	B	D	B	D	B	D	B	D	B	B	
	29	Bottom sediment	D	D	D	D	D	D	D	D	D	D	D	
	30	Accidents	D	B	B	B	B	B	B	B	B	B	B	

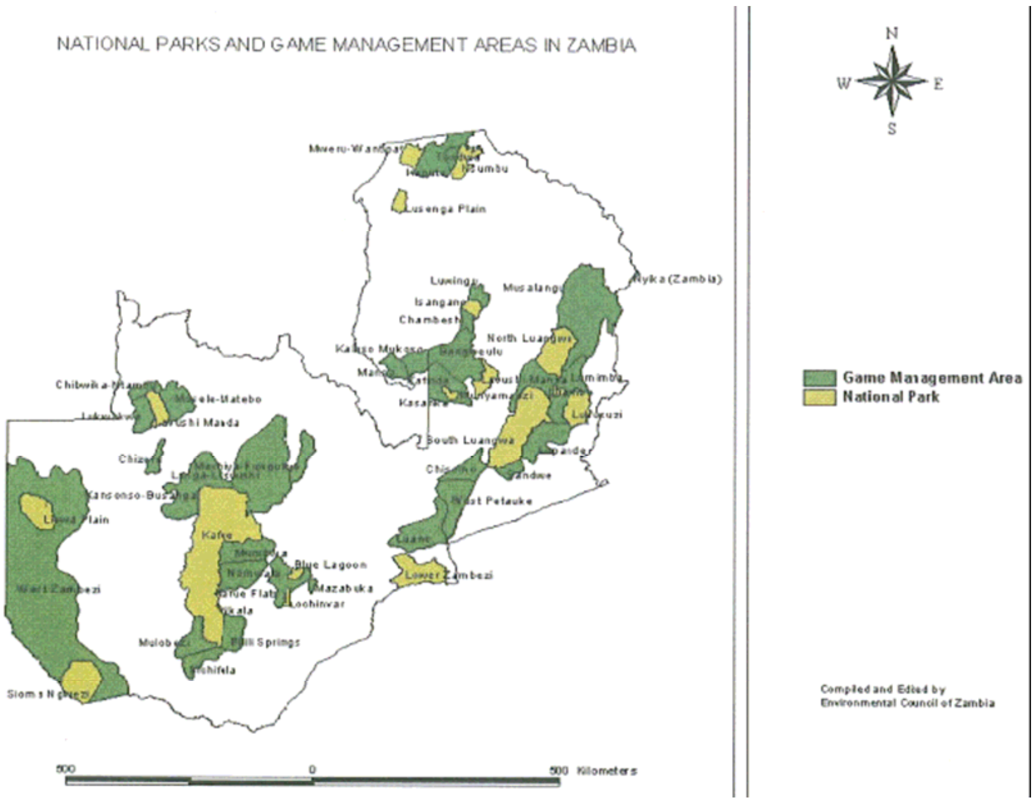
Note: Evaluation categories are as follows:
A : Significant negative impact is expected
B : Negative impact is expected to some extent
C : Negative impact is now known at this stage
D : Negative impact is not expected/negative impact is insignificant

11.3.2. Potential Social and Environmental Impacts of Rural Electrification Master Plan Sub-Projects

In the Rural Electrification Master Plan in Zambia, several rural electrification options will be presented. The least cost option is grid system extension, followed by micro-hydro micro-grid, photovoltaic (SHS) and other renewable installations in the remote areas. The followings are the potential social and environmental impacts to be studied and mitigated for under the REMP Projects.

(1) Vegetation and Wildlife

The clearance of vegetation along the distribution lines and access roads, as well as micro-hydropower generation sites is unavoidable in the construction phase. Disturbance of vegetation may also occur on rocks and soil disposals and camp areas for construction workers. Some rare or endangered vegetation and wildlife species in such areas may be affected. In the operation phase, routine maintenance of the right-of-way (ROW) will inevitably require tree cutting or vegetation clearance within certain way leave. Figure 11-2 shows the map of National Parks and Game Management Areas and Figure 11-3 also shows the National Parks, Environmentally Sensitive Areas, and the Wetland Bird Habitats, including the positions of all RGCs. Among the RGCs, some are located in such environmentally sensitive areas; thus there may be significant negative impacts on the environment. Execution of more detailed impact assessment prior to project implementation in such areas is essential to avoid the risk.



Source: Statement of Environment in Zambia 2000 Figure 7.2: National Parks and Game Management Areas of Zambia

Figure 11-2 National Parks and Game Management Areas in Zambia.

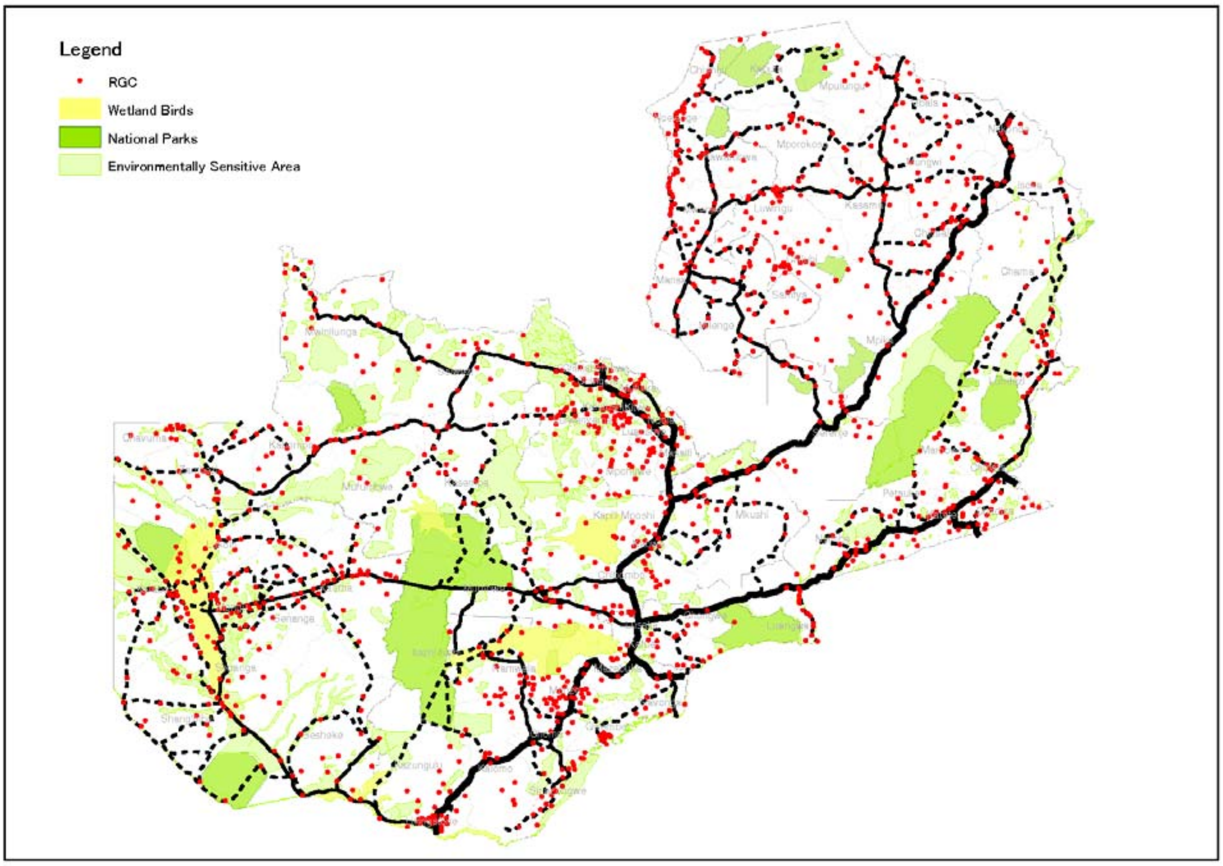
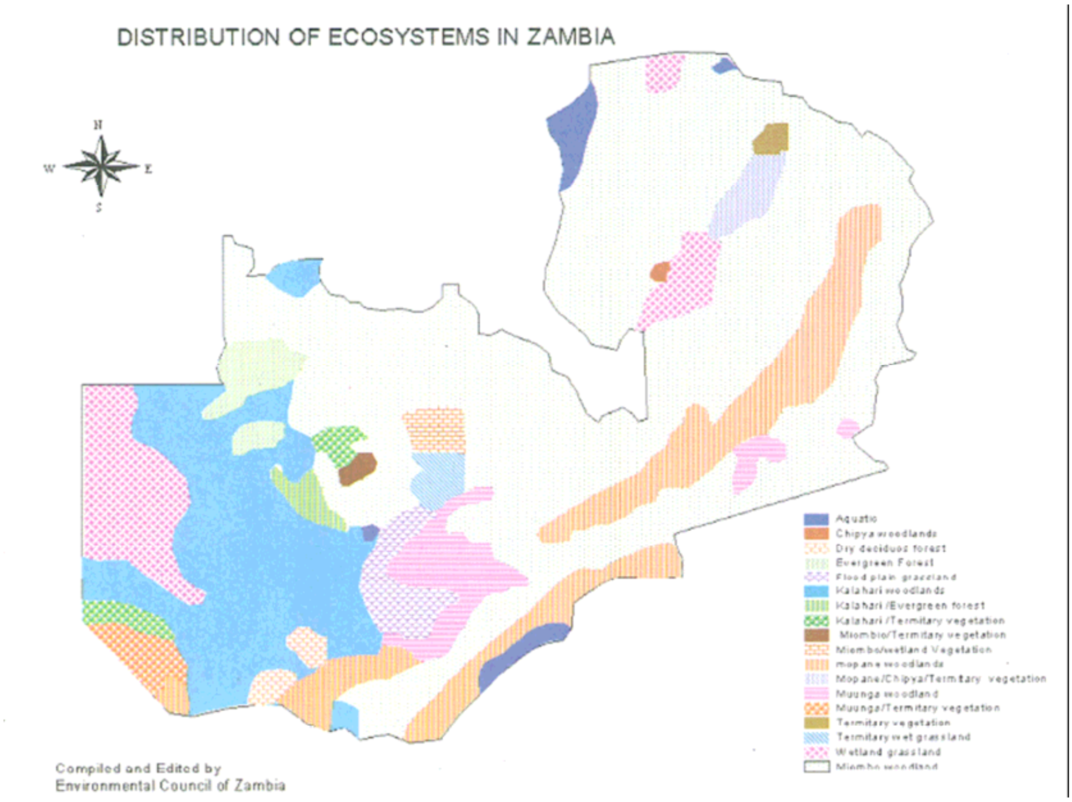


Figure 11-3 National Parks, Environmentally Sensitive Areas, Wetland Bird Habitat, and RGCs

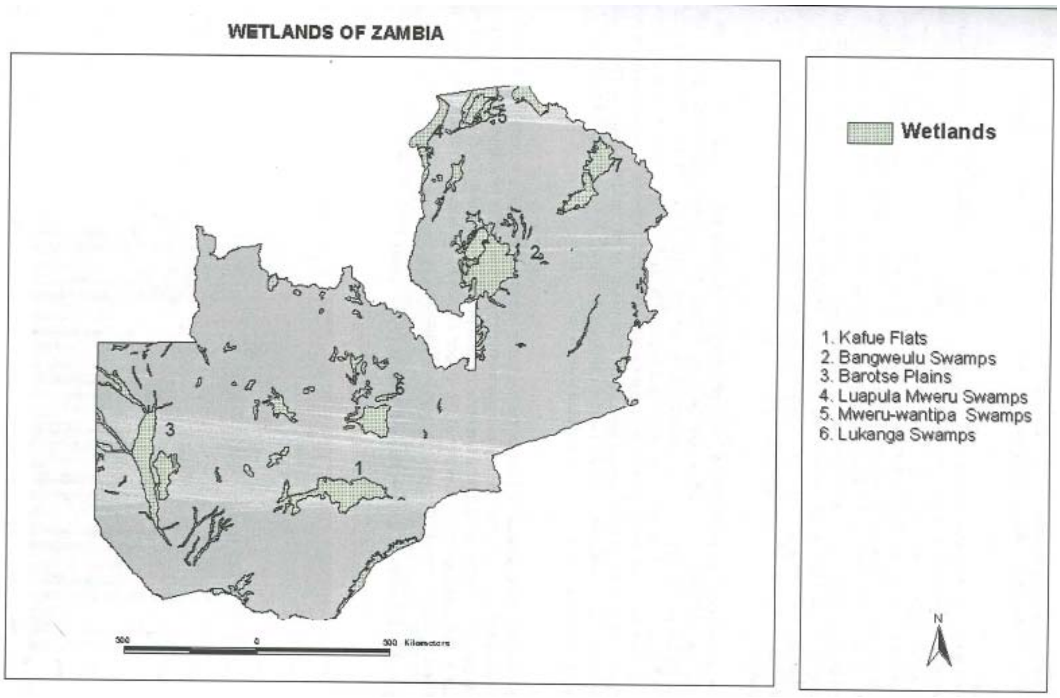
(2) Natural Habitat

Master Plan sub-projects may construct distribution lines and power facilities that may traverse habitats with rare or endangered flora and fauna. Construction of access roads, micro-hydropower plants, camps, rock and soil disposals, excavations, etc. may lead to habitat destruction and compel some species to be displaced from where they used to be. Micro-hydropower sub-projects may divert courses of rivers away from the natural habitats and alter the conditions of the habitats. Figure 11-4 and Figure 11-5 show the distribution of ecosystem and the distribution of wetlands in Zambia, respectively.



Source: Statement of Environment in Zambia 2000 Figure 3.2: Distribution of ecosystems in Zambia

Figure 11-4 Distribution of Ecosystem in Zambia

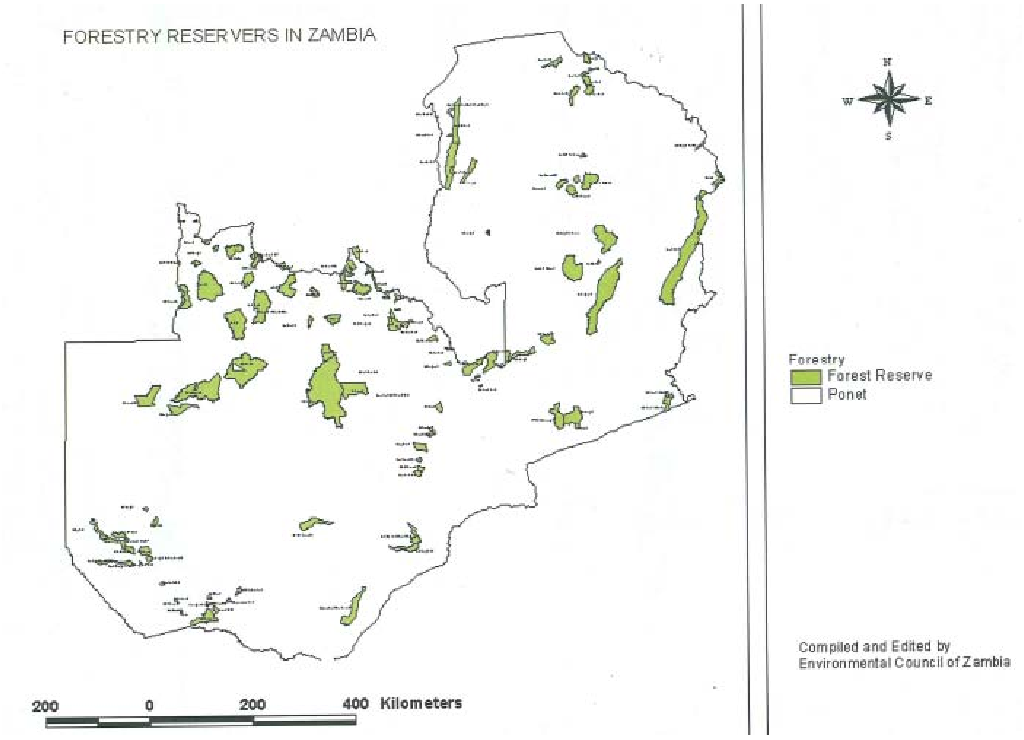


Source: Statement of Environment in Zambia 2000 Figure 4.2: Distribution of Major Wetlands in Zambia

Figure 11-5 Distribution of Wetlands in Zambia

(3) Impacts on Forestry

Construction of distribution lines as well as micro-hydro power plant may require the temporary use of the land for waste treatment/disposal, storage of construction materials, office camp, housing for workers and the like. In rural areas, it will be a rare case that such spaces for temporary use have been cleared in advance. Thus tree cuts are sometimes unavoidable and possible impacts on forestry including non-timber forest products must be carefully examined on a project-by-project basis. Figure 11-6 shows the distribution of forest reserves in Zambia.



Source: Statement of Environment in Zambia 2000 Figure 6.2: Distribution of Local and National Forests

Figure 11-6 Forest Reserves in Zambia

(4) Impacts on Water Quality

In the construction stage of micro-hydropower sub-projects, local water quality may change. Turbidity of water caused by construction of weirs, water channels, and tunnels may causes damage of safe drinking water and negative impacts on some aquatic organisms. Careless handling of fuel, oil, lubricants and other chemicals for construction machinery have a potential risk of spills of them into the river. In the operation stage, leakage of lubricants for hydraulic turbines may cause deterioration of water quality. Thus potential impacts on water quality must be carefully studied.

(5) Soil Erosion

Any construction activities may potentially cause soil erosion. Some sort of soils may result in progressive soil erosion triggered by access road or distribution line construction. Clearing vegetation along distribution lines may also cause soil erosion. Construction of micro-hydro may make the site more vulnerable to flooding or landslides.

(6) Pollution

Any construction activities lead to pollution such as noise, vibration, waste, offensive odour, and air and water pollution, to some extent. On the other hand, pollution during operation is considered to be minimal or negligible for the Master Plan sub-projects. Environmental assessment should recommend measures to minimize such impacts, identify the level of pollution during construction, and calculate compensation adequately if impacts are unavoidable.

(7) Impacts on Landscape

Distribution lines, micro-hydro facilities, and other renewable power facilities, once installed, may result in changes to the landscape, which may lead to social and economic adverse effects, harming local religious and cultural values or damaging potential tourist opportunities. EIA must propose measures to minimize or eliminate impacts and estimate compensation costs if the impacts are residual even after operation.

(8) Loss of Cultural, Spiritual and Religious Properties

In planning, losses of cultural, spiritual and religious properties may be avoidable. However, construction activity sometimes encounters cultural properties such as archaeological sites and historical settlements when excavating. Such kind of cultural properties could be negatively impacted unless proper treatments, conservation of the properties by transferring them to a new location, will be offered in consultation with appropriate authority such as National Heritage Conservation Commission and/or stakeholders. EIA must address compensation and mitigation policies for those important properties.

(9) Involuntary Resettlement

For micro-hydropower sub-projects, temporarily resettlement may be necessary during the construction period for safety reason. For distribution line construction, some houses, which are along the proposed corridor, may have to be demolished or shifted to give way to the proposed lines between substations if it is not avoidable even with deliberate route planning. Any involuntary resettlement, whether temporary or permanent, due to Master Plan sub-project, has to be managed and compensated in a fair and transparent manner. For a sub-project inevitably requiring involuntary resettlement, compensation costs should be carefully assessed at the feasibility study stage of each sub-project. The project developer has to prepare a Resettlement Action Plan (RAP) in line with EIA.

(10) Health and Safety

It is anticipated that construction of distribution lines and micro-hydro allow workers and camp followers to project sites in remote areas. The influx of outsiders may risk remote communities with the potential spread of waterborne diseases and sexually transmitted diseases (STDs) including HIV. In addition, in newly electrified villages, safety in electricity usage becomes significant issues. EIA may address issues regarding health and safety by proposing measures to control any potential health and safety hazard risks.

(11) Dam Safety

The Dam Safety Policy of the International Commission on Large Dams (ICOLD) applies to dams with heights of 15 meters or more, no matter what types of hydropower plants. Micro-hydro power plant sub-projects to be proposed in line with the Master Plan may not exceed this dam height.

(12) Impacts on Locality

An introduction of electricity will change the well being of local people who have not used electricity before the installation of any kinds of power facilities. Reduction in kerosene use may erode sales opportunity of vendors/service providers of kerosene and kerosene appliances such as lamps and refrigerators. The new distribution alignment may trigger or enhance local disputes. Electrification may benefit only those who are originally wealthy if sub-projects are inequitably designed. The Master Plan Study tries to formulate sub-project packages in order to distribute benefits from electrification in a highly equitable manner. EIA for each sub-project has to consult with wide local stakeholders in order to identify potential local issues.

(13) Compensation

All the residual impacts, social or environmental, must be compensated through the project. Any temporary or permanent loss of houses, physical structure, land plots, agricultural crops and trees due to the project implementation as well as operation will require compensation to households, communities, and private businesses. Formulation of transparent, equitable compensation policy and procedures is crucial in order to gain confidence and trustworthiness of project affected people and community. There is currently no specific law in relation to involuntary resettlement; however, there are a variety of articles of relevant laws that provide guidance for legal provision for resettlement. Under the Land Acquisition Act, the principles of compensation are centered on the ground that the value of the property for compensation shall be the value of the amount of the property in question which may expected to be realized if sold on an open market by a willing seller at the time of publication of notice to yield up possession of the property. Besides, under the Part VI of the same Act, a Compensation Advisory Board has been established to advise and assist the Minister in the assessment of any compensation payable under the Act. Under the Part III Environmental Impact Statement of the EIA Regulations, a project developer is responsible for provision of the Environmental Management Plan (EMP) as a part of the Environmental Impact Statement and in the statement, the developer should propose specific compensation policy for the project in question.[30]

(14) Positive Impacts on Social Environment

Some kinds of positive impacts on social environment by implementation of rural electrification sub-projects are envisaged. Agricultural production is likely to increase, as the people will be able to use electricity for irrigation. Medical care in night time by provision of lighting, preservation of medicines using refrigerators, and use of electronic medical equipment by supply of power will enable RHCs to provide higher quality medical services. Schools will be able to conduct classes in the evening. With the availability of electricity, schools may be able to acquire computers for use by both pupils and teachers, thus improving level of education. Pupils will be able to study at night and this could lead to improvement in overall academic standards of the schools in the project catchment area. In social service sector, influx of construction workers will provide a larger customer base for goods and services. Business people will be encouraged to build more and even bigger shops and/or other social amenities. With all above positive social impacts, it is envisaged that implementation of sub-projects will lead to development of local economy and in turn in the standard of living.

11.3.3. Possible Mitigation Measures

Table 11-3 shows major potential impacts of sub-projects in the Master Plan and possible mitigation measures. The mitigation measures that should be considered for specific electrification method(s) are followed by the type of electrification with parenthesis (Ex. (M/H)). Mitigation measures without such description is thought to be applicable to all types of electrification methods shown in the table. The mitigation measures should be properly reviewed and updated based on more detailed environmental impact assessment prior to implementation of each sub project.

In the Rural Electrification Master Plan study, pre-feasibility-study-level case studies were conducted for two proposed mini-hydropower projects in both North-western and Northern Province for the purpose of capacity development. As a part of case studies, the Study Team in collaboration with the Counterpart conducted preliminary environmental impact assessment studies and identified project specific potential impacts on environment. The study results are detailed in Chapter 12 Case Study.

[30] Resettlement Policy Framework for the Increased Access to Energy and Information and Communication Technology Services Project, MEWD, DOE, October 2006

Table 11-3 Mitigation Measures for Adverse Social and Environmental Impacts

No.	Item	Rating D/L C	D/L O	M/H C	M/H O	PV C	PV O	Wind C	Wind O	Biomass C	Biomass O	Possible Mitigatrion Measures
1	Involuntary Resettlement	D	D	B	C	D	D	B	C	D	D	· Avoid construction near settled areas · Consultations with project affected persons (PAPs) · Resettlement plans and alternatives for PAPs · Strengthening of local authorities and agencies responsible for resettlement implementation · Empowerment of PAPs with possible involvement of NGOs
2	Local economy	D	B	B	B	D	B	D	B	D	C	· Relocation support and agricultural extension programs · Compensation for economic damage
3	Land use	B	D	B	B	D	D	D	D	B	B	· Avoid construction near settled areas · Cousultations with PAPs · Fair mechanism for prompt compensation payments, monitoring and grievance procedures
4	Social institutions such as social infrastructure and local decision-making institutions	C	D	C	D	D	D	D	D	D	D	· Consultaions with PAPs and local leaders
5	Existing social infrastructures and services	B	B	B	B	B	B	B	B	B	B	· Public awareness program · Consultaions with PAPs and local leaders
6	The poor, indigenous and ethnic people	D	D	D	D	D	D	D	D	D	D	
7	Misdistribution of benefit and damage	D	B	D	B	D	B	D	B	D	B	· Public awareness program · Consultaions with PAPs and local leaders
8	Cultural heritage	B	D	B	D	D	D	B	D	B	D	· Avoidance of all culturally important sites · Consultations with local and spiritual leaders · Provisions for relocation of important cultural sites*
9	Local conflict of interests	D	D	D	D	D	D	D	D	D	D	· Public awareness program · Consultaions with PAPs and local leaders
10	Water use rights and rights of Common	D	D	B	B	D	D	D	D	D	D	· Minimum bypass flows (M/H) · Measures to reduce organic and inorganic waste (M/H)
11	Sanitation	D	D	D	D	D	D	D	D	D	C	· Proper treatment of gas emissions (Biomass)
12	Hazards (Risk)/Infectious disease such as HIV/AIDS	B	D	B	D	B	D	B	D	B	D	· Strengthening of existing health facilities with possible involvement of NGO as support · Health awareness programs on hygiene, malaria, other water-borne diseases and STD · Supervision of healthcare institutions and worker safety measures during construction · Provisions to ensure safe drinking water
13	Topography and Geological features	C	C	B	B	D	D	C	C	D	D	· Topographically friendly design and construction of the right of way, access road and facilities · Confine construction works within designated access areas · Revegetation and its periodical maintenance
14	Groundwater	D	D	D	D	D	D	D	D	D	D	
15	Soil Erosion	B	B	B	B	D	D	C	C	D	D	· Drainage and erosion prevention and flexible modification technique in construction · Backfilling of excavated soils and rubble from blasted rocks · Restriction of access loads within power station zone (M/H)
16	Hydrological Situation	D	D	B	B	D	D	D	D	D	D	· Minimum bypass flow (M/H)
17	Coastal Zone	D	D	D	D	D	D	D	D	D	D	
18	Flora, Fauna and Biodiversity	C	C	C	C	C	C	C	C	C	C	· Sensitization against poaching and general conservation methods · Sensitization of local community for sustainable fishing methods and conservation practices (M/H) · Vegetation establishment around the reservoir (M/H) · Rehabilitation of construction sites through landscaping, planting of trees and grass, and clearing of any disused materials (M/H)
19	Meteorology	D	D	D	D	D	D	D	D	D	D	
20	Landscape	B	B	B	B	B	B	B	B	B	B	· Consideration of aesthetic and cultural values in design of project features · Revegetation treatment
21	Global Warming	D	D	D	D	D	D	D	D	D	D	
22	Air Pollution	B	D	B	D	B	D	B	D	B	B	· Limited use of construction machinery
23	Water Pollution	C	D	C	D	C	D	C	D	C	D	· Construction of appropriate sanitation facilities and domestic water supply services
24	Soil Contamination	D	D	D	D	D	D	D	D	D	D	
25	Waste	B	D	B	D	B	D	B	D	B	D	· Measures to reduce organic and inorganic waste in construction · Appropriate material waste disposal such as landfill site · Reuse of construction wastes · Limited use of pesticides
26	Noise and Vibration	B	D	B	D	B	D	B	D	B	C	· Limited use of construction machinery · Avoid construction near settled areas
27	Ground Subsidence	D	D	D	D	D	D	D	D	D	D	
28	Offensive Odour	B	D	B	D	B	D	B	D	B	B	· Limited use of chemicals, pesticides and oil during construction · Appropriate material waste disposal such as landfill site · Appropriate odour prevention measures such as storage methods and deodorization equipment
29	Bottom sediment	D	D	D	D	D	D	D	D	D	D	
30	Accidents	B	B	B	B	B	B	B	B	B	B	· Independent review of dam design and safety (M/H) · Electricity safety education for new users and settlements near the new power facilities · Safety education for construction and operation & maintenance workers

Note: Evaluation categories are as same as Table 11-2
*: Rf. 11.3.2 (8) Loss of Cultural, Spiritual and Religious Properties

11.3.4. Alternative Rural Electrification Schemes And Their Impacts On Environment

Besides the proposed electrification schemes in the Rural Electrification Master Plan Study, namely, both mini-hydropower and extension of existing distribution network, alternative rural electrification schemes include more diesel power stations, solar home system (SHS), other renewable energy such as wind power and biomass, and the zero option were compared.

(1) Diesel Power Station

ZESCO has 11 diesel power stations and the green house gas emitted from the facilities contribute towards negative impacts on the environment. Emission of nitrogen oxide (NOx) and sulphur oxide (SOx) generated by sulfur in diesel fuel cause atmospheric pollution and acid rain problems. Thus, a significant negative impact could be expected from an increase in the number of diesel power stations, compared with other electrification schemes such as grid extension and micro hydropower generation, which do not emit such air contaminants in their operation stage.

On the other hand, since Zambia heavily depends on imported diesel fuel, soaring oil prices in recent years have negatively impacted the cost of service provision by ZESCO. Revenues from the areas electrified by diesel generations accounts for only 6% of the fuel cost (in 2004), therefore the replacement of such diesel power stations by either connecting to 66kV transmission lines or construction of micro hydropower stations is an urgent matter for ZESCO.

Increasing the number of diesel power stations may lead to rise in electricity tariffs as a consequence of increased oil prices. People in rural areas have low income and may not be able to pay the tariff or receive the full benefit of electrification. According to the National Energy Policy of GRZ, all District Administrative Centres in the 72 districts are supposed to be electrified. Some areas which are located near the borders and are difficult to reach by means of grid extension due to long distances from the existing distribution grids, new diesel power stations were planned to be installed by January, 2007. However such cases are exceptional. Widespread use of diesel power stations is not feasible because of the aforementioned reasons.

(2) Solar Home System

Zambia’s large area and low population density are factors that favour the use of renewable energy for rural electrification. Compared to other generation schemes which burn fossil fuels like diesel, environmental impacts of the solar energy generation like SHS, are considered insignificant in that its very nature of not emitting pollutants such as NOx and SOx, which will cause air pollution. However, the lead used in the batteries of SHS is a hazardous material and could, if not handled properly, affect human health. Diluted sulphuric acid, used as electrolysis solution, may also affect human health as well as cause ground water pollution when improperly treated. To avoid such negative impacts appropriate measures should be taken to ensure proper disposal used batteries.

(3) Wind-power

With respect to effective energy capture by pinwheel, the conditions suitable for wind power generation are high average wind velocity, stable wind direction, and small turbulence. According to Wind-power Generation Introduction Guidebook (published by the New Energy and Industrial Technology Development Organization (NEDO), 2005), minimum recommended wind velocity at 30m height above the ground is over 6m/s for determining the possibility of wind-power generation business. On the other hand, from the data obtained from the Zambia Meteorological Department for the period 2002 to 2005 the country’s annual average wind speed is 3.2m/s. Therefore, the implementation of large-scale development of wind-power projects may difficult not be feasible. Nevertheless, if, through future studies suitable sites are identified, it will be necessary to conduct studies on impacts on biophysical and socio-economic environments.

(4) Biomass

Biomass power generation is among the environmentally-friendly electrification methods because of its effective unitization of agricultural and/or livestock waste and its carbon neutral characteristics[31]. However, it would be difficult to implement large-scale biomass projects nationwide since the power generation potential is so dependent on the procurement of sufficient raw material significantly. Realization of biomass projects on a large scale in the future would also need to careful account of proper treatment of gas emissions and odour control.

(5) Zero Option

Without implementation of projects by utilization of proposed electrification schemes, in which are proposed in the Rural Electrification Master Plan Study, the target household electrification rate of 35% by 2002, which was set in the PRSP, will have to be accomplished mainly by installation of diesel power stations on a large scale. The possibility of accomplishment is, nevertheless anticipated to be quite low due to aforementioned reasons. Doing nothing therefore, would go against Governmental Policy on rural development.

11.3.5. Monitoring Plan for Environmental and Social Impacts

Under the current legislation on environmental management in Zambia, the monitoring plan for environmental and social impacts is part of the EIS, which is submitted by a project developer to ECZ prior to implementation of the project, and is subjected to review by ECZ under the EIA process. The detailed procedures are stipulated in the EIA Regulations. Thus, both the organizational structure and implementation methods are proposed by the developer depending on the project conditions.

On the other hand, the necessary capacity strengthening framework of institutions for implementation of monitoring plans has been proposed in the Environmental and Social Management Framework for the Increased Access to Electricity Services Project, which was reported in October 2006 by DOE. The project was prepared by GRZ for financing by the World Bank, Global Environmental Facility, other donors, and the Prototype Carbon Fund (PCF). The recommended approach includes training for electricity sector planners, senior design construction and maintenance staff, MEWD and REA staff, and support for Environmental Inspectors and District Environmental Officers. The training take the form of short seminars conducted under the auspices of REA by staff of MTENR, ECZ and the private sector working in environmental management.

According to the Framework, the monitoring plan is to be implemented under the Planning and Projects Department of REA, as follows:

- Establishment of environmental performance indicators for monitoring
- Implementation of projects
- Development of standardized format for recording monitoring and auditing information
- Commissioning of evaluations every 3 years

[31] Being **carbon neutral**, or **carbon neutrality**, refers to neutral (meaning zero) total carbon release, brought about by balancing the amount of carbon released with the amount sequestered. (Source: WIKIPEDIA http://en.wikipedia.org/wiki/Carbon_neutral)

Chapter 12

Case Studies

Chapter 12. Case Studies

12.1. Distribution Grid Extension

12.1.1. Selection of the Distribution Line for Case Study

The purpose of this case study is to make counterparts become the engineers who can review this master plan by themselves in the future. Therefore, the pilot study projects were selected based on the following points with counterparts.

- Around 10 RGCs is included
- Only one project is selected in one province
- Site survey is carried out easily and safely

As a result, following distribution lines were selected as a case study.

- Distribution line from Chilundu new substation (Distribution number 2) Lusaka
- Distribution line from Fig Tree existing substation (Distribution number 1) Central
- Distribution line from Mazabuka existing substation (Distribution number 1) Southern

12.1.2. Method of Case Study

Information data of RGC, substation, road, etc is input on GIS map used by master plan, and almost all data are not acquired by GPS. First of all, actual position of those data should be confirmed with GPS.

Then, the situation RGC should be confirmed, and the transformer installation position will be selected. Moreover, the distribution line route will be selected in consideration of present situation, development plan, road condition and so on at the site.

Based on the data obtained at the site, distribution system prepared for master plan will be revised. Next, voltage calculation will be carried out again and review the results.

12.1.3. The Results of Site Survey

The results in each case are shown as follows, and the maps of the results are attached in Appendix C.

(1) Distribution line from Chilundu new substation (Distribution number 2)

GIS data used for master plan did not have so much difference from actual position. It is considered that the situation of RGCs in this area is along the main road.

The condition of RGCs, except for Boma, was as follows.

- The center of RGC is school and/or hospital, and the scale of RGC is not so large.
- Many households are situated at the center of RGC, but some households are scattered in the surrounding area of RGC.
- RGCs are situated along the main road or approximately 1 or 2km away from main road.

Therefore, it is considered that transformers will be installed near the main road.

The condition of Boma was as follows.

- There are important facilities such as public office, telephone company, etc, and the scale of RGC is large.
- Diesel power generation (800kVA) has already been set up, and power is supplied by 11kV distribution line.

- Five transformers (50kVA x 1, 100kVA x 2, 200kVA x 1, 250kVA x 1) have already been set up.

Therefore, it is considered that 33kV new distribution facilities will be replaced with existing 11kV distribution facilities.

There are two routes for supplying electric power to Kavalamanja. One is the extension of distribution line from Kakaro, and the other is the extension of distribution line from Boma. Construction of lodge, campsite, etc is planned along the road between Boma and Kavalamanja, but there is no household and no future plan between Kakaro and Kavalamanja. Therefore, it is determined that electric power for Kavalamanja will be supplied from Boma as well as the master plan.

Based on the result of site survey, voltage analysis was carried out again. As a result, one line was eliminated between Boma and Kavalamanja.

The construction cost is shown as follows, and the cost of this case study was cheaper than the one of the master plan because of the reduction of distribution line length.

Original/ Case Study	Unit Cost (US$) & Amount				FC (US$)	LC (US$)			Total (US$)
	33kV DL (36,000)	66kV TL (40,000)	66/33 Tr 100kVA (13,700)	New SS 10MVA (1,000,000)	Foreign Costs (0.80166747)	Domestic Costs (0.11816629)	Skilled Labor (0.032067)	Unskilled Labor (0.04810005)	
Original	216	90	51	0.5	10,080,728	1,485,906	403,229	604,844	12,574,700
Case Study	186.4	90	51	0.5	9,226,471	1,359,988	369,059	553,588	11,509,100

(2) Distribution line from Fig Tree existing substation (Distribution number 1)

GIS data used for master plan had so much difference from actual position of RGC and substation, and some RGCs should be supplied the electric power from other substations. In addition, there were some mistakes of RGC’s name (e.g. Waya -> 4Ways).

The condition of RGCs was as follows.

- The center of RGC is school and/or hospital, and the scale of RGC is not so large.
- At Monboshi, there is nothing except for river.
- Many households are situated at the center of RGC, but some households are scattered in the surrounding area of RGC.
- RGCs are situated along the main road or approximately 1 or 2km away from main road.

Therefore, it is considered that transformers will be installed near the main road.

Kasosolo, Kabanga and Mukulushi are situated near Kabwe substation rather than Fig Tree substation, and Chombela and Kayosha are situated near Coventry substation. As a result, the RGCs supplied from Fig Tree substation are 5 RGCs, which are Simukuni, 4Ways, Lifwambula, Momboshi and Kabangala.

The voltage descent has decreased because the entire demand decreases, and the distance shortened about other 3RGC.

Based on the result of site survey, voltage analysis was carried out again. Although the distance from substation to Simukunin and 4Ways became longer comparing with the distance of master plan, the voltage was satisfied with the regulation. The value of voltage drop at other 3 RGCs was reduced because of the decreased demand and the shortened distance.

The construction cost is shown as follows, and the cost of this case study was decreased greatly comparing with the cost of master plan. It depends on the shortened distribution lines and the decreased demand by the exclusion of 4 RGCs. However, the difference of cost will be added to other projects.

Original/ Case Study	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
	33kV DL	66/33 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
	(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.032067)	(0.04810005)	
Original	206	29	1	6,343,274	935,003	253,731	380,596	7,912,600
Case Study	124.2	15	1	3,828,764	564,362	153,151	229,726	4,776,000

(3) Distribution line from Mazabuka existing substation (Distribution number 1)

GIS data used for master plan had much difference from actual position of RGC and substation, and there were some roads which were not input on the map of master plan. In addition, there were many 33kV distribution lines which were not be able to obtain from ZESCO.

The condition of RGCs was as follows.

- The center of RGC is school and/or hospital, and the scale of RGC is not so large.
- Many households are situated at the center of RGC, but some households are scattered in the surrounding area of RGC.
- RGCs are situated along the main road or approximately 1 or 2km away from main road.

Therefore, it is considered that transformers will be installed near the main road.

Distribution line route prepared by master plan was revised depending on the actual location of RGC and substation and road condition.

Based on the result of site survey, voltage analysis was carried out again. Although the revised distribution line route was different from the route prepared by master plan, the value of voltage was satisfied with the regulation because of the small demand.

The construction cost is shown as follows, and the cost of this case study was decreased comparing with the cost of master plan because of the shortened distribution lines.

Original/ Case Study	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
	33kV DL	66/33 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
	(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.032067)	(0.04810005)	
Original	163	25	1	5,058,361	745,606	202,334	303,502	6,309,800
Case Study	148.9	25	1	4,651,435	685,624	186,057	279,086	5,802,200

12.1.4. Result of Case Study

As a result of case study, it was confirmed that it was necessary to revise this master plan greatly. This is because the position data of RGC, substation, distribution line, etc input on the GIS map lacks accuracy, and some road information is missing. Accurate information data is indispensable for distribution system planning. Therefore, we recommend that counterparts acquire all relating information data with GPS, and input these information to GIS map.

12.2. Small Hydropower Plant Development

12.2.1. Purpose of Case Study

Case Studies were undertaken of the only two hydropower potential sites selected among all the hydropower potential sites surveyed by the Study Team (refer to Chapter 8-4). The purposes of the Case Studies were the following:

- To carry out detailed surveys and produce basic designs of hydropower plants, and then verify the technical and economical feasibility of the development at the site,

- To suggest the possible organization of plant management after the development, and
- To transfer to the counterparts the technical skills related to the small hydropower plant development.

12.2.2. Selection of Case Study Sites

(1) Criteria of Case Study Site Selection

Two Case Study sites were selected among 25 hydropower potential sites surveyed by the Study Team based on the following criteria:

- One site should be selected among the sites in Northwestern Province and another in Northern or Luapula Province,
- Two sites should be selected among the sites which are regarded as the best electrification method in the Master Plan, and
- Priority of the electrification of RGC to be electrified by the hydropower plant is high.

(2) Selection of Case Study Sites

The Study Team visited 25 hydropower potential sites from which and nine sites were considered suitable for development as discussed later in the Chapter on the Master Plan. Table 12-1 shows these nine selected sites. In the bottom line of this table, “Hydro” means that the Hydropower Plant Development was selected for the best electrification method in the Master Plan. (D/L means that Distribution Line Extension was selected). Among these nine sites, Upper Zambezi and Mujila Falls Lower sites were marked “Hydro”, which made them natural candidates for Case Study sites. However, the RGCs to be electrified by Upper Zambezi site are Ikelenge RGC and Nyakaseya RGC, which have been already electrified by 700 kW Zengamina Small Hydropower Plant since July 2007. Therefore, the Upper Zambezi site should be developed just as a back up power plant to the Zengamina HP. Also the Study Team considered that selecting both Case Study Sites from Mwinilunga District in Northwestern Province was undesirable. Therefore, the Study Team chose Mujila Falls Lower (MFL) site as the first Case Study site.

The second Case Study site was selected among the four sites in Northern and Luapula Province in Table 12-1. Based on the third criteria above, Namukale Falls site should be selected because the site is located near Mpulungu Central RGC, which is listed on the top of the priority order of the Master Plan. However, the Namukale Falls site could only be accessed by boat, which which would considerably to the surveyed period. Therefore, the Study Team skipped Namukale Falls site and selected Chilambwe Falls site for the second Case Study site. This site was selected not only because the related RGCs have high priority, but also that the target RGCs were located far from the existing substation and that the site could be developed as a conventional hydropower plant. This woule be highly instructional for the transfer of technical skills.

These two Case Study sites, MFL and Chilambwe Falls, were selected after discussions with DoE and REA.

Table 12-1 Probable Hydropower Potential Sites

Name of the Site	Upper Zambezi	Mujila Falls Lower	Mujila Falls Upper	Kasanjiku Falls	Chauka Matambu Falls	Namukale Falls	Chilambwe Falls	Mumbuluma Falls	Chilongo Falls
Province	Northwestern	Northwestern	Northwestern	Northwestern	Northwestern	Northern	Northern	Northern	Luapula
District	Mwinilunga	Mwinilunga	Mwinilunga	Mwinilunga	Mwinilunga	Mpulungu	Mporokoso	Mporokoso	Kawambwa
Name of the River	Zambezi	Mujila	Mujila	Kasanjiku	West Lumuwana	Lunzua	Kafubu	Luangwa	Lufubu
Effective Head [m]	8.0	17.1	13.2	9.0	9.1	15.0	37.8	13.0	37.2
Designed Dischirge [m^3/s]	6.0	10.0	4.0	4.5	2.5	2.3	1.0	9.0	1.7
Potential [kW]	380	1400	420	320	180	270	300	930	500
Electrified RGC 1	Ikelenge	Kanyama (incl. 2 villages)	Kanyama	Ntambu	Lumuwana	Mpulungu Central	Kapatu	Kalabwe	Kanengo
Number of Households in 2006	1763	921	521	416	310	2000	512	425	60
Potential Demand in 2030 [kW]	1995	1065	598	532	371	2201	610	471	79
Priority Order	57	671	671	322	526	1	95	453	1029
Priority in the District	2	4	4	1	5	4	14	10	3
Electrified RGC 2	Nyakaseya	Kakoma					Sibwalya Kapila	Sunkutu	Chibote
Number of Households in 2006	400	301					3646	350	90
Potential Demand in 2030 [kW]	483	350					4013	386	133
Priority Order	445	551					13	512	907
Priority in the District	3	17					2	8	4
Cost Estimation [thousand US$]	2,290	9,782	2,264	3,521	2,000	2,068	3,604	5,504	5,763
Electrification Method in the Master Plan	**Hydro**	**Hydro**	D/L	D/L	D/L	D/L	D/L	D/L	D/L

12.2.3. Result of Case Study 1: Mujila Falls Lower Site

(1) Demand Forecast

The possible electrified RGCs by MFL site are Kanyama RGC and Kakoma RGC. The Study Team curried out the survey of Kanyama RGC to determine the number of households, hammer mills, public facilities, and business entities, which are the essential factors for estimating the potential demand. Although the scope of the Rural Electrification Master Plan is only the RGCs, the Study Team decided that Mujila Village and Kapundu Village should be included in the area to be electrified by MFL site because Mujila Village has large agricultural centre and located on the way from MFL site and Kanyama RGC, and Kapundu Village has the most advanced clinic in Kanyama area and only 8km down from MFL site. Therefore, the Study Team also conducted the survey in these two villages. Table 12-2 shows the results of social survey. The data for Kakoma RGC are quoted from the data submitted by the Mwinilunga District Planners at the Second Workshop because the Study Team could not approach Kakoma RGC due to the bad condition of the road. Figure 12-1 shows the location of MFL site and supplied areas.

The Study Team estimated the potential demand for every five years, and the results are described in Table 12-3. This table shows that the potential demand in 2030, which is the target year of the Master Plan, is about 1,400 kW.

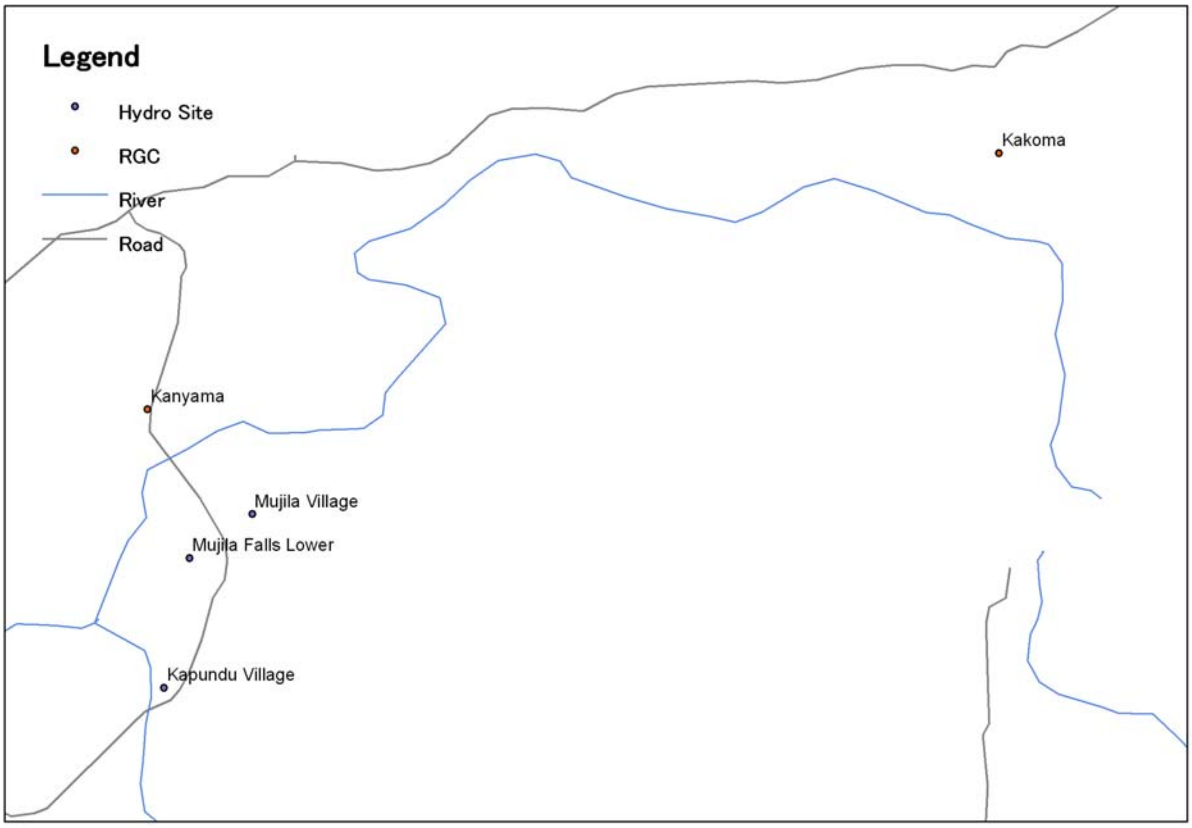


Figure 12-1　Location of MFL Site and RGCs

Table 12-2 Result of Social Survey in Kanyama and Kakoma RGCs

	Kanyama Area			Kakoma RGC
	Kanyama RGC	Mujila Village	Kapundu Village	
No. of Households (as of 2006)	521	200	200	301
No. of Population (as of 2006)	4,000	-	-	1,806
No. of Hammer Mills (as of 2006)	5	2	1	0
Number of Existing Public Facilities	15	2	2	5
1) Basic / Primary School	1	1	1	1
2) Secondary School [under construction]	[1]			
3) Tertiary School				
4) Hospital				
5) Health Centre (Clinic) / Health Post	1		1	1
6) Police Office / Station				
7) Post Office				
8) Church	9			2
9) Mosque				
10) Community Centre				
11) (Agricultural) Depot	2	1		
12) Orphanage				
13) Central Government Office				
14) Provincial Government Office				
15) District Government Office				
16) Other Local Administration Offices				
17) Court	1			1
18) Others				
Number of Existing Business Entities	16	2	0	6

Table 12-3 Demand Forecast for Kanyama and Kakoma RGCs

	Kanyama Area [kW]			Kakoma RGC [kW]	Total [kW]
	Kanyama RGC	Mujila Village	Kapundu Village		
Current (2006)	301	125	125	176	727
2010	349	138	139	196	822
2015	393	154	154	235	936
2020	458	173	173	264	1,068
2025	531	194	195	297	1,217
2030	598	234	234	350	1,416

(2) Generation Capacity

Figure 12-2 shows the flow duration curve at MFL site. The Study Team measured the actual river flow on 1st June 2007 and 17th October 2007, and the results were 15.02m^3/s and 13.38m^3/s respectively. Compared with these actual results, this flow duration curve is reliable enough to estimate the flow characteristic at MFL site.

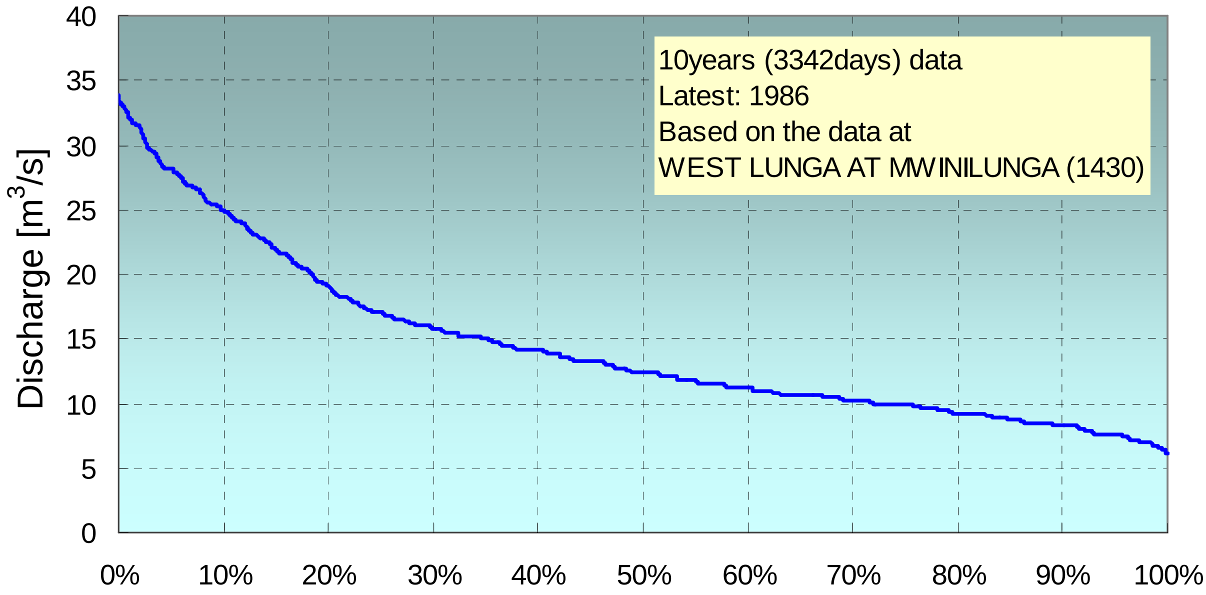


Figure 12-2 Flow Duration Curve at MFL Site

Table 12-4 indicates the river flow at 70%, 80%, 90%, and 100% availabilities and also the generation capacities assuming 17.1m of effective head. To achieve the 1,400kW of generation capacity, river flow at 70% availability is required. Usually, the river flow at 80% to 90% availability is applied to the designed discharge of run-off-river type hydropower plant for rural electrification project, but the low weir to be installed will produce the kind of reservoir with at least 200,000m^3 of storage capacity. This storage capacity would enable a discharge of 4.0m^3/s of additional water during 6 hours of peak demand time. Therefore, the Study Team decided the generation capacity at 1,400kW assuming 10.4m^3/s of designed discharge.

Table 12-4 Generation Capacity of MFL Site

	River Flow [m^3/s]	Generation Capacity [kW]
100% availability	6.12	828
90% availability	8.27	1,120
80% availability	9.21	1,246
70% availability	10.20	1,380

(3) Design of Hydropower Plant

Table 12-5shows the results of the design for civil facilities and electrical equipment.

Table 12-5 Features of Plant and Facilities of Mujila Falls Lower Project

Plant parameters	Mujila Falls Lower Project
Rated output	1,400kW
No. of units	Two [700kW x 2 units]
Design discharge	10.4m^3/s
Effective head	17.1m
Civil facilities	
Weir	Stone masonry with flushing gate H=5m, L=35m
Intake channel	Open channel B=3.5m, H=3.0m, L=20m
Silt basin	No need
Headrace	Non-pressure tunnel B=2.4m, H=2.8m, L=284m
Tailrace	Open channel B=3.0m, H=2.5m, L=10m x 2 lines
Spillway	Open channel B=1.5m, H=1.2m, L=36m
Head tank	Open channel B=7.0m, H=5.5m, L=20m
Penstock	Exposed type D=1.6m, t=6mm, L=20m x 2 lines
Powerhouse	Stone masonry, Aboveground type 10m x 20m x 8m
Electrical Equipment	
Turbine	Closs-flow turvine with sprit guide-vane H_{max}=17.1m, Q_{max}=5.2m^3/s, Pt_{max}=740kW
Generator	3-phase synchronouse generator Rated output: 800kVA, Voltage: 6.6kV Power factor: 0.9, Frequency: 50Hz
Main transformer	Outdoor type Capacity: 1600kVA, Voltage: 6.6kV/33kV
Distribution line	3 phase, 3 wires, Overhead distribution line Voltage: 33kV, L=85km
Pole transformer	Outdoor type Voltage: 33kV/400V, Capacity: 100kVA x 17 units

(4) Project Cost Estimation

Table 12-6 shows the result of MFL project cost estimation.

Table 12-6 Cost Estimation For Mujila Falls Lower Project

	Quantity	Unit Price	Price
I. Construction Cost			**6,165,040 US$**
i) Civil Engineering			1,235,030 US$
[Weir, Intake, Headtank and Power house]			
Concrete	200 m^3	600 US$/$m^3$	120,000 US$
Rebar	20 t	1,400 US$/t	28,000 US$
Masonry	1,201 m^3	150 US$/$m^3$	180,150 US$
Excavation, common	504 m^3	10 US$/$m^3$	5,040 US$
Excavation, rock	2,015 m^3	60 US$/$m^3$	120,900 US$
[Channel and Tailrace]			
Masonry	200 m^3	150 US$/$m^3$	30,000 US$
Excavation, common	73 m^3	10 US$/$m^3$	730 US$
Excavation, rock	291 m^3	60 US$/$m^3$	17,460 US$
Concrete	532 m^3	600 US$/$m^3$	319,200 US$
Tunnel	284 m	1,000 US$/m	284,000 US$
[Penstock and Spillway]			
Concrete	59 m^3	600 US$/$m^3$	35,400 US$
Rebar	6 t	1,400 US$/t	8,400 US$
Excavation, common	63 m^3	10 US$/$m^3$	630 US$
Excavation, rock	252 m^3	60 US$/$m^3$	15,120 US$
[Steel Structures]			
Gate and Screen	15 t	2,800 US$/t	42,000 US$
Penstock	10 t	2,800 US$/t	28,000 US$
ii) Mechanical & Electrical Equipment			4,450,900 US$
Turbine, Gen and Tr	2 Unit	579,000 US$	1,158,000 US$
33kV distribution line	85 km	36,000 US$/km	3,060,000 US$
33kV/400V Transformer	17 Unit	13,700 US$/Unit	232,900 US$
iii) Temporary Works			479,110 US$
Access Road	5 km	30,000 US$	150,000 US$
Road maintenance	1 LS	3,000 US$	3,000 US$
Others [30% of i)]	1 LS	326,110 US$	326,110 US$
II. Engineering Service Cost			**493,204 US$**
8.0% of Item I	1 LS	493,204 US$	493,204 US$
III. Overhead Cost			**1,541,260 US$**
25.0% of Item I	1 LS	1,541,260 US$	1,541,260 US$
IV. Profit Margin			**1,233,008 US$**
20.0% of Item I	1 LS	1,233,008 US$	1,233,008 US$
Grand Total			**9,432,512 US$**

(5) Financial Analysis

As Proposed MFL hydropower plant will be installed two units of 700 kW turbine-generators, the timing of the second turbine installation will affect the financial statement. The Study Team prepared two cases for financial analysis, one is that two turbines, 1,400 kW generation capacity in total, are installed at the same time (Case A-1) and another is that one unit with 700 kW generation capacity is installed only for Kanyama RGC and Mujila Village as the first stage and another 700 kW unit is installed later as the second stage (Case A-2). In Case A-2, the second unit should be installed when the total demand of Kanyama RGC and Kapundu Village exceeds 700kW, and the Study Team estimated that installation work for second unit will be necessary in 2024. The construction works in the second stage will consists of only installation of second turbine, generator and penstock, and extension of 33 kV distribution line 60 km east for Kakoma RGC and 9 km south for Kapundu Village. The Study Team estimated that the construction cost of first stage and second stage will be 4,547,283UD$ and 4,892,604US$ respectively. Table 12-7 shows the results of financial analysis for Case A-1 and Case A-2.

Table 12-7 Comparison of FIRR between One Phase and Two Phase Installation

Tariffs	Case A-1 ZESCO Charge		Case A-2 ZESCO Charge	
	K	US $	K	US $
Households tariffs	102	0.026	102	0.026
Monthly fixed charge	8,475	2.12	8,475	2.12
Commercial tariffs	245	0.06	245	0.06
Monthly fixed charge	43,841	10.96	43,841	10.96
Social tariffs	201	0.05	201	0.05
Monthly fixed charge	34,839	8.71	34,839	8.71
FIRR	-1.16 %		-1.75 %	

In each case, FIRR resulted in negative percentage. In the development of small-scale hydropower plant, construction cost per generation capacity (kW) is much higher than that of large-scale project in general, and the installed capacity must be much bigger than the actual demand in the early stage of electrification because the plant capacity should be decided considering the demand in the future. Since the power plant is isolated from the grid the excess power cannot be sent to the grid, so the generator must be operated in low output for long hours. These are why the financial feasibility of small hydropower project with micro gird is usually low.

In this analysis, electricity tariff is settled at the current tariff of ZESCO. These prices are relatively low, so the Study Team calculated FIRR for eace case using the actual commodity charge and fixed charge of existing Zengamina HP, which is described in Chapter 3.3.2 (3) a), and the results of analysis are shown in Table 12-8 and Table 12-9.

Table 12-8 Comparison of FIRR among Three Tariff Settings for Case A-1

Tariffs	Case A-1-1 ZESCO Charge		Case A-1-2 Zengamina HP Commodity Charge		Case A-1-3 Zengamina HP Fixed Charge	
	K	US $	K	US $	K	US $
Households tariffs	102	0.026	440	0.11	–	–
Monthly fixed charge	8,475	2.12	50,000	12.50	40,000	10.00
Commercial tariffs	245	0.06	440	0.11	600	2.00
Monthly fixed charge	43,841	10.96	50,000	12.50	50,000	15.00
Social tariffs	201	0.05	440	0.11	600	2.00
Monthly fixed charge	34,839	8.71	50,000	12.50	50,000	15.00
FIRR	-1.16 %		6.56 %		1.62 %	

Table 12-9 Comparison of FIRR among Three Tariff Settings for Case A-2

Tariffs	Case A-2-1 ZESCO Charge		Case A-2-2 Zengamina HP		Case A-2-3 Zengamina HP	
	K	US $	K	US $	K	US $
Households tariffs	102	0.026	440	0.11	–	–
Monthly fixed charge	8,475	2.12	50,000	12.50	40,000	10.00
Commercial tariffs	245	0.06	440	0.11	600	2.00
Monthly fixed charge	43,841	10.96	50,000	12.50	50,000	15.00
Social tariffs	201	0.05	440	0.11	600	2.00
Monthly fixed charge	34,839	8.71	50,000	12.50	50,000	15.00
FIRR	-1.75 %		7.69 %		1.76 %	

Case A-2-2 shows the acceptable FIRR, which indicates that MFL project can be approved due to the higher tariff setting. Therefore, phased instration of two turbines are recommended under the higher selectricity charge setting. The details of each analysis are shown Table 12-10 toTable 12-15.

Table 12-10 Financial Statements of Case A-1-1

FIRR = −1.16%
Discount Factor = 12.00%

Year	Capital Costs US$	Operational costs US$	Total Cost US$	Present Cost US$	Power Supply MWh	Revenues MWh	Net Revenue US$	Net Present Value US$
0	2,642,714		2,642,713.73	2,642,713.73			(2,642,713.73)	(2,642,713.73)
1	5,285,427		5,285,427.47	4,719,131.67			(5,285,427.47)	(4,719,131.67)
2	2,642,714	107,271.73	2,749,985.46	2,192,271.57	3,409,337	138,337.33	(2,611,648.13)	(2,081,989.90)
3		107,271.73	107,271.73	76,353.90	3,564,356	146,775.18	39,503.45	28,117.78
4		107,271.73	107,271.73	68,173.12	3,665,069	151,766.95	44,495.22	28,277.52
5		107,271.73	107,271.73	60,868.86	3,740,695	155,762.75	48,491.02	27,515.11
6		107,271.73	107,271.73	54,347.19	3,831,394	160,397.13	53,125.41	26,914.98
7		107,271.73	107,271.73	48,524.28	3,991,472	169,189.77	61,918.05	28,008.58
8		107,271.73	107,271.73	43,325.25	4,095,167	174,234.05	66,962.32	27,044.96
9		107,271.73	107,271.73	38,683.26	4,179,735	178,811.14	71,539.41	25,797.83
10		107,271.73	107,271.73	34,538.62	4,284,527	184,382.70	77,110.97	24,827.67
11		107,271.73	107,271.73	30,838.06	4,456,530	194,063.19	86,791.46	24,950.47
12		107,271.73	107,271.73	27,533.98	4,572,731	199,931.95	92,660.23	23,783.57
13		107,271.73	107,271.73	24,583.91	4,679,844	206,278.04	99,006.31	22,689.69
14		107,271.73	107,271.73	21,949.92	4,859,796	216,641.82	109,370.10	22,379.29
15		107,271.73	107,271.73	19,598.14	4,980,487	223,432.97	116,161.24	21,222.22
16		107,271.73	107,271.73	17,498.34	5,112,255	230,245.36	122,973.63	20,059.66
17		107,271.73	107,271.73	15,623.52	5,289,080	241,067.51	133,795.79	19,486.60
18		107,271.73	107,271.73	13,949.57	5,412,662	247,840.30	140,568.58	18,279.48
19		107,271.73	107,271.73	12,454.97	5,540,941	254,988.25	147,716.52	17,150.89
20		107,271.73	107,271.73	11,120.51	5,770,627	268,816.15	161,544.43	16,746.79
21		107,271.73	107,271.73	9,929.03	5,890,366	275,822.46	168,550.73	15,600.99
22		107,271.73	107,271.73	8,865.20	6,028,763	283,706.50	176,434.77	14,581.01
23		107,271.73	107,271.73	7,915.36	6,222,990	296,372.02	189,100.30	13,953.32
24		107,271.73	107,271.73	7,067.29	6,363,714	304,622.59	197,350.87	13,001.89
25		107,271.73	107,271.73	6,310.08	6,538,609	316,863.50	209,591.77	12,328.88
26		107,271.73	107,271.73	5,634.00	6,675,921	325,672.71	218,400.99	11,470.60
27		107,271.73	107,271.73	5,030.36	6,864,559	338,593.24	231,321.51	10,847.49
28		107,271.73	107,271.73	4,491.39	7,012,775	347,901.66	240,629.94	10,075.00
29		107,271.73	107,271.73	4,010.17	7,185,843	360,950.52	253,678.79	9,483.34
30		107,271.73	107,271.73	3,580.51	7,320,823	369,764.31	262,492.59	8,761.46
31		107,271.73	107,271.73	3,196.88	7,524,792	384,802.33	277,530.60	8,270.89
32		107,271.73	107,271.73	2,854.36	7,693,922	395,764.50	288,492.77	7,676.41
33		107,271.73	107,271.73	2,548.53	7,877,404	409,791.97	302,520.25	7,187.20
34		107,271.73	107,271.73	2,275.48	8,029,715	420,247.13	312,975.40	6,638.92
35		107,271.73	107,271.73	2,031.68	8,252,347	436,784.49	329,512.77	6,240.82
36		107,271.73	107,271.73	1,814.00	8,437,568	448,962.54	341,690.81	5,778.09
37		107,271.73	107,271.73	1,619.64	8,619,958	463,934.77	356,663.04	5,385.07
38		107,271.73	107,271.73	1,446.11	8,819,927	479,867.45	372,595.73	5,022.88
39		107,271.73	107,271.73	1,291.17	8,976,237	491,767.14	384,495.42	4,627.95
40		107,271.73	107,271.73	1,152.83	9,199,931	508,974.15	401,702.42	4,317.01
41		107,271.73	107,271.73	1,029.31	9,357,845	523,944.71	416,672.99	3,998.13
				10,258,175.74			**NPV**	**(8,835,334.85)**

Table 12-11 Financial Statements of Case A-1-2

FIRR = 6.56%
Discount Factor = 12.00%

Year	Capital Costs US$	Operational costs US$	Total Cost US$	Present Cost US$	Power Supply MWh	Revenues MWh	Net Revenue US$	Net Present Value US$
0	2,642,714		2,642,713.73	2,642,713.73			(2,642,713.73)	(2,642,713.73)
1	5,285,427		5,285,427.47	4,719,131.67			(5,285,427.47)	(4,719,131.67)
2	2,642,714	107,271.73	2,749,985.46	2,192,271.57	3,409,337	534,219.63	(2,215,765.83)	(1,766,394.95)
3		107,271.73	107,271.73	76,353.90	3,564,356	559,089.00	451,817.27	321,594.61
4		107,271.73	107,271.73	68,173.12	3,665,069	578,901.31	471,629.59	299,729.13
5		107,271.73	107,271.73	60,868.86	3,740,695	596,235.66	488,963.93	277,451.27
6		107,271.73	107,271.73	54,347.19	3,831,394	615,736.53	508,464.81	257,604.09
7		107,271.73	107,271.73	48,524.28	3,991,472	642,755.78	535,484.05	242,225.79
8		107,271.73	107,271.73	43,325.25	4,095,167	664,301.72	557,030.00	224,975.07
9		107,271.73	107,271.73	38,683.26	4,179,735	684,194.40	576,922.68	208,044.10
10		107,271.73	107,271.73	34,538.62	4,284,527	707,041.48	599,769.75	193,109.81
11		107,271.73	107,271.73	30,838.06	4,456,530	737,510.33	630,238.61	181,178.54
12		107,271.73	107,271.73	27,533.98	4,572,731	762,238.45	654,966.72	168,113.64
13		107,271.73	107,271.73	24,583.91	4,679,844	787,203.15	679,931.43	155,822.73
14		107,271.73	107,271.73	21,949.92	4,859,796	820,259.23	712,987.51	145,891.37
15		107,271.73	107,271.73	19,598.14	4,980,487	847,569.20	740,297.48	135,249.58
16		107,271.73	107,271.73	17,498.34	5,112,255	876,346.77	769,075.05	125,452.80
17		107,271.73	107,271.73	15,623.52	5,289,080	911,119.36	803,847.63	117,075.86
18		107,271.73	107,271.73	13,949.57	5,412,662	940,118.68	832,846.95	108,303.08
19		107,271.73	107,271.73	12,454.97	5,540,941	970,430.46	863,158.74	100,218.58
20		107,271.73	107,271.73	11,120.51	5,770,627	1,014,048.05	906,776.32	94,002.57
21		107,271.73	107,271.73	9,929.03	5,890,366	1,044,594.27	937,322.54	86,758.21
22		107,271.73	107,271.73	8,865.20	6,028,763	1,078,045.14	970,773.42	80,227.15
23		107,271.73	107,271.73	7,915.36	6,222,990	1,119,459.59	1,012,187.87	74,687.27
24		107,271.73	107,271.73	7,067.29	6,363,714	1,154,632.42	1,047,360.69	69,002.33
25		107,271.73	107,271.73	6,310.08	6,538,609	1,195,202.50	1,087,930.77	63,995.69
26		107,271.73	107,271.73	5,634.00	6,675,921	1,231,655.06	1,124,383.33	59,053.52
27		107,271.73	107,271.73	5,030.36	6,864,559	1,275,389.97	1,168,118.24	54,777.25
28		107,271.73	107,271.73	4,491.39	7,012,775	1,314,728.34	1,207,456.61	50,555.32
29		107,271.73	107,271.73	4,010.17	7,185,843	1,358,464.39	1,251,192.66	46,773.68
30		107,271.73	107,271.73	3,580.51	7,320,823	1,397,441.96	1,290,170.23	43,063.20
31		107,271.73	107,271.73	3,196.88	7,524,792	1,447,290.93	1,340,019.21	39,934.87
32		107,271.73	107,271.73	2,854.36	7,693,922	1,492,950.73	1,385,679.01	36,871.08
33		107,271.73	107,271.73	2,548.53	7,877,404	1,541,525.42	1,434,253.69	34,074.64
34		107,271.73	107,271.73	2,275.48	8,029,715	1,586,552.71	1,479,280.99	31,378.91
35		107,271.73	107,271.73	2,031.68	8,252,347	1,642,950.68	1,535,678.96	29,085.04
36		107,271.73	107,271.73	1,814.00	8,437,568	1,694,560.55	1,587,288.82	26,841.52
37		107,271.73	107,271.73	1,619.64	8,619,958	1,747,078.49	1,639,806.77	24,758.59
38		107,271.73	107,271.73	1,446.11	8,819,927	1,803,151.48	1,695,879.75	22,861.79
39		107,271.73	107,271.73	1,291.17	8,976,237	1,854,015.15	1,746,743.43	21,024.53
40		107,271.73	107,271.73	1,152.83	9,199,931	1,915,560.68	1,808,288.96	19,433.32
41		107,271.73	107,271.73	1,029.31	9,357,845	1,969,003.09	1,861,731.37	17,863.97
				10,258,175.74			**NPV**	**(4,839,175.84)**

Table 12-12 Financial Statements of Case A-1-3

FIRR = 1.62%
Discount Factor = 12.00%

Year	Capital Costs US$	Operational costs US$	Total Cost US$	Present Cost US$	Power Supply MWh	Revenues MWh	Net Revenue US$	Net Present Value US$
0	2,642,714		2,642,713.73	2,642,713.73			(2,642,713.73)	(2,642,713.73)
1	5,285,427		5,285,427.47	4,719,131.67			(5,285,427.47)	(4,719,131.67)
2	2,642,714	107,271.73	2,749,985.46	2,192,271.57	3,409,337	248,288.01	(2,501,697.44)	(1,994,337.89)
3		107,271.73	107,271.73	76,353.90	3,564,356	264,602.74	157,331.02	111,985.11
4		107,271.73	107,271.73	68,173.12	3,665,069	271,992.27	164,720.55	104,682.88
5		107,271.73	107,271.73	60,868.86	3,740,695	277,706.93	170,435.21	96,709.51
6		107,271.73	107,271.73	54,347.19	3,831,394	284,192.72	176,920.99	89,633.68
7		107,271.73	107,271.73	48,524.28	3,991,472	300,679.08	193,407.36	87,487.67
8		107,271.73	107,271.73	43,325.25	4,095,167	307,422.48	200,150.75	80,837.53
9		107,271.73	107,271.73	38,683.26	4,179,735	313,805.68	206,533.95	74,478.21
10		107,271.73	107,271.73	34,538.62	4,284,527	321,747.09	214,475.37	69,055.33
11		107,271.73	107,271.73	30,838.06	4,456,530	339,466.93	232,195.20	66,750.57
12		107,271.73	107,271.73	27,533.98	4,572,731	347,161.00	239,889.27	61,573.60
13		107,271.73	107,271.73	24,583.91	4,679,844	356,807.75	249,536.02	57,187.22
14		107,271.73	107,271.73	21,949.92	4,859,796	375,457.80	268,186.07	54,876.18
15		107,271.73	107,271.73	19,598.14	4,980,487	384,968.91	277,697.18	50,734.24
16		107,271.73	107,271.73	17,498.34	5,112,255	393,698.66	286,426.94	46,722.44
17		107,271.73	107,271.73	15,623.52	5,289,080	413,217.88	305,946.16	44,559.33
18		107,271.73	107,271.73	13,949.57	5,412,662	421,984.60	314,712.88	40,925.13
19		107,271.73	107,271.73	12,454.97	5,540,941	431,244.10	323,972.37	37,615.39
20		107,271.73	107,271.73	11,120.51	5,770,627	455,452.71	348,180.99	36,094.80
21		107,271.73	107,271.73	9,929.03	5,890,366	464,547.49	357,275.77	33,069.31
22		107,271.73	107,271.73	8,865.20	6,028,763	474,567.63	367,295.91	30,354.26
23		107,271.73	107,271.73	7,915.36	6,222,990	497,000.07	389,728.34	28,757.26
24		107,271.73	107,271.73	7,067.29	6,363,714	507,455.55	400,183.82	26,364.95
25		107,271.73	107,271.73	6,310.08	6,538,609	529,650.11	422,378.38	24,845.69
26		107,271.73	107,271.73	5,634.00	6,675,921	541,727.17	434,455.44	22,817.95
27		107,271.73	107,271.73	5,030.36	6,864,559	564,198.12	456,926.40	21,426.91
28		107,271.73	107,271.73	4,491.39	7,012,775	576,099.86	468,828.13	19,629.49
29		107,271.73	107,271.73	4,010.17	7,185,843	599,660.16	492,388.43	18,407.09
30		107,271.73	107,271.73	3,580.51	7,320,823	610,859.77	503,588.05	16,808.72
31		107,271.73	107,271.73	3,196.88	7,524,792	637,406.12	530,134.39	15,798.92
32		107,271.73	107,271.73	2,854.36	7,693,922	651,636.64	544,364.91	14,484.83
33		107,271.73	107,271.73	2,548.53	7,877,404	675,948.06	568,676.34	13,510.47
34		107,271.73	107,271.73	2,275.48	8,029,715	689,272.89	582,001.17	12,345.57
35		107,271.73	107,271.73	2,031.68	8,252,347	717,603.16	610,331.43	11,559.39
36		107,271.73	107,271.73	1,814.00	8,437,568	732,644.92	625,373.20	10,575.25
37		107,271.73	107,271.73	1,619.64	8,619,958	758,720.02	651,448.30	9,835.88
38		107,271.73	107,271.73	1,446.11	8,819,927	785,841.59	678,569.86	9,147.65
39		107,271.73	107,271.73	1,291.17	8,976,237	801,810.42	694,538.69	8,359.76
40		107,271.73	107,271.73	1,152.83	9,199,931	829,743.44	722,471.71	7,764.26
41		107,271.73	107,271.73	1,029.31	9,357,845	856,537.99	749,266.26	7,189.48
				10,258,175.74			**NPV**	**(7,781,221.39)**

Table 12-13 Financial Statements of Case A-2-1

FIRR = -1.75%
Discount Factor = 12.00%

Year	Capital Costs US$	Operational costs US$	Total Cost US$	Present Cost US$	Power Supply MWh	Revenues MWh	Net Revenue MWh	Net Present Value US$
0	1,319,490		1,319,489.80	1,319,489.80			(1,319,489.80)	(1,319,489.80)
1	2,638,980		2,638,979.59	2,356,231.78			(2,638,979.59)	(2,356,231.78)
2	1,319,490	51,714.20	1,371,204.00	1,093,115.43	3,409,337	81,667.75	(1,289,536.24)	(1,028,010.40)
3		51,714.20	51,714.20	36,809.14	3,564,356	83,808.97	32,094.77	22,844.43
4		51,714.20	51,714.20	32,865.31	3,665,069	86,567.21	34,853.01	22,149.72
5		51,714.20	51,714.20	29,344.02	3,740,695	92,727.91	41,013.71	23,272.28
6		51,714.20	51,714.20	26,200.02	3,831,394	95,926.07	44,211.87	22,399.11
7		51,714.20	51,714.20	23,392.88	3,991,472	98,788.31	47,074.11	21,293.94
8		51,714.20	51,714.20	20,886.50	4,095,167	101,597.70	49,883.50	20,147.11
9		51,714.20	51,714.20	18,648.66	4,179,735	104,337.65	52,623.46	18,976.55
10		51,714.20	51,714.20	16,650.59	4,284,527	107,520.98	55,806.78	17,968.29
11		51,714.20	51,714.20	14,866.60	4,456,530	114,838.25	63,124.05	18,146.66
12		51,714.20	51,714.20	13,273.75	4,572,731	118,085.21	66,371.01	17,035.78
13		51,714.20	51,714.20	11,851.56	4,679,844	121,830.04	70,115.84	16,068.74
14		51,714.20	51,714.20	10,581.75	4,859,796	125,297.26	73,583.06	15,056.55
15		51,714.20	51,714.20	9,447.99	4,980,487	129,005.50	77,291.30	14,120.83
16	2,650,961.86	51,714.20	2,702,676.06	440,865.01	5,112,255	132,988.60	(2,569,687.46)	(419,171.69)
17	2,650,961.86	51,714.20	2,702,676.06	393,629.47	5,289,080	241,067.51	(2,461,608.55)	(358,519.36)
18		107,355.59	107,355.59	13,960.48	5,412,662	247,840.30	140,484.71	18,268.57
19		107,355.59	107,355.59	12,464.71	5,540,941	254,988.25	147,632.65	17,141.15
20		107,355.59	107,355.59	11,129.21	5,770,627	268,816.15	161,460.56	16,738.09
21		107,355.59	107,355.59	9,936.79	5,890,366	275,822.46	168,466.86	15,593.23
22		107,355.59	107,355.59	8,872.14	6,028,763	283,706.50	176,350.90	14,574.08
23		107,355.59	107,355.59	7,921.55	6,222,990	296,372.02	189,016.43	13,947.14
24		107,355.59	107,355.59	7,072.81	6,363,714	304,622.59	197,267.00	12,996.36
25		107,355.59	107,355.59	6,315.01	6,538,609	316,863.50	209,507.90	12,323.95
26		107,355.59	107,355.59	5,638.40	6,675,921	325,672.71	218,317.12	11,466.19
27		107,355.59	107,355.59	5,034.29	6,864,559	338,593.24	231,237.64	10,843.56
28		107,355.59	107,355.59	4,494.90	7,012,775	347,901.66	240,546.07	10,071.49
29		107,355.59	107,355.59	4,013.30	7,185,843	360,950.52	253,594.93	9,480.21
30		107,355.59	107,355.59	3,583.31	7,320,823	369,764.31	262,408.72	8,758.66
31		107,355.59	107,355.59	3,199.38	7,524,792	384,802.33	277,446.73	8,268.39
32		107,355.59	107,355.59	2,856.59	7,693,922	395,764.50	288,408.90	7,674.18
33		107,355.59	107,355.59	2,550.53	7,877,404	409,791.97	302,436.38	7,185.21
34		107,355.59	107,355.59	2,277.26	8,029,715	420,247.13	312,891.53	6,637.14
35		107,355.59	107,355.59	2,033.26	8,252,347	436,784.49	329,428.90	6,239.23
36		107,355.59	107,355.59	1,815.41	8,437,568	448,962.54	341,606.94	5,776.67
37		107,355.59	107,355.59	1,620.91	8,619,958	463,934.77	356,579.17	5,383.80
38		107,355.59	107,355.59	1,447.24	8,819,927	479,867.45	372,511.86	5,021.75
39		107,355.59	107,355.59	1,292.18	8,976,237	491,767.14	384,411.55	4,626.94
40		107,355.59	107,355.59	1,153.73	9,199,931	508,974.15	401,618.55	4,316.11
41		107,355.59	107,355.59	1,030.12	9,357,845	523,944.71	416,589.12	3,997.32
				5,989,863.75			**NPV**	**(4,994,613.61)**

Table 12-14 Financial Statements of Case A-2-2

FIRR = 7.69%
Discount Factor = 12.00%

Year	Capital Costs US$	Operational costs US$	Total Cost US$	Present Cost US$	Power Supply MWh	Revenues MWh	Net Revenue MWh	Net Present Value US$
0	1,319,490		1,319,489.80	1,319,489.80			(1,319,489.80)	(1,319,489.80)
1	2,638,980		2,638,979.59	2,356,231.78			(2,638,979.59)	(2,356,231.78)
2	1,319,490	51,714.20	1,371,204.00	1,093,115.43	3,409,337	310,945.14	(1,060,258.85)	(845,231.86)
3		51,714.20	51,714.20	36,809.14	3,564,356	320,455.36	268,741.16	191,284.65
4		51,714.20	51,714.20	32,865.31	3,665,069	331,511.96	279,797.76	177,816.54
5		51,714.20	51,714.20	29,344.02	3,740,695	348,436.05	296,721.85	168,367.95
6		51,714.20	51,714.20	26,200.02	3,831,394	360,643.94	308,929.74	156,513.42
7		51,714.20	51,714.20	23,392.88	3,991,472	372,240.89	320,526.69	144,990.00
8		51,714.20	51,714.20	20,886.50	4,095,167	384,439.52	332,725.33	134,382.18
9		51,714.20	51,714.20	18,648.66	4,179,735	396,096.46	344,382.26	124,187.70
10		51,714.20	51,714.20	16,650.59	4,284,527	409,144.52	357,430.32	115,083.00
11		51,714.20	51,714.20	14,866.60	4,456,530	429,624.87	377,910.67	108,640.29
12		51,714.20	51,714.20	13,273.75	4,572,731	443,633.90	391,919.70	100,596.02
13		51,714.20	51,714.20	11,851.56	4,679,844	458,257.56	406,543.36	93,169.25
14		51,714.20	51,714.20	10,581.75	4,859,796	472,827.50	421,113.30	86,168.12
15		51,714.20	51,714.20	9,447.99	4,980,487	488,115.91	436,401.71	79,728.96
16	2,650,961.86	51,714.20	2,702,676.06	440,865.01	5,112,255	504,693.56	(2,197,982.50)	(358,538.56)
17	2,650,961.86	51,714.20	2,702,676.06	393,629.47	5,289,080	911,119.36	(1,791,556.71)	(260,930.10)
18		107,355.59	107,355.59	13,960.48	5,412,662	940,118.68	832,763.09	108,292.17
19		107,355.59	107,355.59	12,464.71	5,540,941	970,430.46	863,074.87	100,208.84
20		107,355.59	107,355.59	11,129.21	5,770,627	1,014,048.05	906,692.45	93,993.87
21		107,355.59	107,355.59	9,936.79	5,890,366	1,044,594.27	937,238.68	86,750.45
22		107,355.59	107,355.59	8,872.14	6,028,763	1,078,045.14	970,689.55	80,220.22
23		107,355.59	107,355.59	7,921.55	6,222,990	1,119,459.59	1,012,104.00	74,681.09
24		107,355.59	107,355.59	7,072.81	6,363,714	1,154,632.42	1,047,276.82	68,996.80
25		107,355.59	107,355.59	6,315.01	6,538,609	1,195,202.50	1,087,846.90	63,990.75
26		107,355.59	107,355.59	5,638.40	6,675,921	1,231,655.06	1,124,299.46	59,049.12
27		107,355.59	107,355.59	5,034.29	6,864,559	1,275,389.97	1,168,034.37	54,773.31
28		107,355.59	107,355.59	4,494.90	7,012,775	1,314,728.34	1,207,372.75	50,551.81
29		107,355.59	107,355.59	4,013.30	7,185,843	1,358,464.39	1,251,108.79	46,770.54
30		107,355.59	107,355.59	3,583.31	7,320,823	1,397,441.96	1,290,086.36	43,060.40
31		107,355.59	107,355.59	3,199.38	7,524,792	1,447,290.93	1,339,935.34	39,932.37
32		107,355.59	107,355.59	2,856.59	7,693,922	1,492,950.73	1,385,595.14	36,868.85
33		107,355.59	107,355.59	2,550.53	7,877,404	1,541,525.42	1,434,169.82	34,072.64
34		107,355.59	107,355.59	2,277.26	8,029,715	1,586,552.71	1,479,197.12	31,377.13
35		107,355.59	107,355.59	2,033.26	8,252,347	1,642,950.68	1,535,595.09	29,083.45
36		107,355.59	107,355.59	1,815.41	8,437,568	1,694,560.55	1,587,204.95	26,840.10
37		107,355.59	107,355.59	1,620.91	8,619,958	1,747,078.49	1,639,722.90	24,757.32
38		107,355.59	107,355.59	1,447.24	8,819,927	1,803,151.48	1,695,795.89	22,860.66
39		107,355.59	107,355.59	1,292.18	8,976,237	1,854,015.15	1,746,659.56	21,023.52
40		107,355.59	107,355.59	1,153.73	9,199,931	1,915,560.68	1,808,205.09	19,432.42
41		107,355.59	107,355.59	1,030.12	9,357,845	1,969,003.09	1,861,647.50	17,863.17
				5,989,863.75			**NPV**	**(2,224,043.00)**

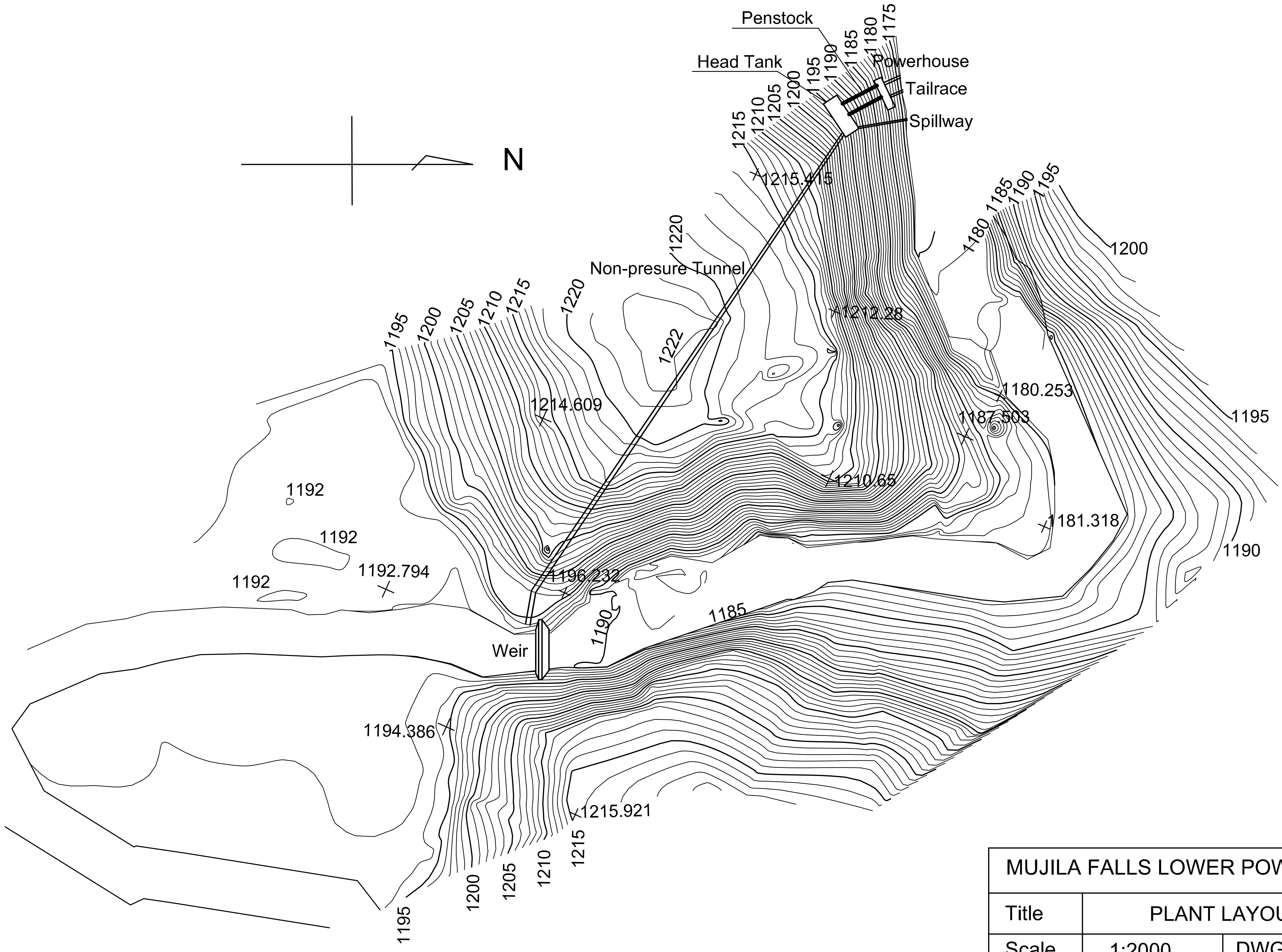
Table 12-15 Financial Statements of Case A-2-3

FIRR = 1.76%
Discount Factor = 12.00%

Year	Capital Costs US$	Operational costs US$	Total Cost US$	Present Cost US$	Power Supply MWh	Revenues MWh	Net Revenue MWh	Net Present Value US$
0	1,319,490		1,319,489.80	1,319,489.80			(1,319,489.80)	(1,319,489.80)
1	2,638,980		2,638,979.59	2,356,231.78			(2,638,979.59)	(2,356,231.78)
2	1,319,490	51,714.20	1,371,204.00	1,093,115.43	3,409,337	149,172.43	(1,222,031.57)	(974,196.09)
3		51,714.20	51,714.20	36,809.14	3,564,356	152,215.47	100,501.27	71,534.82
4		51,714.20	51,714.20	32,865.31	3,665,069	156,162.04	104,447.84	66,378.49
5		51,714.20	51,714.20	29,344.02	3,740,695	168,911.85	117,197.65	66,501.09
6		51,714.20	51,714.20	26,200.02	3,831,394	173,992.27	122,278.07	61,949.87
7		51,714.20	51,714.20	23,392.88	3,991,472	178,136.90	126,422.71	57,187.21
8		51,714.20	51,714.20	20,886.50	4,095,167	181,950.67	130,236.48	52,600.33
9		51,714.20	51,714.20	18,648.66	4,179,735	185,903.51	134,189.31	48,390.01
10		51,714.20	51,714.20	16,650.59	4,284,527	190,415.69	138,701.49	44,658.17
11		51,714.20	51,714.20	14,866.60	4,456,530	204,910.13	153,195.93	44,040.17
12		51,714.20	51,714.20	13,273.75	4,572,731	209,230.29	157,516.10	40,430.46
13		51,714.20	51,714.20	11,851.56	4,679,844	214,953.46	163,239.26	37,410.23
14		51,714.20	51,714.20	10,581.75	4,859,796	219,706.11	167,991.91	34,374.47
15		51,714.20	51,714.20	9,447.99	4,980,487	224,819.94	173,105.74	31,625.77
16	2,650,961.86	51,714.20	2,702,676.06	440,865.01	5,112,255	230,078.04	(2,472,598.02)	(403,334.30)
17	2,650,961.86	51,714.20	2,702,676.06	393,629.47	5,289,080	413,217.88	(2,289,458.18)	(333,446.63)
18		107,355.59	107,355.59	13,960.48	5,412,662	421,984.60	314,629.01	40,914.23
19		107,355.59	107,355.59	12,464.71	5,540,941	431,244.10	323,888.50	37,605.65
20		107,355.59	107,355.59	11,129.21	5,770,627	455,452.71	348,097.12	36,086.10
21		107,355.59	107,355.59	9,936.79	5,890,366	464,547.49	357,191.90	33,061.54
22		107,355.59	107,355.59	8,872.14	6,028,763	474,567.63	367,212.04	30,347.32
23		107,355.59	107,355.59	7,921.55	6,222,990	497,000.07	389,644.48	28,751.07
24		107,355.59	107,355.59	7,072.81	6,363,714	507,455.55	400,099.95	26,359.43
25		107,355.59	107,355.59	6,315.01	6,538,609	529,650.11	422,294.51	24,840.76
26		107,355.59	107,355.59	5,638.40	6,675,921	541,727.17	434,371.57	22,813.55
27		107,355.59	107,355.59	5,034.29	6,864,559	564,198.12	456,842.53	21,422.98
28		107,355.59	107,355.59	4,494.90	7,012,775	576,099.86	468,744.27	19,625.98
29		107,355.59	107,355.59	4,013.30	7,185,843	599,660.16	492,304.57	18,403.96
30		107,355.59	107,355.59	3,583.31	7,320,823	610,859.77	503,504.18	16,805.92
31		107,355.59	107,355.59	3,199.38	7,524,792	637,406.12	530,050.53	15,796.42
32		107,355.59	107,355.59	2,856.59	7,693,922	651,636.64	544,281.05	14,482.60
33		107,355.59	107,355.59	2,550.53	7,877,404	675,948.06	568,592.47	13,508.48
34		107,355.59	107,355.59	2,277.26	8,029,715	689,272.89	581,917.30	12,343.79
35		107,355.59	107,355.59	2,033.26	8,252,347	717,603.16	610,247.57	11,557.80
36		107,355.59	107,355.59	1,815.41	8,437,568	732,644.92	625,289.33	10,573.83
37		107,355.59	107,355.59	1,620.91	8,619,958	758,720.02	651,364.43	9,834.61
38		107,355.59	107,355.59	1,447.24	8,819,927	785,841.59	678,486.00	9,146.52
39		107,355.59	107,355.59	1,292.18	8,976,237	801,810.42	694,454.82	8,358.75
40		107,355.59	107,355.59	1,153.73	9,199,931	829,743.44	722,387.84	7,763.36
41		107,355.59	107,355.59	1,030.12	9,357,845	856,537.99	749,182.39	7,188.67
				5,989,863.75			**NPV**	**(4,252,024.18)**

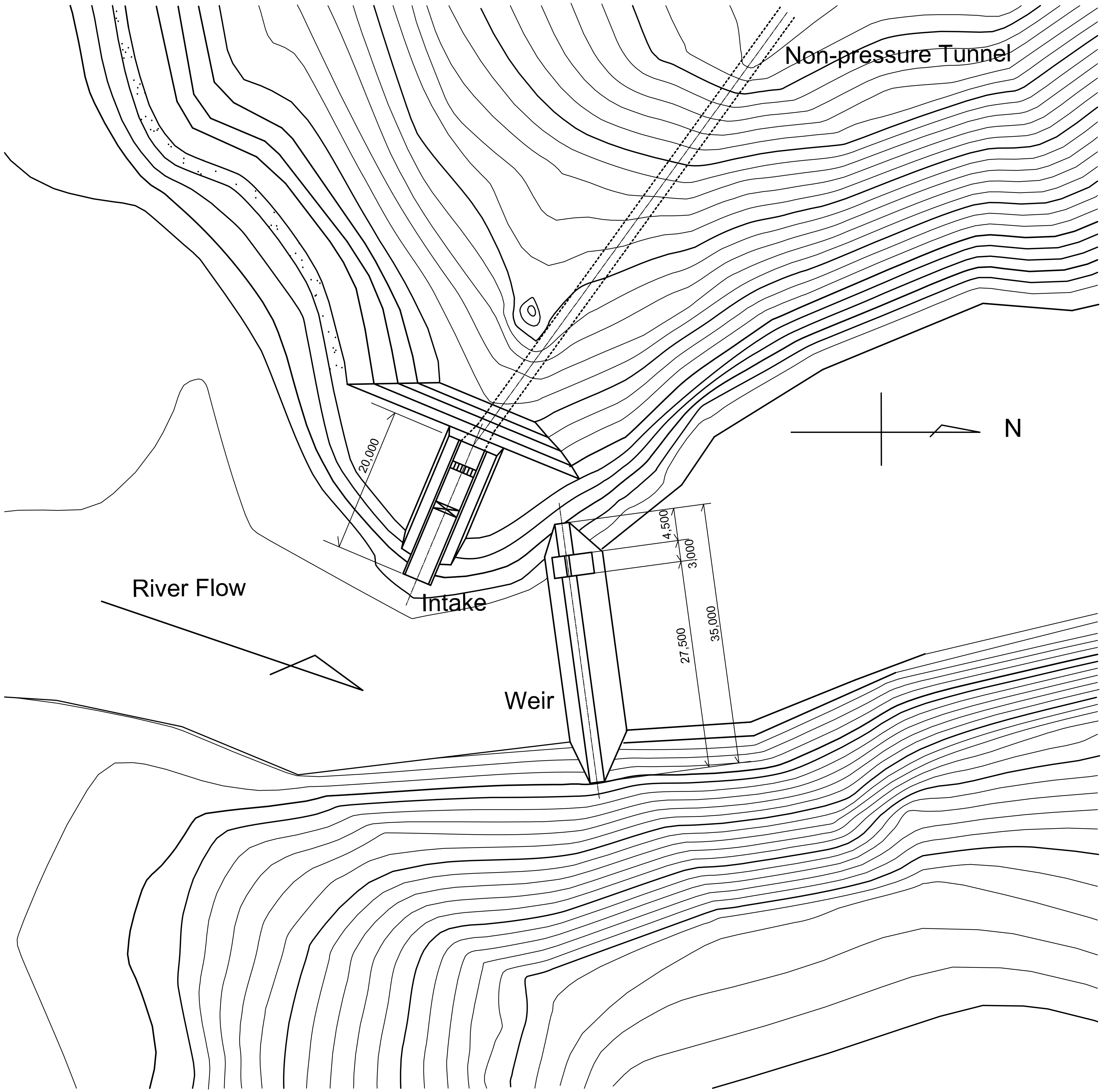
(6) Drawings

Followings are the drawings of Mujila Falls Lower site.

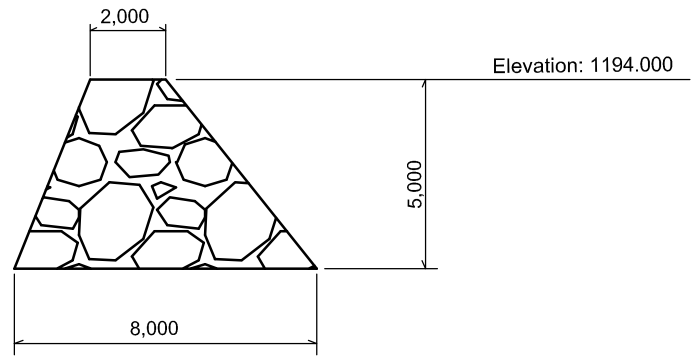


MUJILA FALLS LOWER POWER STATION			
Title	PLANT LAYOUT		
Scale	1:2000	DWG No.	MFL-1
TEPCO JICA STUDY TEAM		16-JAN-2008	

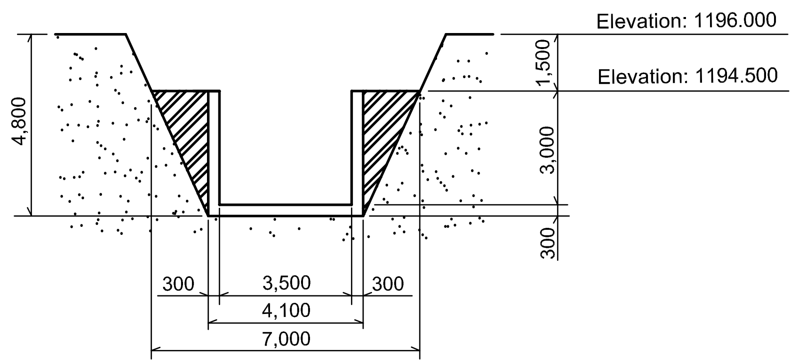
Weir and Intake Plan



Weir Section (1:200)

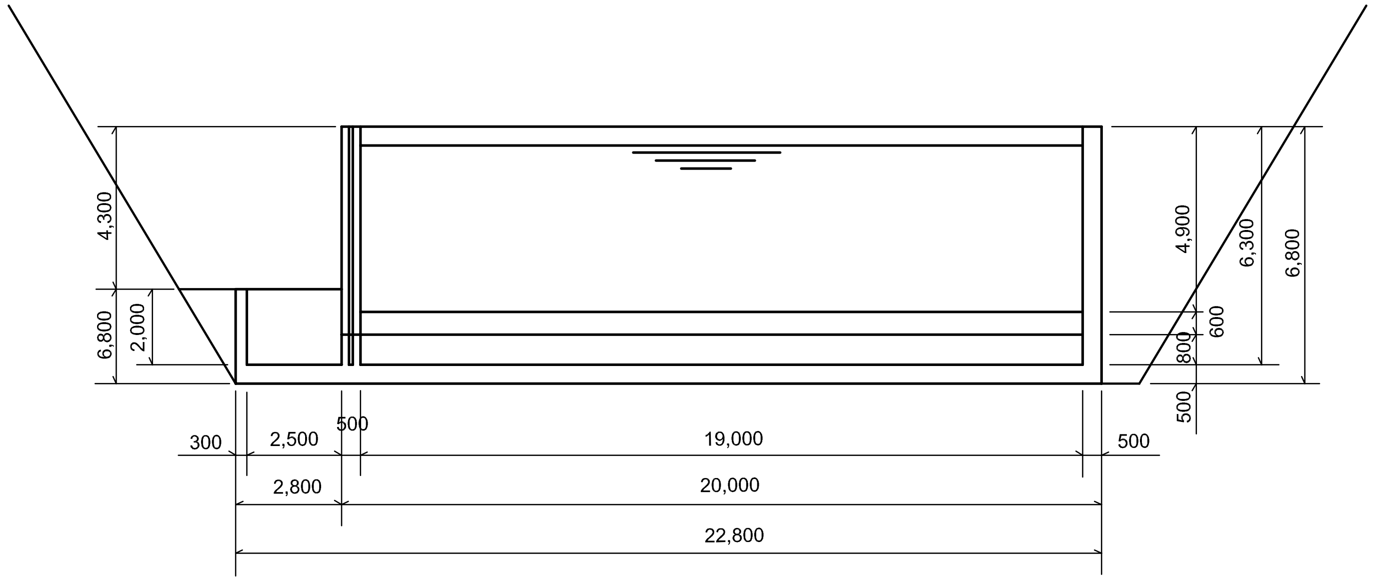


Intake Section (1:200)

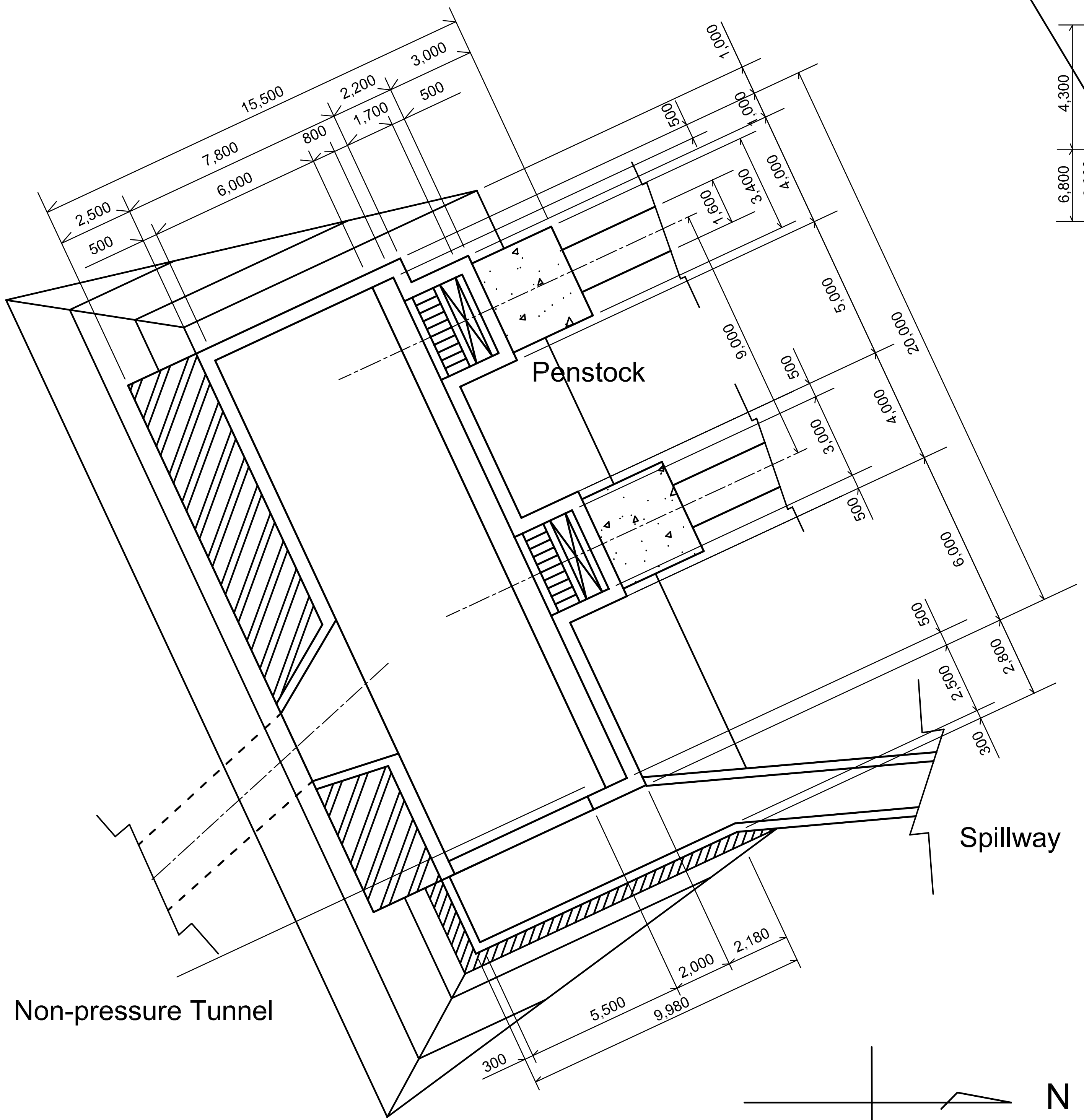


MUJILA FALLS LOWER POWER STATION			
Title	WAIR AND INTKE		
Scale	1:600	DWG No.	MFL-2
TEPCO JICA STUDY TEAM		16-JAN-2008	

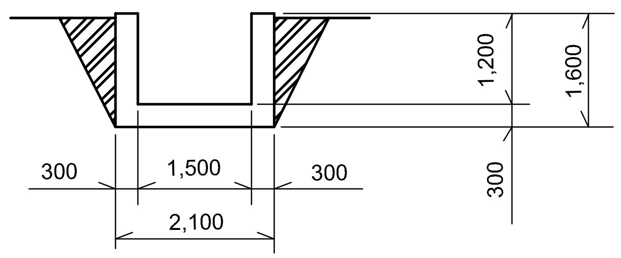
Head Tank Section



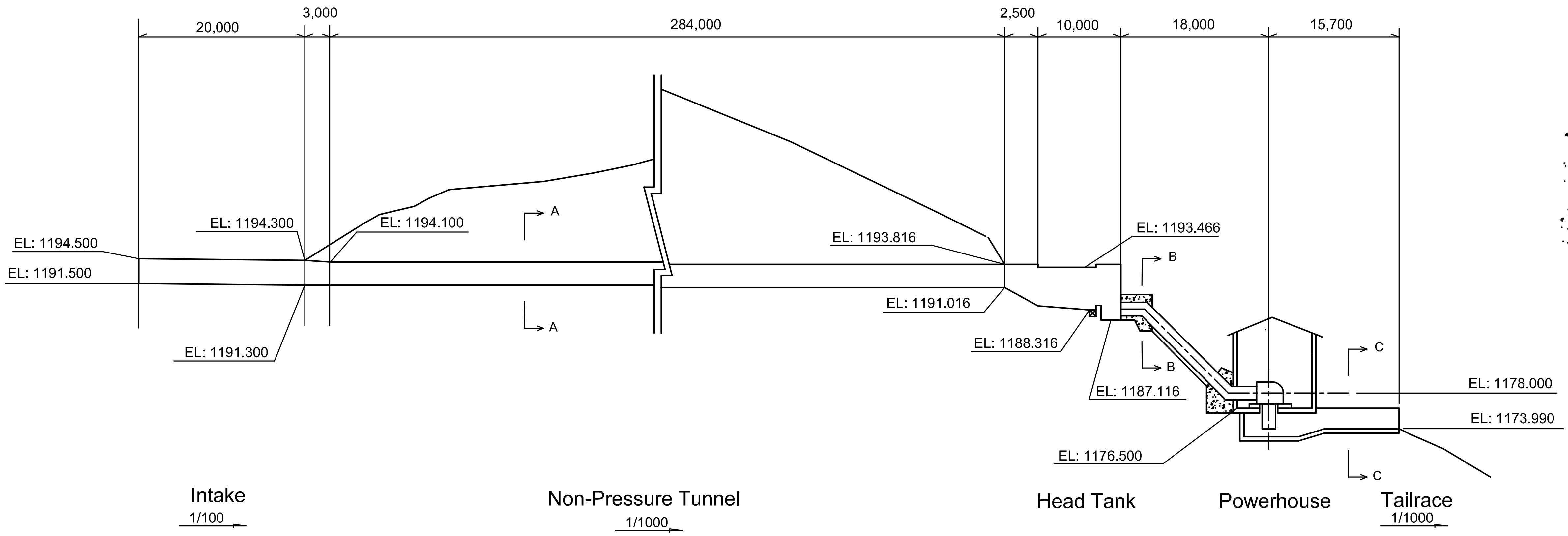
Head Tank Plan



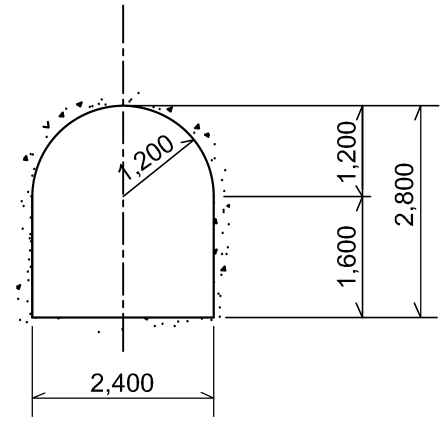
Spillway Section (1:100)



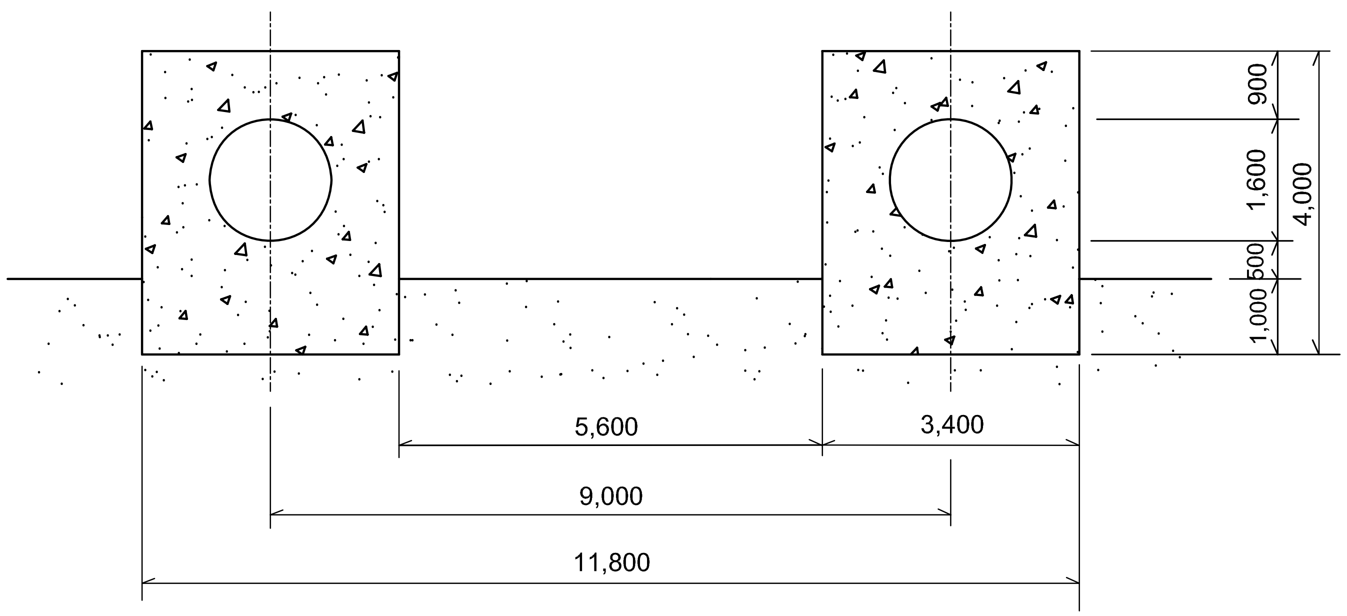
MUJILA FALLS LOWER POWER STATION			
Title	HEAD TANK		
Scale	1:200	DWG No.	MFL-3
TEPCO JICA STUDY TEAM		16-JAN-2008	



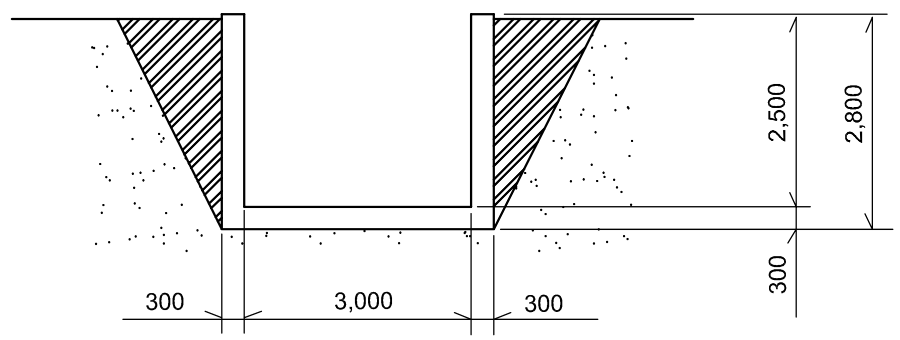
A - A Section (1:100)



B - B Section (1:100)



C - C Section (1:100)



MUJILA FALLS LOWER POWER STATION			
Title	WATER WAY SECTION		
Scale	1:600	DWG No.	MFL-4
TEPCO JICA STUDY TEAM		16-JAN-2008	

12.2.4. Result of Case Study 2 : Chilambwe Falls Site

(1) Demand Forecast

Figure 12-3 shows the location of Chilambwe Falls site and surrounding RGCs, Kapatu RGC and Sibwalya Kapila RGC. Both RGC has very big potential demand based on the preliminary demand forecast, and the potential generation capacity of this site is about 300 kW, which is too small to supply electricity for both RGCs, and distribution line extension has been selected as the optimum electrification mode in the Master Plan. Therefore, the Study Team selected only Kapatu RGCs in this Case Study. Table 12-16 shows the result of social survey in Kapatu RGC, and the Study Team estimated the potential demand, which is shown in Table 12-17.

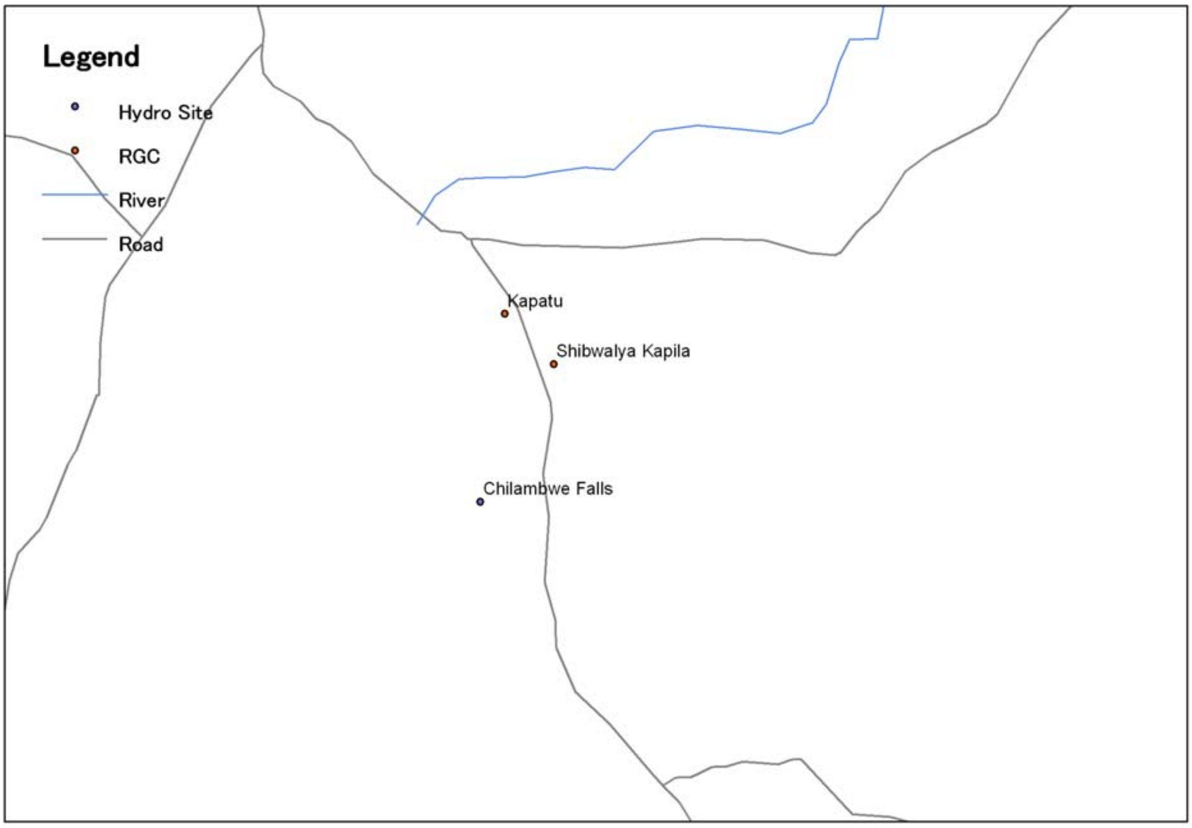


Figure 12-3 Location of Chilambwe Falls Site and RGCs

Table 12-16 Result of Social Survey in Kapatu RGC

	Kapatu RGC
No. of Households (as of 2006)	535
No. of Population (as of 2006)	2,750
No. of Hammer Mills (as of 2006)	2
Number of Existing Public Facilities	13
1) Basic / Primary School	1
2) Secondary School [under construction]	[1]
3) Tertiary School	
4) Hospital	
5) Health Centre (Clinic) / Health Post	1
6) Police Office / Station	
7) Post Office	
8) Church	1
9) Mosque	
10) Community Centre	7
11) (Agricultural) Depot	2
12) Orphanage	
13) Central Government Office	
14) Provincial Government Office	
15) District Government Office	
16) Other Local Administration Offices	
17) Court	
18) Others	
Number of Existing Business Entities	22

Table 12-17 Demand Forecast for Kapatu RGC

	Kapatu RGC [kW]
Current (2006)	303
2010	366
2015	413
2020	481
2025	559
2030	647

(2) Generation Capacity

Figure 12-4 indicates the flow duration curve at Chilambswe Falls Site, which is edited converting the river flow data measured at Kasama-Kuwing Road Bridge Gauging Station on Lukulu River. The actual river flow amount at Chilambwe Falls site measured on 14th August 2007 was 1.47 m^3/s, which corresponds to about 50% available discharge in Figure 12-4. The actual river flow is a bit large in mid August if the duration curve is reliable. This is due to the much more amount of rainfall in the last rainy season than usual.

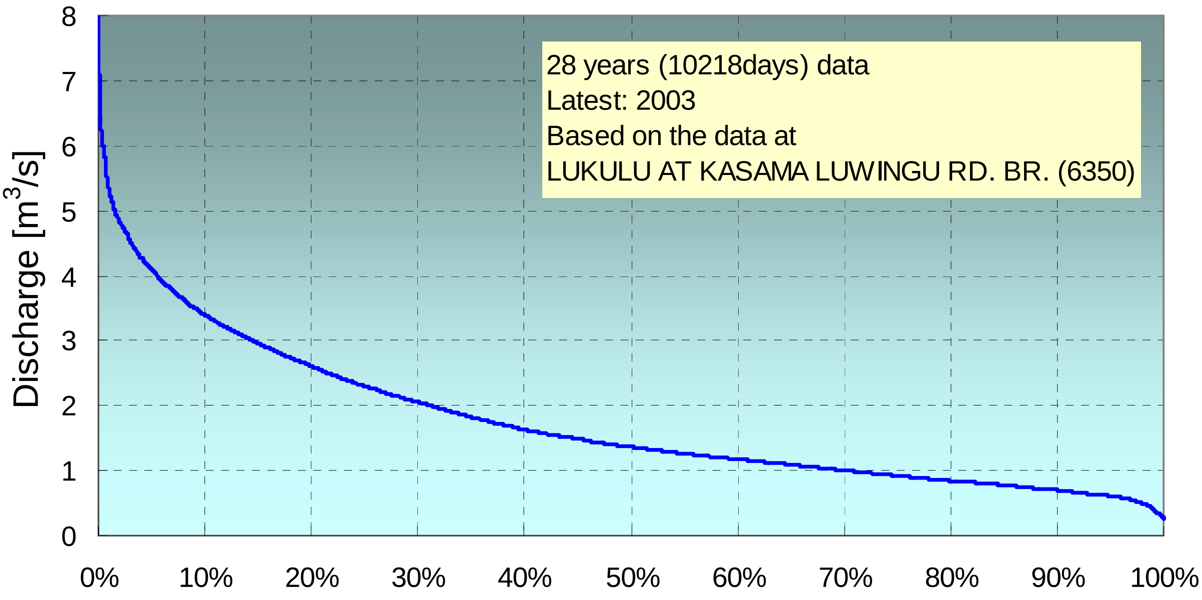


Figure 12-4 Flow Duration Curve at Chilambwe Falls Site

Table 12-18 shows the 70%, 80%, 90% and 100% available discharge at Chilambwe Falls site, and also the generation capacity assuming 36.9 m of effective head.

Table 12-18 Generation Capacity of Chilambwe Falls Site

	River Flow [m^3/s]	Generation Capacity [kW]
100% availability	0.26	78
90% availability	0.70	210
80% availability	0.85	253
70% availability	1.01	302

The Study Team estimated the total electricity supply quantity from proposed Chilambwe hydropower station up to 2030 in order to compare the generation cost (US$/kWh) among 1.0$m^3$/s, 0.85$m^3$/s, and 0.70$m^3$/s of designed discharge. Table 12-19 shows the result for each designed discharge, and the case designed at 1.0m^3/s indicates the lowest construction cost per kWh. Therefore, the generation capacity is decided at 300kW with 1.0m^3/s of designed discharge.

Table 12-19 Comparison for Designed Discharge and Generation Cost

		70% Available Discharge		80% Available Discharge		90% Available Discharge	
Plant Reliability		95 %		95 %		95 %	
Days of Planed Outage (Low Flow Season)		10 days		10 days		10 days	
Design Discharge		**1.00 m^3/s**		**0.85 m^3/s**		**0.70 m^3/s**	
Max. Output		300 kW		254 kW		209 kW	
Days at Max. Output		243 days		277 days		312 days	
Ave. Low Discharge		0.76 m^3/s		0.68 m^3/s		0.57 m^3/s	
Ave. Output at Low Dis.		226 kW		203 kW		171 kW	
Days at Low Output		94 days		59 days		25 days	
Actual Generation							
Year	Demand [kWh]	Supply [kWh]	S/D	Supply [kWh]	S/D	Supply [kWh]	S/D
2010	1,604,540	1,434,037	89.4%	1,406,780	87.7%	1,351,440	84.2%
2011	1,642,865	1,462,543	89.0%	1,435,149	87.4%	1,371,677	83.5%
2012	1,681,190	1,490,390	88.7%	1,462,407	87.0%	1,391,890	82.8%
2013	1,723,165	1,520,799	88.3%	1,490,458	86.5%	1,414,114	82.1%
2014	1,766,235	1,551,653	87.9%	1,517,658	85.9%	1,435,664	81.3%
2015	1,806,385	1,580,338	87.5%	1,542,936	85.4%	1,454,694	80.5%
2016	1,921,725	1,661,412	86.5%	1,608,372	83.7%	1,497,178	77.9%
2017	1,969,905	1,694,372	86.0%	1,633,354	82.9%	1,512,922	76.8%
2018	2,014,070	1,722,790	85.5%	1,655,186	82.2%	1,526,260	75.8%
2019	2,058,600	1,749,415	85.0%	1,676,761	81.5%	1,539,286	74.8%
2020	2,106,780	1,778,547	84.4%	1,700,120	80.7%	1,549,265	73.5%
2021	2,170,655	1,816,346	83.7%	1,731,085	79.7%	1,564,222	72.1%
2022	2,221,025	1,843,557	83.0%	1,752,284	78.9%	1,574,201	70.9%
2023	2,271,395	1,868,262	82.3%	1,771,818	78.0%	1,584,517	69.8%
2024	2,402,795	1,921,688	80.0%	1,810,948	75.4%	1,597,165	66.5%
2025	2,454,990	1,945,328	79.2%	1,825,806	74.4%	1,605,921	65.4%
2026	2,514,120	1,972,015	78.4%	1,841,179	73.2%	1,616,023	64.3%
2027	2,580,550	1,999,226	77.5%	1,854,907	71.9%	1,627,809	63.1%
2028	2,638,950	2,020,980	76.6%	1,866,615	70.7%	1,637,600	62.1%
2029	2,705,015	2,045,145	75.6%	1,880,402	69.5%	1,649,501	61.0%
2030	2,838,605	2,080,342	73.3%	1,892,783	66.7%	1,659,644	58.5%
Total	45,093,560	37,159,185	82.4%	35,357,008	78.4%	32,160,992	71.3%
Construction Cost		3,397,121 US$		3,288,093 US$		3,210,568 US$	
Const. Cost / kWh		**9.14 US Cents**		**9.30 US Cents**		**9.98 US Cents**	

(3) Design of Hydropower Plant

Table 12-20 shows the results of the design for civil facilities and electrical equipment.

Table 12-20 Features of Plant and Facilities of Chilambwe Falls Project

Plant parameters	Chilambwe Falls Project
Rated output	300kW
No. of units	One
Design discharge	1.0m^3/s
Effective head	36.9m
Civil facilities	
Weir	Stone masonry with flushing gate H=2m, L=50m
Intake channel	Open channel B=2.0m, H=1.5m, L=12m
Silt basin	No need
Headrace	Open channel B=1.5m, H=1.5m, L=208m
Tailrace	Open channel B=2.0m, H=2.3m, L=55m
Spillway	Open channel B=0.8m, H=1.0m, L=45m
Head tank	Open channel B=3.0m, H=3.5m, L=12m
Penstock	Exposed type D=0.75m, t=5mm, L=200m x 1 line
Powerhouse	Stone masonry, Aboveground type 5.5m x 10m x 4m
Electrical Equipment	
Turbine	Closs-flow turvine with sprit guide-vane H_{max}=36.9m, Q_{max}=1.0m^3/s, Pt_{max}=310kW
Generator	3-phase synchronouse generator Rated output: 330kVA, Voltage: 6.6kV Power factor: 0.9, Frequency: 50Hz
Main transformer	Outdoor type Capacity: 330kVA, Voltage: 6.6kV/33kV
Distribution line	3 phase, 3 wires, Overhead distribution line Voltage: 33kV, L=34km
Pole transformer	Outdoor type Voltage: 33kV/400V, Capacity: 100kVA x 6 units

(4) Project Cost Estimation

Table 12-21 shows the result of Chilambwe Falls project cost estimation.

Table 12-21 Cost Estimation For Chilambwe Falls Project

	Quantity	Unit Price	Price
I. Construction Cost			**2,220,340 US$**
i) Civil Engineering			406,840 US$
[Weir, Intake, Headtank and Power house]			
Concrete	80 m^3	600 US$/$m^3$	48,000 US$
Rebar	8 t	1,400 US$/t	11,200 US$
Masonry	321 m^3	150 US$/$m^3$	48,150 US$
Excavation, common	170 m^3	10 US$/$m^3$	1,700 US$
Excavation, rock	679 m^3	60 US$/$m^3$	40,740 US$
[Channel and Tailrace]			
Masonry	525 m^3	150 US$/$m^3$	78,750 US$
Excavation, common	278 m^3	10 US$/$m^3$	2,780 US$
Excavation, rock	1,112 m^3	60 US$/$m^3$	66,720 US$
[Penstock and Spillway]			
Concrete	41 m^3	600 US$/$m^3$	24,600 US$
Rebar	5 t	1,400 US$/t	7,000 US$
Excavation, common	40 m^3	10 US$/$m^3$	400 US$
Excavation, rock	160 m^3	60 US$/$m^3$	9,600 US$
[Steel Structures]			
Gate and Screen	5 t	2,800 US$/t	14,000 US$
Penstock	19 t	2,800 US$/t	53,200 US$
ii) Mechanical & Electrical Equipment			1,616,200 US$
Turbine, Gen and Tr	1 LS	310,000 US$	310,000 US$
33kV distribution line	34 km	36,000 US$/km	1,224,000 US$
33kV/400V Transformer	6 Unit	13,700 US$/Unit	82,200 US$
iii) Temporary Works			197,300 US$
Access Road	3 km	30,000 US$	90,000 US$
Road maintenance	1 LS	3,000 US$	3,000 US$
Others [30% of i)]	1 LS	104,300 US$	104,300 US$
II. Engineering Service Cost			**177,628 US$**
8.0% of Item I	1 LS	177,628 US$	177,628 US$
III. Overhead Cost			**555,085 US$**
25.0% of Item I	1 LS	555,085 US$	555,085 US$
IV. Profit Margin			**444,068 US$**
20.0% of Item I	1 LS	444,068 US$	444,068 US$
Grand Total			**3,397,121 US$**

(5) Financial Analysis

Table 12-22 shows the results of financial analysis for Chilambwe Falls project. As same as the MFL project, FIRR resulted in negative percentage. In case the tariff level is set at commodity charge in Zengamina HP (Case B-2), FIRR increased up about 7 %. The financial statement for each case is shown from Table 12-23 to Table 12-25.

Table 12-22 Results of Financial Analysis for Chilambwe Falls Project

Tariffs	Case B-1 ZESCO Charge		Case B-2 Zengamina HP Commodity Charge		Case B-3 Zengamina HP Fixed Charge	
	K	US $	K	US $	K	US $
Households tariffs	102	0.026	440	0.11	–	–
Monthly fixed charge	8,475	2.12	50,000	12.50	40,000	10.00
Commercial tariffs	245	0.06	440	0.11	600	2.00
Monthly fixed charge	43,841	10.96	50,000	12.50	50,000	15.00
Social tariffs	201	0.05	440	0.11	600	2.00
Monthly fixed charge	34,839	8.71	50,000	12.50	50,000	15.00
FIRR	-1.42 %		6.97 %		2.20 %	

Table 12-23 Financial Statements of Case B-1

FIRR = -1.42%
Discount Factor = 12.00%

Year	Capital Costs US$	Operational costs US$	Total Cost US$	Present Cost US$	Power Supply MWh	Revenues US$	Net Revenue US$	Net Present Value US$
0	951,651		951,650.94	951,650.94			(951,650.94)	(951,650.94)
1	1,903,302		1,903,301.88	1,699,376.68			(1,903,301.88)	(1,699,376.68)
2	951,651	38,633.93	990,284.87	789,449.04	1,434,037	62,667.96	(927,616.91)	(739,490.52)
3		38,633.93	38,633.93	27,498.87	1,462,543	64,323.14	25,689.22	18,285.08
4		38,633.93	38,633.93	24,552.56	1,494,591	66,108.31	27,474.38	17,460.46
5		38,633.93	38,633.93	21,921.93	1,520,799	67,740.52	29,106.60	16,515.86
6		38,633.93	38,633.93	19,573.15	1,551,653	69,671.37	31,037.44	15,724.53
7		38,633.93	38,633.93	17,476.03	1,580,338	71,423.71	32,789.78	14,832.43
8		38,633.93	38,633.93	15,603.60	1,666,091	76,833.96	38,200.03	15,428.35
9		38,633.93	38,633.93	13,931.78	1,694,372	78,824.78	40,190.85	14,493.22
10		38,633.93	38,633.93	12,439.09	1,722,790	80,679.62	42,045.70	13,537.59
11		38,633.93	38,633.93	11,106.33	1,749,415	82,340.51	43,706.58	12,564.60
12		38,633.93	38,633.93	9,916.37	1,783,553	84,450.39	45,816.46	11,759.94
13		38,633.93	38,633.93	8,853.90	1,816,346	87,232.40	48,598.47	11,137.52
14		38,633.93	38,633.93	7,905.27	1,843,557	89,169.23	50,535.31	10,340.52
15		38,633.93	38,633.93	7,058.27	1,868,262	91,043.56	52,409.63	9,575.04
16		38,633.93	38,633.93	6,302.03	1,927,092	96,114.97	57,481.04	9,376.40
17		38,633.93	38,633.93	5,626.81	1,945,328	97,832.27	59,198.34	8,621.90
18		38,633.93	38,633.93	5,023.94	1,972,015	100,023.11	61,389.18	7,983.02
19		38,633.93	38,633.93	4,485.66	1,999,226	102,475.65	63,841.72	7,412.46
20		38,633.93	38,633.93	4,005.05	2,026,659	104,624.70	65,990.77	6,841.05
21		38,633.93	38,633.93	3,575.94	2,045,145	106,657.78	68,023.85	6,296.26
22		38,633.93	38,633.93	3,192.80	2,080,342	110,908.60	72,274.67	5,972.96
23		38,633.93	38,633.93	2,850.72	2,098,008	112,809.57	74,175.64	5,473.27
24		38,633.93	38,633.93	2,545.28	2,121,940	115,316.38	76,682.46	5,052.00
25		38,633.93	38,633.93	2,272.58	2,129,051	116,023.41	77,389.49	4,552.31
26		38,633.93	38,633.93	2,029.09	2,144,556	117,124.72	78,490.79	4,122.40
27		38,633.93	38,633.93	1,811.68	2,159,295	119,763.57	81,129.64	3,804.46
28		38,633.93	38,633.93	1,617.57	2,181,734	121,159.78	82,525.85	3,455.30
29		38,633.93	38,633.93	1,444.26	2,189,633	121,974.57	83,340.64	3,115.55
30		38,633.93	38,633.93	1,289.52	2,203,103	122,967.71	84,333.78	2,814.89
31		38,633.93	38,633.93	1,151.36	2,219,971	124,350.71	85,716.79	2,554.51
32		38,633.93	38,633.93	1,028.00	2,239,682	127,197.42	88,563.49	2,356.56
33		38,633.93	38,633.93	917.86	2,244,261	127,863.62	89,229.69	2,119.90
34		38,633.93	38,633.93	819.51	2,256,640	129,006.89	90,372.97	1,917.02
35		38,633.93	38,633.93	731.71	2,267,563	130,002.13	91,368.21	1,730.47
36		38,633.93	38,633.93	653.31	2,286,829	132,807.47	94,173.55	1,592.50
37		38,633.93	38,633.93	583.31	2,292,078	133,573.68	94,939.75	1,433.45
38		38,633.93	38,633.93	520.82	2,305,428	134,769.47	96,135.54	1,295.98
39		38,633.93	38,633.93	465.01	2,319,020	135,982.05	97,348.12	1,171.72
40		38,633.93	38,633.93	415.19	2,338,671	138,767.41	100,133.49	1,076.11
41		38,633.93	38,633.93	370.71	2,342,322	139,557.12	100,923.19	968.39
				3,694,043.53			**NPV**	**(3,105,752.15)**

Table 12-24 Financial Statements of Case B-2

FIRR = 6.97%
Discount Factor = 12.00%

Year	Capital Costs US$	Operational costs US$	Total Cost US$	Present Cost US$	Power Supply MWh	Revenues US$	Net Revenue US$	Net Present Value US$
0	951,651		951,650.94	951,650.94			(951,650.94)	(951,650.94)
1	1,903,302		1,903,301.88	1,699,376.68			(1,903,301.88)	(1,699,376.68)
2	951,651	38,633.93	990,284.87	789,449.04	1,434,037	230,194.38	(760,090.49)	(605,939.48)
3		38,633.93	38,633.93	27,498.87	1,462,543	237,072.06	198,438.14	141,244.35
4		38,633.93	38,633.93	24,552.56	1,494,591	244,382.96	205,749.03	130,757.23
5		38,633.93	38,633.93	21,921.93	1,520,799	251,172.36	212,538.44	120,600.02
6		38,633.93	38,633.93	19,573.15	1,551,653	258,784.47	220,150.54	111,535.12
7		38,633.93	38,633.93	17,476.03	1,580,338	266,113.49	227,479.56	102,900.20
8		38,633.93	38,633.93	15,603.60	1,666,091	279,981.24	241,347.32	97,476.13
9		38,633.93	38,633.93	13,931.78	1,694,372	287,751.43	249,117.51	89,834.27
10		38,633.93	38,633.93	12,439.09	1,722,790	295,614.83	256,980.91	82,740.97
11		38,633.93	38,633.93	11,106.33	1,749,415	303,361.85	264,727.92	76,102.95
12		38,633.93	38,633.93	9,916.37	1,783,553	312,285.54	273,651.62	70,239.55
13		38,633.93	38,633.93	8,853.90	1,816,346	321,828.68	283,194.76	64,900.93
14		38,633.93	38,633.93	7,905.27	1,843,557	330,295.85	291,661.92	59,679.81
15		38,633.93	38,633.93	7,058.27	1,868,262	338,559.43	299,925.50	54,795.27
16		38,633.93	38,633.93	6,302.03	1,927,092	351,362.09	312,728.17	51,012.74
17		38,633.93	38,633.93	5,626.81	1,945,328	359,204.01	320,570.08	46,689.22
18		38,633.93	38,633.93	5,023.94	1,972,015	368,506.14	329,872.21	42,896.45
19		38,633.93	38,633.93	4,485.66	1,999,226	378,225.57	339,591.65	39,428.89
20		38,633.93	38,633.93	4,005.05	2,026,659	387,789.09	349,155.16	36,195.79
21		38,633.93	38,633.93	3,575.94	2,045,145	396,631.06	357,997.14	33,136.08
22		38,633.93	38,633.93	3,192.80	2,080,342	407,715.87	369,081.94	30,501.86
23		38,633.93	38,633.93	2,850.72	2,098,008	416,751.00	378,117.07	27,900.49
24		38,633.93	38,633.93	2,545.28	2,121,940	427,039.80	388,405.88	25,589.00
25		38,633.93	38,633.93	2,272.58	2,129,051	430,574.60	391,940.67	23,055.25
26		38,633.93	38,633.93	2,029.09	2,144,556	435,219.53	396,585.60	20,829.00
27		38,633.93	38,633.93	1,811.68	2,159,295	439,832.17	401,198.25	18,813.62
28		38,633.93	38,633.93	1,617.57	2,181,734	445,507.23	406,873.30	17,035.49
29		38,633.93	38,633.93	1,444.26	2,189,633	449,366.07	410,732.14	15,354.51
30		38,633.93	38,633.93	1,289.52	2,203,103	454,009.88	415,375.96	13,864.39
31		38,633.93	38,633.93	1,151.36	2,219,971	459,171.37	420,537.44	12,532.74
32		38,633.93	38,633.93	1,028.00	2,239,682	464,790.07	426,156.14	11,339.45
33		38,633.93	38,633.93	917.86	2,244,261	468,431.84	429,797.91	10,211.03
34		38,633.93	38,633.93	819.51	2,256,640	473,188.57	434,554.64	9,217.89
35		38,633.93	38,633.93	731.71	2,267,563	477,807.67	439,173.74	8,317.74
36		38,633.93	38,633.93	653.31	2,286,829	483,658.35	445,024.42	7,525.49
37		38,633.93	38,633.93	583.31	2,292,078	487,608.90	448,974.97	6,778.84
38		38,633.93	38,633.93	520.82	2,305,428	492,765.40	454,131.47	6,122.05
39		38,633.93	38,633.93	465.01	2,319,020	498,027.64	459,393.72	5,529.45
40		38,633.93	38,633.93	415.19	2,338,671	504,246.33	465,612.41	5,003.84
41		38,633.93	38,633.93	370.71	2,342,322	508,197.40	469,563.48	4,505.63
				3,694,043.53			**NPV**	**(1,524,773.40)**

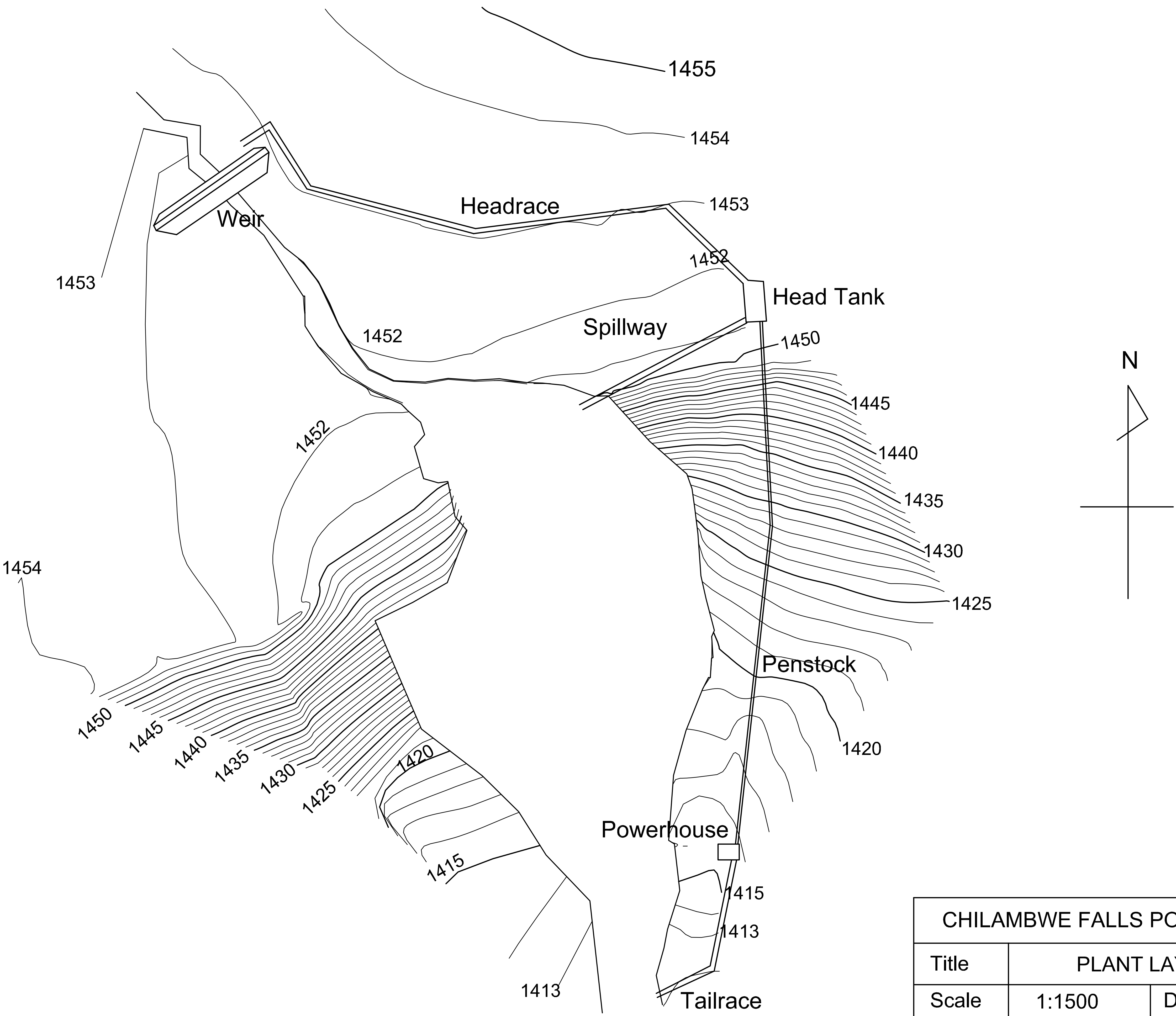
Table 12-25 Financial Statements of Case B-3

FIRR = 2.20%
Discount Factor = 12.00%

Year	Capital Costs US$	Operational costs US$	Total Cost US$	Present Cost US$	Power Supply MWh	Revenues US$	Net Revenue US$	Net Present Value US$
0	951,651		951,650.94	951,650.94			(951,650.94)	(951,650.94)
1	1,903,302		1,903,301.88	1,699,376.68			(1,903,301.88)	(1,699,376.68)
2	951,651	38,633.93	990,284.87	789,449.04	1,434,037	118,825.67	(871,459.20)	(694,721.93)
3		38,633.93	38,633.93	27,498.87	1,462,543	121,443.75	82,809.82	58,942.39
4		38,633.93	38,633.93	24,552.56	1,494,591	124,191.77	85,557.84	54,373.55
5		38,633.93	38,633.93	21,921.93	1,520,799	127,111.80	88,477.87	50,204.72
6		38,633.93	38,633.93	19,573.15	1,551,653	130,289.35	91,655.42	46,435.49
7		38,633.93	38,633.93	17,476.03	1,580,338	133,020.72	94,386.79	42,695.79
8		38,633.93	38,633.93	15,603.60	1,666,091	144,783.18	106,149.25	42,871.90
9		38,633.93	38,633.93	13,931.78	1,694,372	148,312.65	109,678.72	39,551.25
10		38,633.93	38,633.93	12,439.09	1,722,790	151,238.30	112,604.37	36,255.59
11		38,633.93	38,633.93	11,106.33	1,749,415	153,834.67	115,200.74	33,117.46
12		38,633.93	38,633.93	9,916.37	1,783,553	157,090.85	118,456.93	30,404.94
13		38,633.93	38,633.93	8,853.90	1,816,346	162,507.60	123,873.68	28,388.65
14		38,633.93	38,633.93	7,905.27	1,843,557	165,613.99	126,980.06	25,982.64
15		38,633.93	38,633.93	7,058.27	1,868,262	168,652.43	130,018.50	23,753.89
16		38,633.93	38,633.93	6,302.03	1,927,092	180,782.56	142,148.63	23,187.52
17		38,633.93	38,633.93	5,626.81	1,945,328	183,704.44	145,070.51	21,128.70
18		38,633.93	38,633.93	5,023.94	1,972,015	187,461.51	148,827.58	19,353.48
19		38,633.93	38,633.93	4,485.66	1,999,226	191,932.80	153,298.87	17,799.04
20		38,633.93	38,633.93	4,005.05	2,026,659	195,434.53	156,800.61	16,255.01
21		38,633.93	38,633.93	3,575.94	2,045,145	199,357.75	160,723.83	14,876.53
22		38,633.93	38,633.93	3,192.80	2,080,342	210,161.14	171,527.21	14,175.44
23		38,633.93	38,633.93	2,850.72	2,098,008	213,544.29	174,910.37	12,906.28
24		38,633.93	38,633.93	2,545.28	2,121,940	218,247.96	179,614.03	11,833.35
25		38,633.93	38,633.93	2,272.58	2,129,051	217,738.55	179,104.63	10,535.53
26		38,633.93	38,633.93	2,029.09	2,144,556	218,018.76	179,384.84	9,421.44
27		38,633.93	38,633.93	1,811.68	2,159,295	224,571.62	185,937.69	8,719.28
28		38,633.93	38,633.93	1,617.57	2,181,734	225,094.92	186,460.99	7,806.99
29		38,633.93	38,633.93	1,444.26	2,189,633	224,718.70	186,084.77	6,956.46
30		38,633.93	38,633.93	1,289.52	2,203,103	224,338.76	185,704.83	6,198.44
31		38,633.93	38,633.93	1,151.36	2,219,971	225,611.38	186,977.45	5,572.25
32		38,633.93	38,633.93	1,028.00	2,239,682	232,158.41	193,524.49	5,149.43
33		38,633.93	38,633.93	917.86	2,244,261	231,359.43	192,725.50	4,578.72
34		38,633.93	38,633.93	819.51	2,256,640	231,759.10	193,125.18	4,096.62
35		38,633.93	38,633.93	731.71	2,267,563	231,400.32	192,766.40	3,650.91
36		38,633.93	38,633.93	653.31	2,286,829	237,543.01	198,909.08	3,363.61
37		38,633.93	38,633.93	583.31	2,292,078	236,860.02	198,226.10	2,992.91
38		38,633.93	38,633.93	520.82	2,305,428	236,998.48	198,364.55	2,674.11
39		38,633.93	38,633.93	465.01	2,319,020	237,100.48	198,466.55	2,388.83
40		38,633.93	38,633.93	415.19	2,338,671	242,708.77	204,074.85	2,193.15
41		38,633.93	38,633.93	370.71	2,342,322	242,282.88	203,648.96	1,954.08
				3,694,043.53			**NPV**	**(2,593,003.18)**

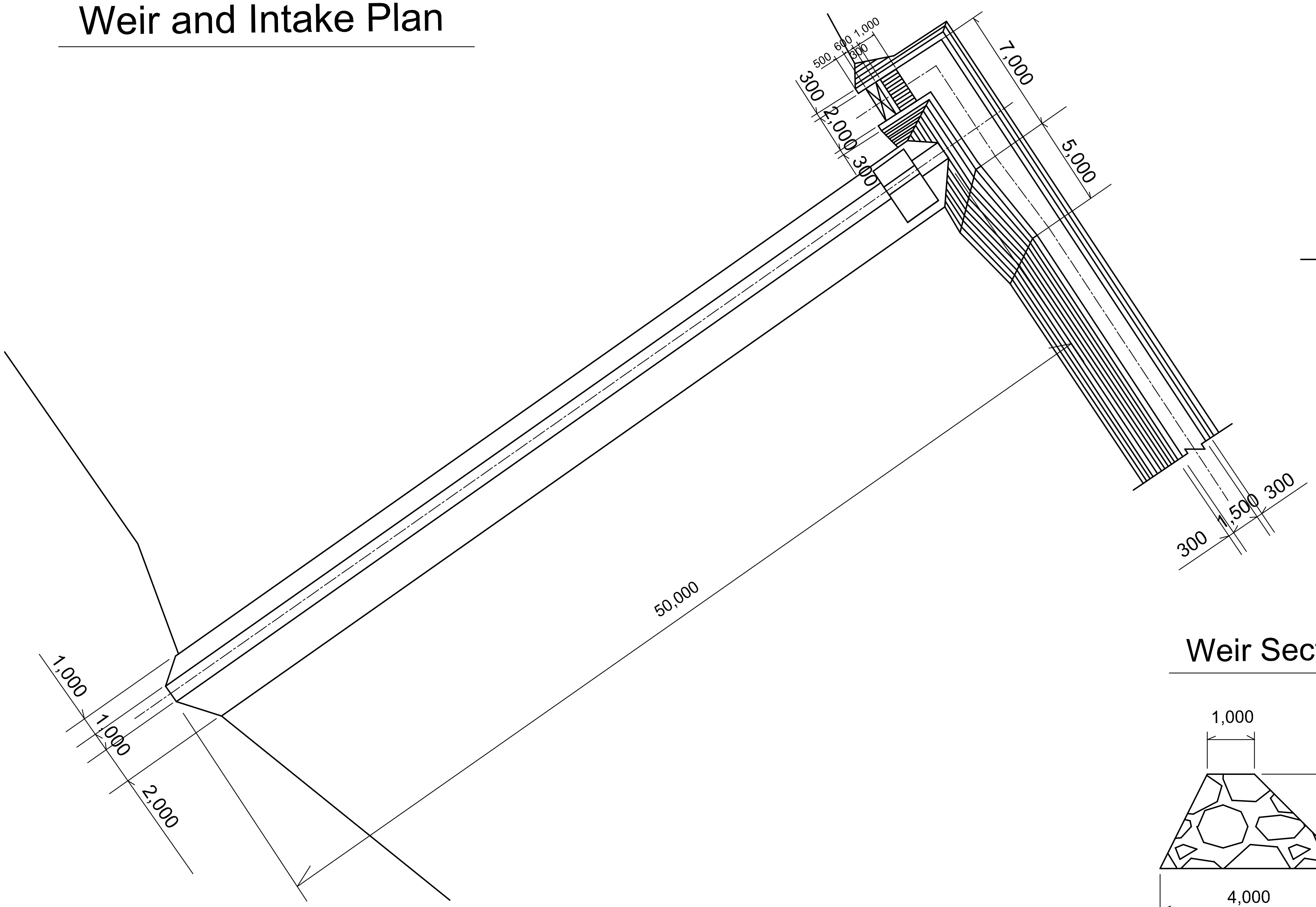
(6) Drawings

Followings are the drawings of Chilambwe Falls site.

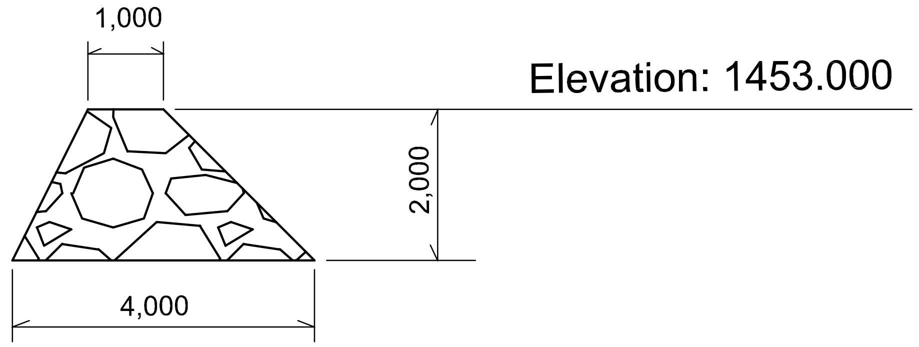


CHILAMBWE FALLS POWER STATION			
Title	PLANT LAYOUT		
Scale	1:1500	DWG No.	CBF-1
TEPCO JICA STUDY TEAM		16-JAN-2008	

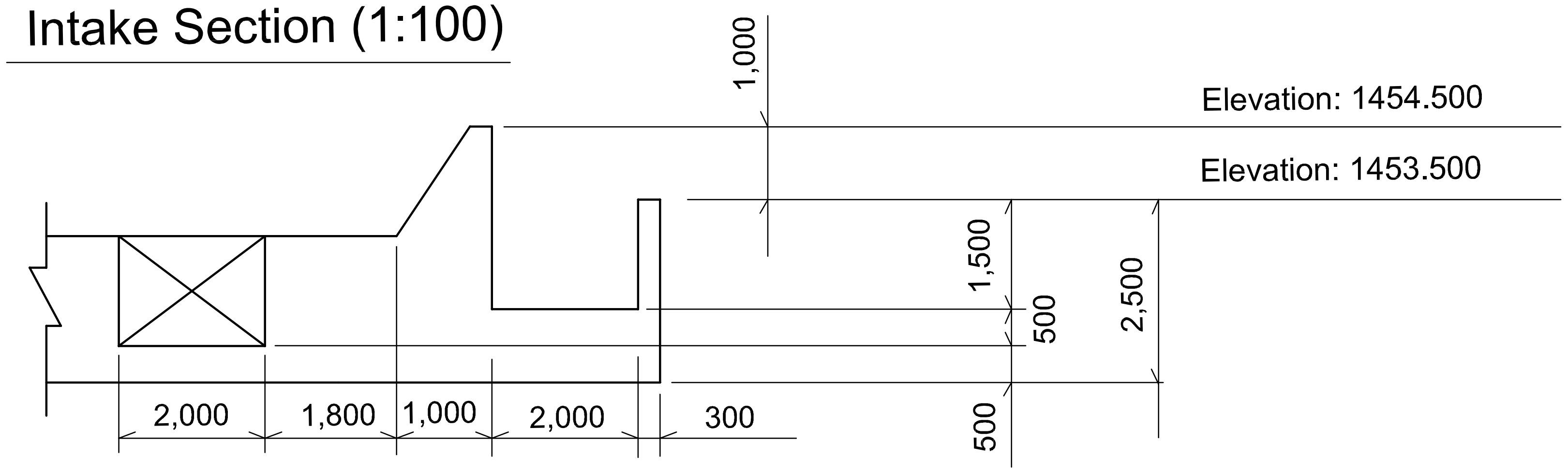
Weir and Intake Plan



Weir Section (1:100)

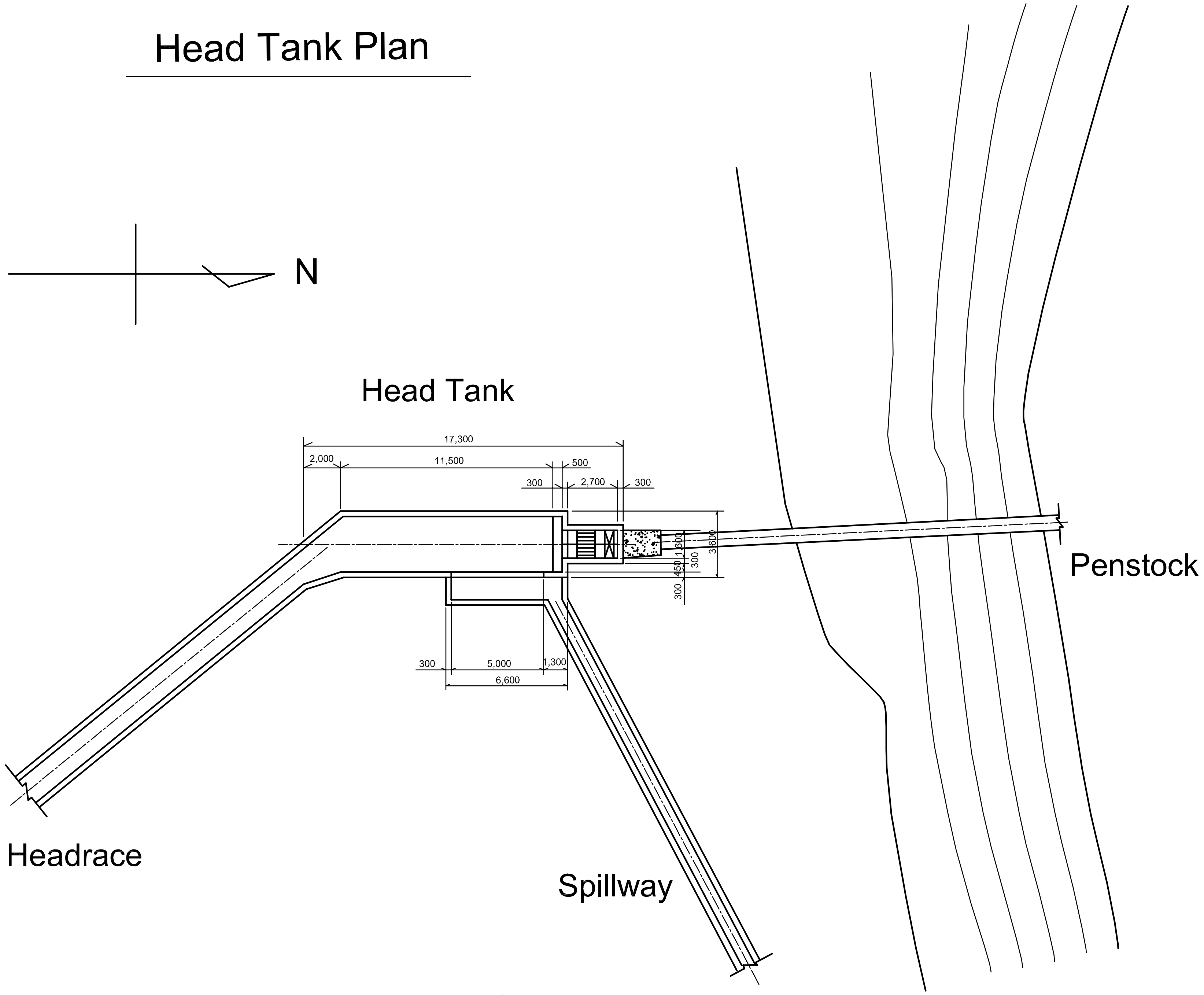


Intake Section (1:100)

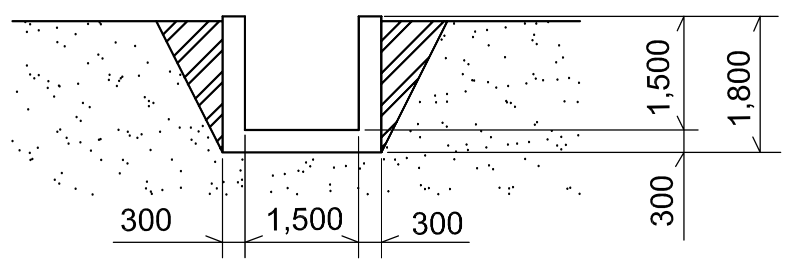


CHILAMBWE FALLS POWER STATION			
Title	WEIR AND INTAKE		
Scale	1:250	DWG No.	CBF-2
TEPCO JICA STUDY TEAM		16-JAN-2008	

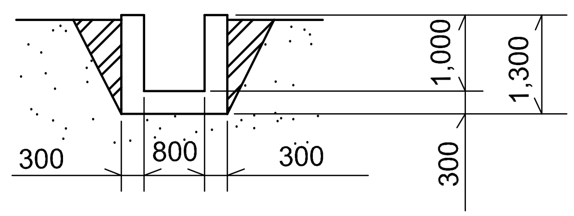
Head Tank Plan



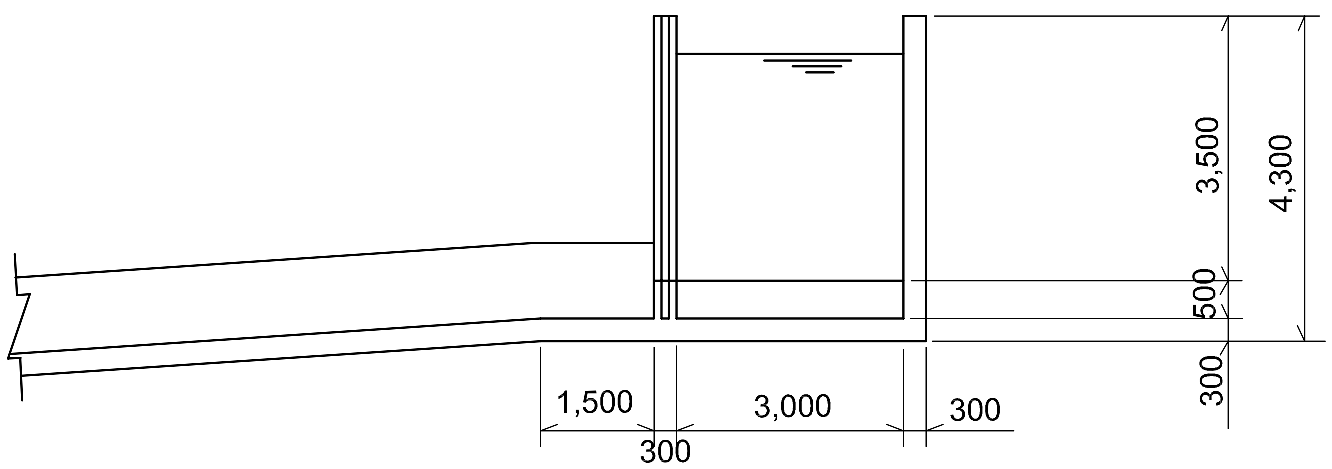
Headrace Section (1:100)



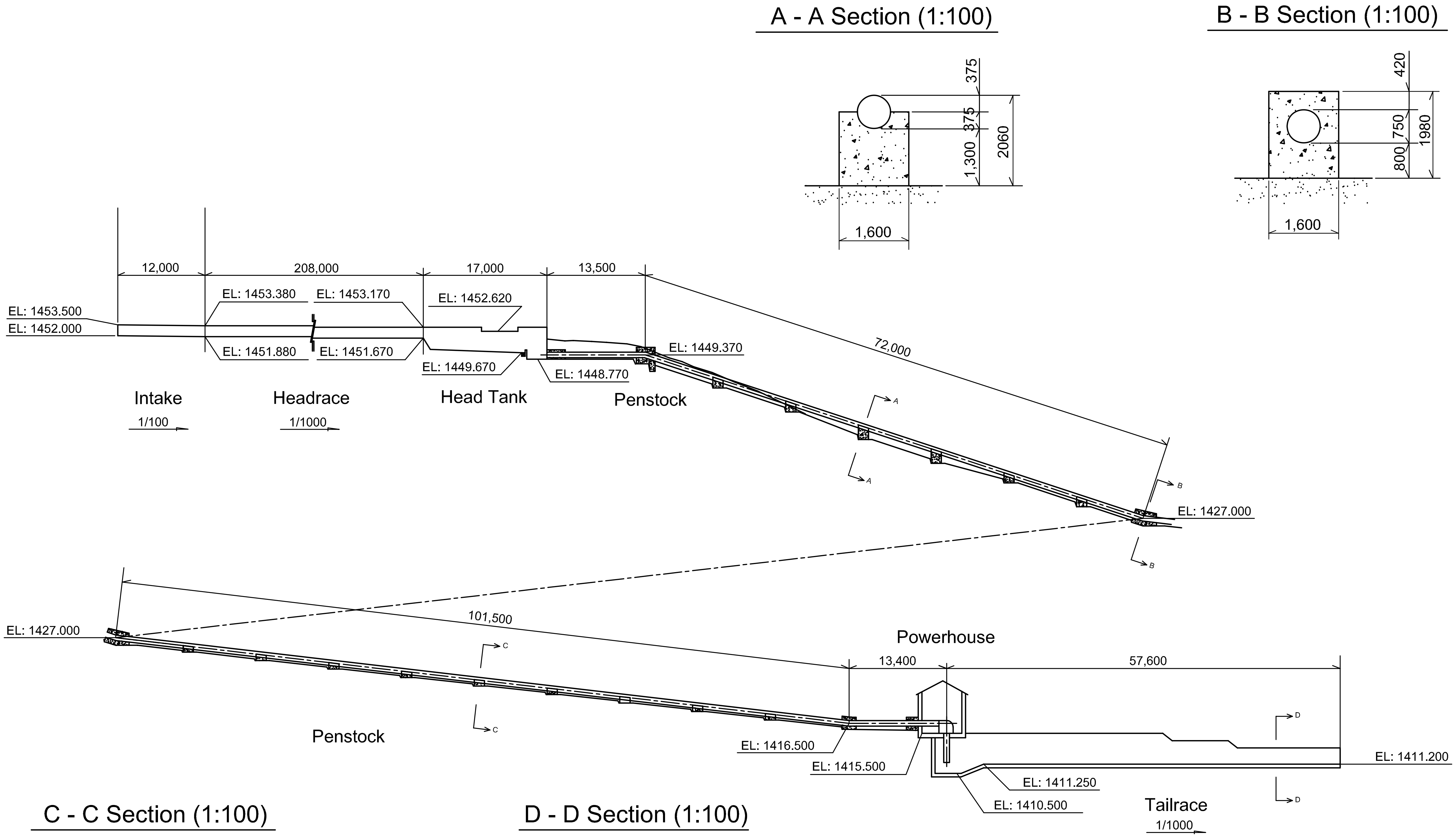
Spillway Section (1:100)

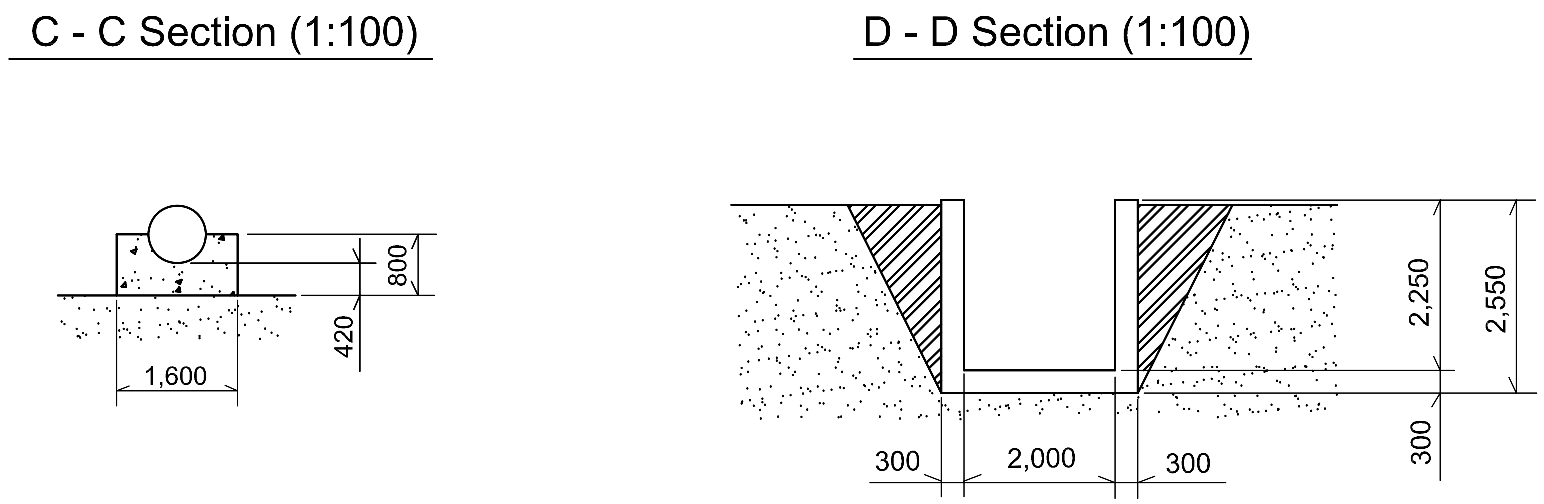


Headrace Section (1:100)



CHILAMBWE FALLS POWER STATION			
Title	HEAD TANK		
Scale	1:300	DWG No.	CBF-3
TEPCO JICA STUDY TEAM		16-JAN-2008	





CHILAMBWE FALLS POWER STATION			
Title	WATER WAY SECTION		
Scale	1:600	DWG No.	CBF-4
TEPCO JICA STUDY TEAM		16-JAN-2008	

12.2.5. Proposed Method of Hydropower Plant Management

Here The Study Team proposes an approache to the management of small hydropower plant in rural areas.

The easiest way of the plant management would be for REA to own the plant and to outsource all plant management to an experienced company such as ZESCO. The plant manager would collect the service revenues and transfer the money to the REA. Then REA would reimburse the management fee to the company and provide funds for purchasing spare parts. The remainder would be kept in the Rural Electrification Fund to meet the costs of future capital replacement costs.

It would be ideal if plant management were the responsibility of the local community. Such a community could handle all the works such as plant operation, maintenance, revenue collection, accounting, security and so on.

But in reality it is difficult to implement this idea especially in the initial stage of electrification. Therefore, the Study Team recommends establishing the structure shown in Table 12-26. Key personnel such as the Manager and Accountant should be seconded by REA, and at least one skilled electrical engineer, to supervise the daily operations, maintenance, and troubleshooting, should be hired by REA. It is desirable that a skilled Mechanical Engineer and a Civil engineer are also resident, but part-time working would be sufficient if the permanent Electrical Engineer had basic skill and knowledge for civil and mechanical facilities. Two sub-accountants and four operators (at least) should be selected from the local residents. Sub-accountants help the Manager and the Accountant. Operators work on a three-shift-a-day basis, which means one of them stays in the plant 24 hours 365 days (three work for 8 hours in turn and one is off), and curry out the daily operation and also have a responsibility for the plant security. If the local residents are very cooperative, it is recommended expanding the number of operators to eight and forming four Operation Couples to be engaged in 8 hours shift work.

The most important thing is, of course, that the local residents should acquire the skills and knowledge of accounting and O&M through On the Job Training, and the REA staff and Outsourced Engineers hand over their responsibilities to talented local residents. In this way, the plant would be managed sustainably without relying on the REA. The Study Team estimates that the REA would need to take care of the plant with its permanent staff for at least three years.

Finally, the Study Team strongly recommend that some periodical checking function especially for revenue and expenditure should be remained and also assistant structure for serious trouble should be established in REA continuously.

Table 12-26 Proposed Staff Members of Hydropower Plant

	No.	Working Form	Status
Manager	1	Day shift	REA
Accountant	1	Day shift	REA
Sub-accountant	2	Day shift	Local
Electrical Engineer	1	Day shift	Outsource
Mechanical Engineer	1	Temporary/Periodical	Outsource
Civil Engineer	1	Temporary/Periodical	Outsource
Operator	4(8)	Shift work	Local

12.2.6. Capacity Development

Some counterparts from DoE and REA accompanied the Study Team during the whole Hydropower Potential Surveys and Detailed Surveys (Case Studies) period, and the following techniques have been transferred:

- Topographic survey
- River flow measurement
- Method for converting an existing river flow data into the river flow data at specific site
- Hydropower potential estimation
- Basic design of hydropower plant layout
- Social survey

12.3. Preliminary Environmental Impact Assessment (EIA) Activities

As a part of case studies, the Study Team in collaboration with Counterpart conducted preliminary environmental impact assessment activities and produced relevant environmental clearance documents (PBs) at the later stage of the Study for the purpose of capacity development.

12.3.1. Targets of Studies

The Study Team selected two mini-hydropower project sites and their surrounding areas and the areas along the associated 33kV distribution line. These targets were selected based on the mini-hydropower potential survey conducted in North-western, Luapula, and Northern Provinces, respectively. The followings are the description of the two project sites.

(1) Mujila Falls Lower Mini-Hydropower Station Site

The proposed Mujila Lower mini-hydropower station is located about 50km east of Mwinilunga town. It is about 2km off district road number RD 277 on the Mujila River. The proposed power plant is located about 50m from the weir site. The project component has a distribution network of 33kV lines from the power plant to various schools, health centres and traditional administrative centres at Kanyama and Kakoma. Figure 12-5 outlines the location of the Mujila Lower Fall Power Plant and its associated distribution network.

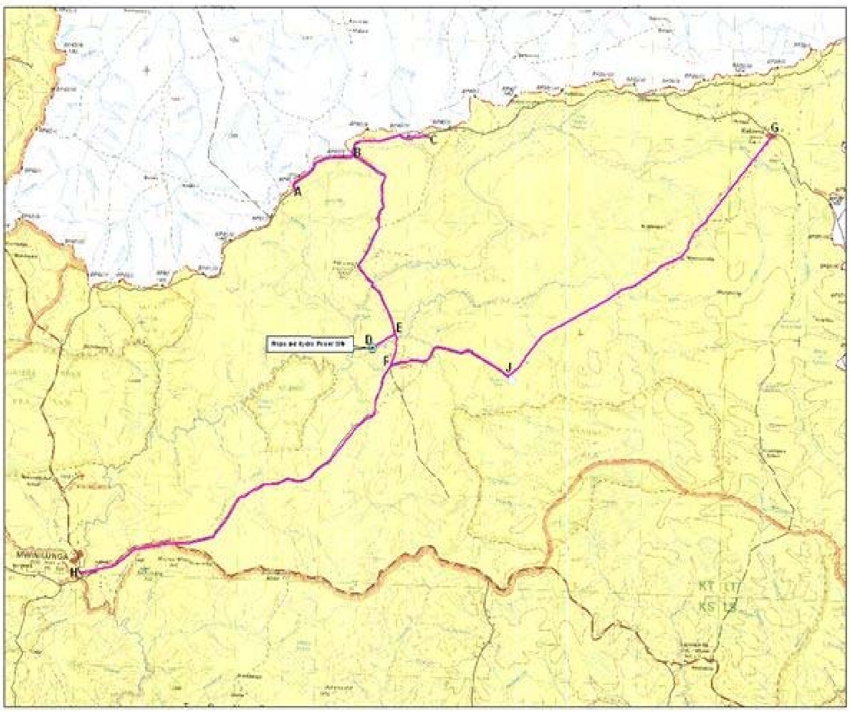


Figure 12-5 Location of Mujila Mini-Hydropower Station and proposed electricity grid

(2) Chilambwe Falls Mini-Hydropower Station Site

The proposed Chilambwe falls mini-hydropower station is located about 80 km North of Kasama town. It is a 20 km distance on the Kasama – Luwingu road and is 57 km on the D20 Mpororkoso road to Chilambwe falls turn off in Philipo Village. The distance from the turn off to the falls is approximately 2 km.

Figure 12-6 outlines the location of the Chilambwe Falls Power Plant and its associated distribution network.

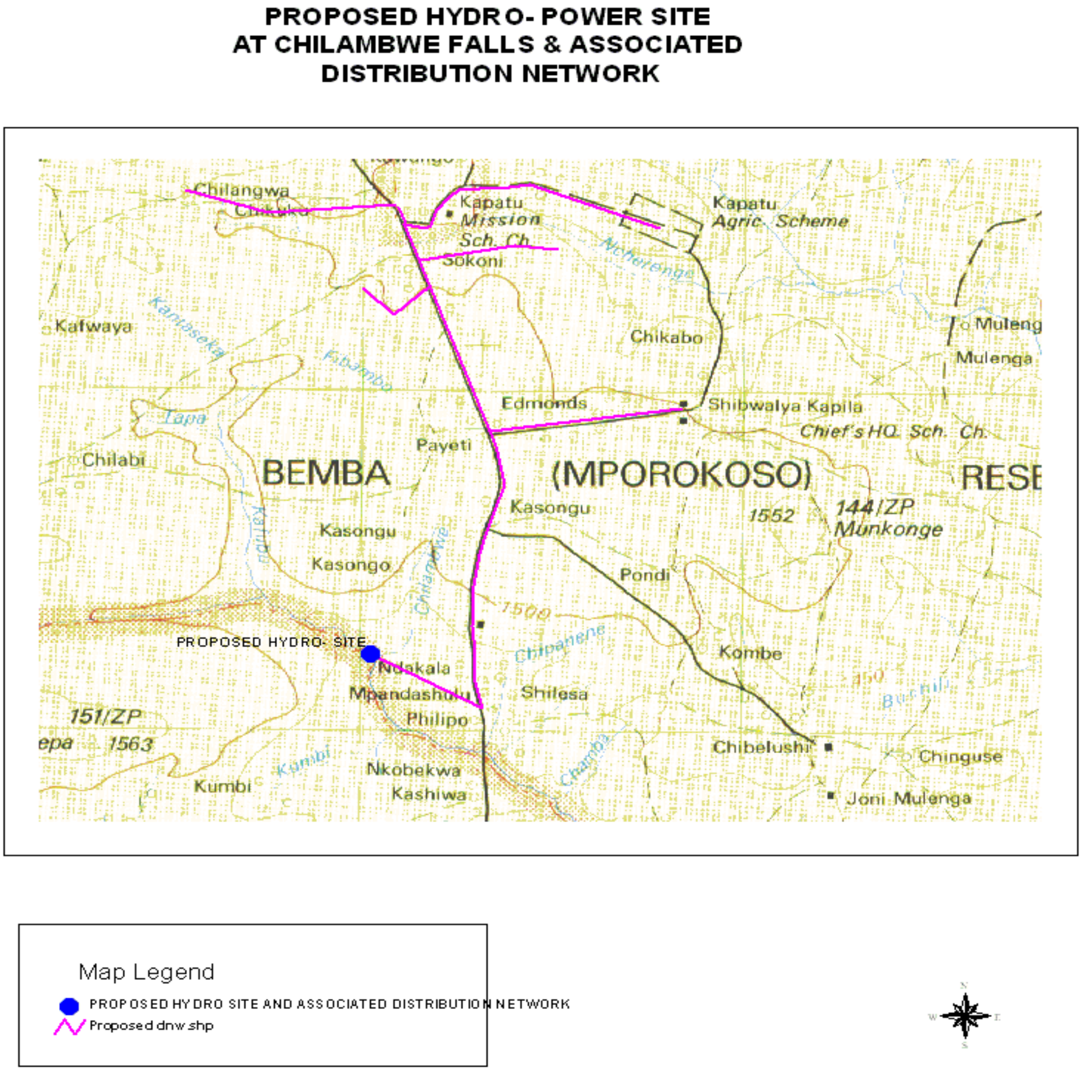


Figure 12-6 Location of Chilambwe Falls Mini-Hydropower Station and proposed electricity grid

Table 12-27 shows the outlines of both Mujila Falls Lower and Chilambwe Falls mini-hydropower projects, respectively.

Table 12-27 Outline of Mujila Falls Lower and Chilambwe Falls mini-hydropower projects

Name	Mujila Falls Lower	Chilambwe Falls
Province	North-western	Northern
Location	S11° 30′ 51.6″ E24° 46′ 23.9″	S09° 49′ 58″ E30° 43′ 26″
Catchment Area	1,146km^2	175km^2
Discharge 80% of time	9.21m^3/s	—
Design Discharge	10.4 m^3/s	0.85 m^3/s
Effective Head	17.1m	36.9m
Generation Capacity	1,400kW	300kW
Length of Channel	284m	208m
Length of Penstock	20m	200m
Length of Tailrace	10m	55m
Length of Spillway	36m	45m
Length of Weir	35m	50m
Height of the Weir	5m	2m
Length of 33kV Line	85km	34km

12.3.2. Survey Items

The study team conducted field studies for both the proposed sites for the mini-hydro power stations and their associated distribution networks to collect information on physical, biological, and socio-economic environment, respectively, then identified potential impacts on these environments. The information collected included:

(1) Physical

Location of the project, climate, topography, soils and geology, hydrology, wetlands, water quality, air quality, noise level, waste management, and landscape

(2) Biological

Flora (woody plant, and understory plant) and fauna (mammals, reptiles, birds, and fish), vegetation, protected areas (National Parks, and Forest Reserves)

(3) Socio-economic

Population, settlements, agricultures and fisheries, local economy, mining, energy, water and sanitation, health, education, employment, infrastructure and social services, archaeological and cultural, and tourism

12.3.3. Methodology

Literature review, scoping, data collection, and public consultation with the Chief and people in the villages in the project areas, and government officers in schools, health centers and agricultural officers in the project areas were conducted to recognize principal environmental problems anticipated.

12.3.4. Description of the Present Environment

(1) Mujila Falls Lower Mini-Hydropower Station Site and areas around the associated 33kV distribution line route

Physical Environment

Climate

Mwinilunga is located in the third agro-ecological region of the country. In this Zone, the rainfall is over 1000mm in a season. Mwinilunga area in particular has average annual rainfall of 1402mm which occurs in about 142 rainy days. The rainfall mainly commences in the month of September and ends in the month of May. The temperatures in this area are moderate with the minimum temperatures of around 6.50C occurring in the month of July while the maximum temperature of around 31.00C occurring in the month of October.

Topography

The study area is generally hilly and gently undulating with some low lying areas. The power plant and weir will be located in a gorge downstream and upstream of Mujila Lower Falls, respectively. The general topography ranges from 1350m above sea level for low lying areas to 1450m above sea level in hilly areas. Moderate and undulating areas occur in the 1400m above sea level topography ranges. Within the gorge which forms the Mujila Lower Falls, steep slopes are a common characteristic of the hills. The general pattern is that the wider parts of the river valleys form wetland type of marshes characterized with grasslands. These are the normal flooding zones when the river flows are at peak flood flows.

Soils and Geology

Soil types in the study area differ from upland to low lying areas: in low lying areas (the valley floors) soils are poorly drained to very poorly drained , very deep, grayish brown to grey, slightly firm, fine loamy to clayey soils with humic top soils (orthic-dystric GLEYSOLS). Soils in upland areas are predominantly Kanyama Series that are some what excessively drained, very deep, very pale brown to yellowish brown, loose to very friable sandy soils (orthic-ferralic ARENOSOLS).

The soils in the study area are mainly derived from acidic rocks that are rich in various minerals such as iron and copper.

Hydrology

The study area is endowed with unpolluted water bodies such as the West Lunga River with its tributaries such as the Mujila River, Kapundu, Mundwiji, and others. Most of the streams are perennial while some recharge zones known as dambos are wide spread in the headwaters and the sides of streams. The presence of dambos account for the high base flows that the rivers in this region have. This confirms their perennial nature even in the years when rainfall is below normal, such as drought years. The dambos are key features that also provide much needed rich breeding grounds for most of the fish found in the area. The side stream dambos are a key feature providing the much needed riverine flood control in this high rainfall area. This means that at peak flood flows, the river would overflow its banks and flood the side stream dambos to reduce the amount of water the river is carrying. The water is then released slowly back to the river when the water level goes down.

Wetlands

Dambos form the main type of wetlands in the study area. There are two types of dambos, the head water dambos and the side stream dambos. The headwater dambos are mainly found at the sources of the streams and the various tributaries while the side stream dambos are found in low laying areas of the river systems. The headwater dambos act as temporal storage for runoff at peak flows and recharge the streams slowly through out the year. The side stream dambos areas are key for flood control as they are able to act as temporal storage for peak flood river flows. Lake Chibeshya is one such head water wetland which is a good tourist attraction.

Water Quality

Water sources in the study area for both domestic and agricultural use, are mainly from surface (stream run off) and underground (wells and boreholes). The water quality in the study area, especially surface water can be said to be of good quality. Both domestic animals and humans use water from streams and dambos for drinking. The baseline data on water quality indicate that the water quality is good for domestic and other uses.

Air Quality

The air quality in the area is generally and naturally good since there are no gas emitting industries nor construction activities. The proposed site for the mini-hydropower station is located in an isolated place away from major settlements. The site is in a gorge where the air quality is good and the area has pristine vegetation. The expected area of inundation upstream of the weir is likely to be disturbed during construction but would soon be filled with water suppressing any dust emissions.

Noise Level

The location of the proposed project site is in a gorge where the main source of noise is the water falls at Mujila Lower Falls. Natural noise levels are generally low in the area. However, it is anticipated that during construction, there will be noise from construction equipment.

Protected Area (National Parks and Forest Reserves)

The proposed site for the Mujila Lower Mini-hydro power station is in a gorge and in an area that is under traditional land ownership system. The nearest protected area, the Kalenga PFA No. 95, is located several kilometers west of the proposed site for the mini-hydro and associated distribution network.

Waste

Waste management in the study area vary from locality to locality. The well-established theological training centres, clinics and schools, use appropriate waste pits and some incineration facilities. However, traditional practices of waste dumping and burning are common in villages. Use of pit latrines is common in the study area although the standard and quality differ from place to place.

Landscape

The Mujila site is located in a gorge and is rarely noticed from the access road to the Discipleship Centre. The weir site too is in a gorge upstream of Mujila Lower Falls.

Biological Environment

Flora

The vegetation in Mwinilunga is quite intact compared to other areas in the province. This can be attributed to the high regeneration rates due to the high rainfall and rich soils in the area. The other reason for the intact forests is the people’s reliance on dry dead wood and not charcoal for their energy needs.

The sawmilling business in the area is also relatively new and therefore, the forests have not yet been exploited.

The vegetation between Mwinilunga District Administrative Centre and the project area forms a thick, three-storeyed forest with a closed evergreen canopy comprising either Parinari or Marquesia species or both existing together. A few open areas are predominantly miombos comprising Jubernardia, Isoberslinia and Brachystegia species. Some sections around the high areas of Mujila are purely Uaapaca forest with a few miombo species.

Common hard wood tree species harvested by the local community include: Pterocarpus angolensis, Guibourtia coleosperma, Faurea intermedia, F. saligna, Afzelia quanzensis (Pod Mahogany), Swartzia madagascariensis, Burkea africana, Pericopsis angolensis, etc.

Charcoal production is not common in the area. Tree cutting for domestic use is done mainly for brick kilns and construction of houses, canoes, furniture, hoe and axe handles and other utensils.

Mujila River is characterized by fast flowing waters and a rich riverine forest. The common plants growing around the river are palms like Phoenix reclinata, and Raphia farinifera, ferns such as Royal fern (Osmunda regalis), Bog scaly lady fern (Thelypteris confluence), and various types of grasses.

Riverine trees that are prominent in the project area include Syzygium cordatum, Syzygium guineense ssp afromontanum, S. owariense, Gardenia imperialis, Rothmmania whitfieldii and Swatrzia madagascariensis.

Due to its meandering nature, Mujila River forms a number of small islands. Most of these islands are sandy and are covered with soft broomy grass. The common tree species on the sandy islands is Gardenia imperialis which in most cases look rather stunted. A sedge like plant that produces red fruit locally known as intungulu, is also common on the islands.

Figure 12-7 and Figure 12-8 show the typical miombo woodland found in the area and the riverine riparian thickforests along the river channels, respectively.

Figure 12-7 Typical Miombo woodland vegetation in the study area

Figure 12-8 Riverine riparian forests along the Mujila stream

Fauna

Traditionally and from time immemorial the people of North-Western Province have been hunters of wildlife. However, following the Government's development of wildlife policies and strict hunting regulations after independence, hunting of wildlife in many parts of the country is now controlled. The establishment of the Zambia Wildlife Authority (ZAWA), a more efficient and semi autonomous body compared to the National Parks and Wildlife Services, has also contributed to the conservation of wildlife in many parts of Zambia.

The project area has remained undisturbed over the years, however, large game such as elephants, do not exist any more in the area. The common mammals found in the study area are antelopes such as Waterbuck, Duiker, Baboons, Monkey, Hippos and various species of rodents such as cane rats.

Reptiles in the project area include Crocodile, Water monitor, Snakes such as Spitting Cobra, Puff adder, Black mamba, Python, green tree snake. Others are common lizards, Chameleon, Blue headed lizards and others.

The project area is a good water fowl habitat. Birds enjoy the nectar rich vegetation alongside the fresh waters. The common birds noticed in the area include the Fish eagle, Sun bird, Cuckoo, King Fisher and owls.

There are no National Parks in the Project area.

Socio-economic Environment

Population

According to the Mwinilunga district office of the Central Statistics office (CSO) estimated the population to be 124, 485. The male comprise of 59, 753 (48%) of the population and female 64, 732 (52%). The population density of the area is 6 people per square kilometer. The study area start about 40.0km from the main town of Mwinilunga and has a population of 7, 920, which was estimated by using the population catered by Kanyama clinic and information from the Ward Councilor.

Settlements

Mwinilunga town is a planned and zoned area into residential and commercial/offices and has settlements in the rural parts of the districts that are organized in form of villages. A village is made up of many households living in a defined geographical area under the leadership of a headman. A group of villages in a defined geographical area make up a chiefdom that is headed by a chief. The project area has 48 settlements all in Chief Kanyama's village. The project area is located on land that belongs to the Lunda speaking people of Mwinilunga district and under Chief Kanyama. The power distribution network however, is expected to be extended to Chief Kakoma's area where a rural load centre was also identified.

Agriculture and Fisheries

Agriculture is the most predominant and important economic activity in the study area, though it is mainly at subsistence level. Most people grow crops for their livelihood and to sale. The crops that are grown for commercial purposes are maize, cassava, beans and pineapples. Chitemene system of agriculture (see Figure 12-9) is also practiced though minimal. Chitemene system is used to grow Finger Millet, which is mostly used to brew beer. Rice and sweet potatoes are also grown on a small scale. In addition, fruit trees such as mango, avocado, guava, lemon, orange and banana are also grown on a small scale. Although production in the district is low, there is great potential for increasing agricultural production. The abundant water in streams, dambos and wetlands can support large-scale irrigation farming.

Figure 12-9 Typical Chitemene system of agriculture

There is some emerging commercial farming in the project area with most farmers getting good maize harvests. The agricultural activities are being spearheaded by the local Chief in the area. Some of the people combine crop farming with rearing of livestock such as cattle, sheep, pigs, goats, village chickens and guinea fowls.

Fishing activities are also significant in the project area since River Mujila and other streams in the area have a wide variety of fish species. There are different species in the river channel along the study area. The dominant ones are also of commercial value and these include; Snake

Barbel (Clarias theodorae), Silver barbel (Shilbe mystus), Blunt toothed barbel (Clarias mellandi), Squaker (Syndontis macrostigma), stripe tailed citharinid (Alestes lateralis), Red breasted bream (Tilapia rendalli), Oreochromis niloticus, Salmon (Anguilla nebullosa labiata), Three spotted bream (Oechromis anersonnii), Mpumbu (Labeo ativelis), Pike (Hepsetus odoe), Parrot fish (Gnathonenus macroleptus), Banded bream (Tilapia sparmannii), Dwarf bream (Haplochronis philander), Climbing perch (Ctenopoma multispine), English eel (Mastasembals mellanchi) , Green headed bream, (Oreochromis machrochir), and Marcusenius macrolepidotus.

Local Economy

The economy of the project area depends largely on farmers who produce maize, cassava, beans and millet and a few civil servants in the Ministries of Agriculture, Health and Education. Other activities that generate income or contribute to the local economy are honey production, handicrafts, timber, bricklaying and fishing. Even though the project is not very big but it is expected to have some improvement in the income levels and in turn, the standard of living. There is great potential in the area in mining, fishing, carpentry, welding, tourism and many others.

Mining

The area is rich in minerals though not fully utilized. The minerals mined in this area are: copper, iron and amethyst.

Energy

The residents of Kanyama village largely depend on firewood and charcoal for energy for cooking and heating. The rural health center, Kanyama clinic and some basic schools use solar panels for their energy requirements, but most of these solar panels are non functional as they have been either vandalized (some components stolen) or batteries discharged and are not working. Isolated places such as the United Methodist Mujila Agricultural Centre, use a combination of solar and diesel generators for energy, especially for water pumping.

Water and Sanitation

Mwinilunga is endowed with abundant water supplies since it is in the equatorial region that is an extension of the rain forest of Congo. Many villages are located near streams and this enhances easy accessibility to water. Villages largely depend on water from the streams and rivers in the area. The water is used for drinking and other domestic uses such as cooking, washing, bathing and watering their gardens along the riverbanks. Despite the abundance of water, accessibility to safe water still remains a challenge.

A number of houses have pit latrines and bathing shelters that are constructed of local materials with thatched roofs. Use of open bush is common in villages without pit latrines.

Health

Kanyama village has one major clinic, Kanyama clinic, which is the second largest from the main District Hospital in Mwinilunga. Kanyama clinic has a medical officer and a nurse with other daily employees. The clinic used to rely on solar panels but the batteries are no longer working. The clinic relies on fuel wood for heating to sterilize equipment and candles for light. There are a number of rural health centers in the area Kapundu and Muuwa centers which also rely on solar panels distributed by the Ministry of Health. The area also has health posts, namely; Nyangala, Nyaminkanda and Chanuvu.

Common diseases in the project area are; malaria, diarrhea, upper respiratory trunk infection, pneumonia, malnutrition and sexually transmitted diseases (STIs) especially among young people. The village has not reported any HIV/AIDS cases as there are no screening facilities hence there is no definite information regarding the magnitude of the problem. The area does get

Voluntary Counseling and Testing (VCT) conducted by a mobile clinic, which comes from the Mwinilunga Hospital when requested upon by the clinic in Kanyama.

The clinic also has provided Traditional Birth Attendants (TBA) to help pregnant women to deliver. The clinic lacks mid wives and nurses and has no maternity ward. The bed space is also limited from the 25 beds there are only 10 in good condition. The infant mortality and mortality rate is quite low in this area and they have not reported any deaths through the clinic and the health centers since 2004.

The capacity of the existing health facilities to meet demand is very low. The health centers do not have any electrical or adequate medical equipment. Drugs and other necessities are in low supply, as the Ministry of Health does not deliver on time. The clinic and health centers do not have ambulance nor mortuary facilities. This makes work difficult since the clinic has to radio Mwinilungu hospital for assistance.

Education

There are a number of schools in the area; primary, basic and secondary. The only secondary school in the area is Kanyama Secondary School with classes from grade 1 to grade 12 and the population of the school is 703. The progression of pupils is generally very low among pupils of both genders however, there are more girl-child pupils dropping out of school in higher grades than among boys. The attribution of low levels of progression among girls is early marriages and lack of role models. The secondary school caters for all the pupils in the area and some students have to travel long distances as far as 12km from the school. The school has 17 teachers though they are supposed to be more but they refuse to come because of the non-availability of power.

The Ministry of Education runs most of the basic schools which are Munwa, Nsweta, Kapundu, Kamaneng'u, Kanyama and the Ministry of Community Development and Social Services runs the community schools which are; Mujila Kansang'a, Lokokwa and Changuvu. The community schools have been established mainly because of the inadequate number of public schools in the area and the long distance it takes for pupils to go to school. The pass mark of the pupils is fairly average and this is attributed to lack of electricity for studying.

Employment

The main activities in the village that involve formal employment are the civil servants (Government) such as teachers, health workers, agricultural extension officers and magistrate.

Subsistence farming is the most common occupation in the project area. During the farming season from October to February people are engaged in cultivation and from April, in sales of agricultural produce and in sale of honey in October.

Infrastructure and Social Services

Basic infrastructure in the area such as: clinics, schools that are government owned and some churches, are poor. There are no recreation centers although the area has national radio coverage. The road leading to the village is not gravelled nor tarred so it is not in good condition. The distance to the village from the main road is 30km and from the main town of Mwinilunga is about 60km.

Archaeological and cultural

The study area has no known archeological sites. However, Kanyama village has a cultural site used for the rain festival called "Chidika cha Mvula." However, the festival has since evolved from traditional type of worship to a modern Christian festival that attracts various preachers and clergy.

Tourism

The study area has no organized tourism activity although plans are now underway to put up a nature conservation area around Lake Chibeshya. The National Heritage Conservation Commission (NHCC) is spearheading the project in collaboration with the local community.

The site for construction of the power station has no tourist attraction and nor facilities. There are no lodging facilities, restaurants and other facilities that can promote tourism in the area but there is potential for tourism. There is Lake Chibeshya that is within the project area and two waterfalls, Mujila Lower and Mujila upper.

(2) Chilambwe Falls Mini-Hydropower Station Site and areas around the associated 33kV distribution line route

Physical Environment

Climate

The project area experiences four main types of seasons: cool and dry (June to August), hot and dry (September to October), hot and wet (November to February) and cool and wet (March to May). The average annual rainfall ranges between 1,100mm and 1,240mm. The mean annual temperature is around 18OC. The project area lies within Ecological Zone III, which receives high rainfall.

Topography

The study area lies on a plateau, which is generally flat and gently undulating with some low-lying areas. The water diversion and reservoir will be located upstream of Chilambwe Falls while the power plant will be located 30 meters below the falls. The general topography of the area ranges from 1,450m above sea level for low-lying areas to 1,600m above sea level in hilly areas. Moderate and undulating areas occur in the 1,400m above sea level topography ranges.

Soils and Geology

The geology of the project area represents one of Zambia’s rock formations from Precambrian to early Paleozoic. Basement Complex, Muva Super Group, Katanga Super Group lie as base rock of the Northern Province in which the project area lies. Granitic gneisses are widely spread at the central part of the province. Quartzites, shale of Muva Super group are distributed at north western and south western part of the granite zone, and shale, sandstones of Kundelungu group are distributed eastward of Lake Bangweulu. Upper Karoo Super group are distributed along the Luangwa valley. The project area has acidic sand loamy soils, which are also pervious.

Hydrology

The study area lies in the Chambishi River catchment. The Chambeshi catchment and the project area is endowed with a lot of perennial streams and rivers which are unpolluted due to non existence of industries and commercial farming activities. The streams are also surrounded with dambos that act as recharge zones. The main drainage system is the Chambeshi River in the project area. Other river and streams include, Mabale, Katutwa, Mwitakubili, Mukolwe and Kashida.

The proposed power plant shall be located on the Kafubu River. Other streams, which contribute to the Kafubu, are Tapa, 10 kilometres upstream of the proposed location, Nkwale and Kasawa streams after the falls. The Kafubu drains into Lake Tanganyika in Nsumbu National Park.

Wetlands

Dambos form large part of wetlands in the proposed project area. They are situated in areas at the head water before the waterfall. The tributary systems also have similar wetlands in form of dambos.

Water Quality

The water quality in the project area is good since there is no industrial or commercial farming activities or indeed other polluting activities in the study area. The baseline data indicates that the water quality is good and suitable for domestic, agriculture and other uses which include hydropower generation.

Air Quality

The air quality in the area is generally good as there are not industrial, commercial farming or construction activities. The proposed mini hydropower site is in a remote area with very few settlements. Air pollution from chitemene activities (especially burning) is localized and is at intervals.

Noise Level

The location of the proposed project site is in an open and low populated area. Noises experienced at the moment are from nature, which include the waterfall, and this is generally low. Natural noise levels are generally low in the area.

Waste

In the villages in the project area, very little waste is generated. The little waste generated is mainly domestic waste comprising leftover foodstuffs, which are thrown in rubbish pits for disposal. Pit latrines are used for the disposal of human waste.

Biological Environment

Flora

Woody plants

Mporokoso lies within the high rainfall area that is predominantly vegetated by Miombo woodland that is two-storeyed with an open and semi-evergreen canopy 15 – 20m high. The principle trees are Brachystegia, Julbernardia and Isoberlinia species, these include: Brachystegia stipulata, B. allenii, B. Manga, B. boehmii, B. bussei, B. floribunda, B. longifolia, B. microphylla, B. spiciformis, B. taxifolia, B. utilis, Isoberlinia angolensis, Julberlinia globiflora and J.paniculata.

The project site has a mushitu forest around the waterfall and the immediate downstream. A mushitu forest is basically a riparian riverine thicket with a wide range of tree species. Common tree species include Combretum zehyeri, Cassipourea mollis, Croton, Macrostachys, Ficalhoa laurifolia, Olea capensis, Podocarpus latifolius and Polyscias fulva. Figure 12-10 shows the part of riverine riparian forest around Chilambwe Falls.

Figure 12-10 Part of riverine riparian forest around Chilambwe Falls

However, riverine riparian forests in the project area are threatened by human activities. People in the projects area are cutting down the forests to make gardens for vegetable and sugarcane growing along Kafubu River and its tributaries. This practice poses a serious threat to the very survival of the affected rivers and streams and in turn, affects the proposed project since it depends on water for power generation.

The Chitemene system of agriculture (slash and burn), which is widely practiced in the area, has contributed greatly to the depletion of the woodlands. Trees are cut down and branches heaped together before burning. When rains come, the burnt area is planted with finger millet and other crops. The following year, another area is cleared.

Understorey plants

The relatively discontinuous under storey is dominated by Anisophyllea boehmi, Baphia bequaertii, B. massaiensis, Monotes glaber, M. africanus, M. katagensis, Hymenocardia acida, Combretum psidioides, C. celastroides, C. collinum, C. fragrans, C. imberbe, C. molle, C. zeyheri, Terminalia mollis, T. stenostachya, Diplorhynchus condylocarpon, and Uapaca kirkiana.

Common shrubs found in area include Ximenia americana, Oldfielda dactylophylla, Diplorrhynchus mossambicensis, D. condylocarpon. Other common shrubs are members of the following genera:- Lannea and Ziziphus. Grass species present in the area are associated with the Brachystegia-Julbernardia-Isoberlinia Woodland. The common species include Eragrostis brizoide, Alloteropsis semialata, Anthephora acuminata, Aristida adscensionosis, Monocymbium sp Bewsia biflora, Heteropholis sukata, Sporobolus rhodesiensis, Thysia huillensis, Sporobolus pyramidalis, Chloris gayana, Digitaria scalarum, Tristachya hubbardiana, Brachiaira brizantha, Homozeugos cylesi, Piptostachya inamoena, Pennisetum purpureum, Erythrophloeum africanum, Trichopteryx lanata, Andropogon sp., Diheteropogon amplectens, Sporobolus pyramidalis and Hyparrhenia cymbaria, H. filipendula, H. nyassae, H.cymbaria, H. rufa, H. bracteata. The Hyparrhenia sp., tend to congregate on the forest margins.

Fauna

Mammals

The project area is an open area (not protected area), and hence man’s activities, especially through poaching and encroachment have led to the reduction in numbers of wild animals in the project area. Common mammals reported to be in the study area include; Bush buck (Tragelaphus scriptus), Bush pig (Potamochoerus porcus), Sitatunga, Common duiker (Sylvicapra grimmia) Blue Duiker (Cephalus monticola) and Puku (Kobus vardonii) are all found in the project area in small pockets.

The natural habitat of the area is still suitable for big game provided measures are put in place to control poaching. Other wildlife species, which exist in the area, are rodents and rabbits.

Reptiles

Reptiles that occur in the project area include common lizards like: Rainbow Skink (Mabuya qumquetaeniata margaritifer), Striped skink (Mabuya striata wahlbergii), Bibrons gecko (Pachydactylus bibronii), House gecko (Hemidactylus mabonia), and the Chameleon (Chamaeleo dilepis). There is also the Crocodile (Crocodylus niloticus)

Species of snakes include Pythons (Morelia viridis), Puff adders (Bitis arietans), Spitting Cobra (Naja nigricollis nigricincta), and Black mambas (Dendroaspis angusticeps).

Birds

Birds common in the area include Guinea fowl (Numida meleagris), Francolin (Francolinus swainsonii), Nubian nightjar (Caprimulgus nubicus), Fish eagle (Heliaeetus vocifer) and species of Doves such as Dusky turtle dove (Streptopelia lugens), Namaqua dove (Oena capensis) and Morning dove (Streptopelia decipiens).

Fish

Subsistence fishing activities are quite significant due to many rivers that exist in the area. Species of dominance in the rivers and streams crossing the corridor which might be harvested by the communities, include: Stripe tailed citharinid (Alestes lateralis), Barbel fish (Clarias gariepinus), Snake Barbel (Clarias theodorae), Dwarf bream (Haplochromis philander), Banded bream (Tilapia sparmanii) and Red-breasted bream (Tilapia rendalli).

Protected Areas (National Parks and Forest Reserves)

There are no protected areas in the project area.

Socio-economic Environment

Population

According to the 2000 Census Summary Report (CSO) the population of Mporokoso District was at 73, 929. The male population comprises 36, 975 (50.2%) of the population and female 36, 954 (49.8%) with an average annual growth rate of 3.0%. The study area starts about 80.0km from the main town of Mporokoso and has a population of 6, 800, which was estimated by using the catchment population of both Kapatu and Shibwalya Kapila Rural Health Centres (RHC).

Settlements

Mporokoso town is planned and zoned into residential and commercial/offices areas and has settlements in the rural parts of the districts that are organized in form of villages. A village is made up of many households living in a defined geographical area under the leadership of a headman. A group of villages in a defined geographical area make up a chiefdom that is headed by a chief.

People in the project area are Bemba by tribe living in 52 settlements under Chief Shibwalya Kapila. The distribution network however, is expected to be extended to Kapatu Mission a growth centre comprising of a Rural Health Centre, a basic school, a parish and a farming block. This is also under Chief Shibwalya Kapila's area.

Most of the houses in the project area are made of mud or burnt bricks with grass thatched roofs. Good standard houses with iron or asbestos roofs are also found in the area and most of them belong to various government departments.

Agriculture and Fisheries

Agriculture is the most predominant and important economic activity in the study area, though it is mainly at subsistence level. Most of the people in the area combine crop farming with rearing of livestock such as pigs, goats, village chickens and guinea fowls. These are both for their livelihood and for sell. The crops mainly grown are maize, cassava, beans groundnuts, and millet. Chitemene system of agriculture is widely practiced in the area. Chitemene system is used to grow finger millet, which is mostly used to brew beer. Rice and sweet potatoes are also grown in the project area though on a small scale.

In addition, there is also a farming block in the project area called Kapatu Farming block/scheme. Farmers in the farming block mainly grow maize, sunflower, groundnuts, soybeans, cassava and different types of vegetables. The farmers also engage in pig rearing and fish farming, though on small scale.

Fruit trees such as mango, avocado, guava, lemon, orange and banana are also grown in the area. Although production in the district is low, there is great potential for increased agricultural production. The abundant water in streams, dambos and wetlands can support large-scale irrigation farming.

Subsistence fishing activities are quite significant in the project area since Kafubu River and other streams in the area such as Lukupa have a wide variety of fish species. There are different species in the river channel along the study area. The dominant species which are also of commercial value include; Yellow-belly Bream (Serranochromis robustus) Bottlenose (Mormyrus lacerda), Red breasted bream (Tilapia rendalli), stripe tailed citharinid (Alestes lateralis), Snake Barbel (Clarias theodorae), Silver barbel (Shilbe mystus), Smooth –Spined Barb (Barbus poechii), Blunt toothed barbel (Clarias mellandi), Three spotted bream (Oechromis anersonnii), Mpumbu (Labeo ativelis), Parrot fish (Gnathonenus macroleptus), Banded bream (Tilapia sparmannii), Dwarf bream (Haplochronis philander) and Green headed bream (Oreochromis machrochir).

The numerous rocks on the riverbed and bank, the side stream dambos along the river channel and the headwater dambos provide good breeding grounds for the fish.

Some of the people combine crop farming with rearing of livestock such as sheep, pigs, goats, village chickens and guinea fowls. Cattle rearing are not common.

Local Economy

The economy of the project area depends largely on farming producing crops such as maize, cassava, beans and millet. Other activities that generate income or contribute to the local economy are pig rearing, handicrafts, timber, bricklaying and fishing farming. Even though the project is not very big, it is expected to have some improvement in the income levels and in turn, the standard of living. There is great potential in the area in fishing farming, carpentry, tourism and many others.

Mining

The area has no mining activities. However, there is some sand mining in the project area at small scale. However, the area is said to have various minerals such as copper, iron and semi precious stones.

Energy

The residents of Chipundu village largely depend on firewood and charcoal for energy (cooking and heating). The rural health centers at Shibwalya Kapila RHC, Kapatu RHC and some basic schools like Kafubu use solar panels for their energy requirements. Isolated places such as the Kapatu Agricultural Centre, use a combination of solar and diesel generators for energy, especially for water pumping.

Water and Sanitation

Mporokoso district is endowed with abundant water supplies. Many villages are located near streams and this enhances easy accessibility to water. Villages largely depend on water from the streams and rivers in the area, and those that are a bit further from these streams and rivers have dug some wells. The water is used for drinking and other domestic uses such as cooking, washing, bathing and watering their gardens along the riverbanks. Despite the abundance of water, accessibility to safe water still remains a problem.

A number of houses have pit latrines and bathing shelters that are constructed of local materials with thatched roofs.

Health

The project area has two health centers, namely; Kapatu and Shibwalya Kapila Rural Health Centres (RHC). Kapatu RHC has one qualified nurse, two other classified daily employees (CDEs) who assist the nurse and one watchman. The clinic relies on solar panels distributed by the Ministry of Health and also uses paraffin for their refrigerator for keeping medicines. The clinic relies on fuel wood for heating to sterilize the equipment.

The catchment area for the clinic extends from Tapa, which is about 18km, Luangwa 22km, Sambala 22km, Chipulya 16km, Miyamba 23km, Chilangwa 9km, and Shimwalota 10km. Other nearby villages in the area that the health centre caters for include Sokoni, Chisembe, Andrew Chisha, Ndaito, Kaungo and Chikuku. The health centre caters for about 9,422 people.

Shibwalya Kapila Rural Health Centre is also understaffed and lacks facilities such as laboratory and admission wards. The clinic relies on solar for lighting and paraffin for their refrigerator for keeping medicines. The clinic relies on fuel wood for heating to sterilize the equipment.

Common diseases in the project area include; malaria, diarrhea, upper respiratory tract infection, Scabies, conjunctivitis, and sexually transmitted diseases (STIs) especially among young people. The village has not reported any HIV/AIDS cases as there are no screening facilities hence there is no definite information regarding the magnitude of the problem. However the clinic has two referral cases from Kasama who are also on T.B treatment. The clinic does conduct sensitization programs on HIV/AIDS Malaria, conducted by a mobile clinic, which also conducts under five clinics in the villages and distributes mosquito nets.

The clinic also has provided Traditional Birth Attendants (TBA) to help pregnant women to deliver in the villages. The clinic lacks mid wives and nurses and has no maternity ward.

The capacity of the existing health facilities to meet demand is very low. The health centers do not have any electrical or adequate medical equipment. Drugs and other necessities are in low supply, as the Ministry of Health does not deliver on time. The two RHCs do not have ambulance and mortuary facilities; this makes work difficult because they have to refer the difficult cases to Mporokosos District Hospital or Kasama General Hospital for assistance.

Education

There are a number of schools in the district mostly run by the Ministry of Education; 20 basic schools, 37 middle basic schools and 1 high School. Some of the basic schools in the project area include Kafubu, Kapatu, Mporokoso, Mukupa Kaoma, Chandamali, Shibwaya Kapila and Chitoshi. The district has only one secondary school in the area Mporokoso Secondary School with classes from grade 10 to grade 12. Basic schools provide education from Grade 1 to Grade 9 and those who pass the Grade 9 examinations are offered places at Mprorokoso High School and other high schools in the Province.

The closest schools to the project area are Kafubu, Shibwalya Kapila and Kapatu Mission basic schools. Kafubu basic school the closest to the project site has an enrolment of about 693 pupils, with about 353 girls and 340 boys. The school catchment area extends from Kasongo, which is about 8km to Chilongoshi, which is about 17km. The school has 9 teachers of which 6 are female and 3 are male. The progression rate of pupils is generally very low among both boys and girls. However, there are more girls dropping out of school in higher grades than boys. This can be attributed to early marriages and lack of role models. The pass mark of the pupils is fairly average and this is attributed to lack of electricity for studying in the evening.

The only secondary school in district caters for all the pupils in the area and some students have to travel long distances as far as 12km to the school.

However, there are plans to build a high school in the area and the construction of Kapatu High School has started already with funding from Ministry of Education.

Because of lack of electricity in schools, Ministry of Education and donors cannot provide some education tools and equipment such as computers and this affects the performance of teachers and pupils as they lag behind in new technology.

Employment

Formal employment in the area is very low as there are no employment opportunities. The few people in formal employment are mainly civil servants (Government employees) such as teachers, health workers and agricultural extension officers.

Subsistence farming is the most common occupation in the project area. During the farming season from October to March people are engaged in cultivation and after April they are engaged in harvesting and selling of their agricultural produce.

Infrastructure and Social Services

Basic infrastructure in the area is generally poor. The main road (Kasama - Mporokoso road) is a gravel road and is in bad condition due to lack of maintenance. Even the 2.8km road to Chilambwe Falls is just a bush truck which may be impassable to motor vehicles in one place during the rainy season because there is no culvert at a small river crossing.

The project area has no telephone services and no television (TV) coverage. Radio reception is bad. Banking services are only available in Kasama. Small shops, stocked with a limited range of commodities are available in the project area. Most of the people (especially Government employees) travel to Mporokoso and Kasama to buy most of the household items. Recreation facilities, except for football pitches at local schools, are very limited.

Archaeological and cultural

The study area has no known archeological sites. People in the project area have a long history of ancestral spirits worship at Chilambwe Falls. Every year at the appointed time after crop harvest, people gather at Chilambwe falls to give various foodsfuffs and locally brewed beer to thank the ancestral spirits for the good harvest and ask for blessings. A cow, sheep or goat is slaughtered and sacrificed to the spirit that resides at the waterfall whose name is Chilambwe.

Tourism

Chilambwe falls has potential to attract both local and foreign tourists. However, the waterfall is not well known to the general public outside the project area because it not marketed. Even on the road to the waterfall, there is no poster to show that there is a beautiful waterfall. Hence, there are very few tourists (local and foreign) who visit the waterfall. According to the information obtained from Mr. Chipundu who lives near the falls, they receive an average of one tourist per month. There are no lodging facilities, restaurants and other facilities that can promote tourism in the area.

12.3.5. Environmental Impacts and Mitigation Measures

Potential impacts on physical, biological, and socio-economic environments in the project sites and along the distribution line routes and corresponding mitigation measures are outlined in Table 12-28 and 12-29.

Table 12-28 Potential Impacts and Mitigation Measures (Mujila Falls Lower Mini-Hydropower Station Site and areas along the route of associated 33kV distribution line)

Item	Potential Impacts	Possible Mitigation Measures
Physical Environment		
Location	- Construction activities will cause introduction of new equipment, people, and services in the locality.	- Necessity of early definition of the power plant zone - Restriction of the distribution lines to road reserves - Protection of the immediate catchment area from land use
Climate	- Changes of local micro climate due to inundation of a defined area and the submerging of some islands	- Weir design taking into consideration confining the inundation zone within the islands and low lying areas
Topography	- Alterations and modifications to the topography caused by tunnelling, blasting, cutting and back filling during construction	- Confine construction work area to designated access area - Protection of slopes from erosion by appropriate vegetation planting and management
Soils and Geology	- Impacts on soils and general geological stability of the area caused by excavation, tunnelling, blasting, cutting and back filling, construction of penstocks of 23m x2. - River bank erosion down stream due to new source of water creation by tailrace (30m)	- Back filling of excavated soils - Rehabilitation of construction area by landscaping and tree and grass planting - Reuse of wasted rocks from tunnelling process to both weir and other infrastructure
Hydrology	- Disturbance to the natural flow regime caused by weir construction. However, the low height of the weir (5m) will encourage free flow of water over the weir to ensure minimal	- Operation rules taking into account the required minimum water flows for ecological restoration - Keeping enough distance from poles to stream banks

	disturbance to the natunal flow regime. - The area extending not more than 1km upstream will be permanently inundated along the river channel and its flood plains on both left and right bank of the Mujila river. - Erosion on the river banks due to modification in the river channel at tailrace discharge point is expected but the gorge has a very stable geological formation, thus entailing confining the river channel within the gorge channel.	
Wetlands	- Expanse of localized wetland on the islands and areas of inundation due to weir construction - Upstream of the proposed weir site exists a natural flood plain which will be permanently inundated for a distance of about 1km.	- Control of access to the new reservoir and all activities around powerhouse site by power station administration - Avoidance of crossing the wetlands by distribution network as much as possible
Water Quality	- Alteration of some water quality parameters due to weir construction However, the potential impacts will be minimal since the area of impoundment will be confined within the natural flood zone of the immediate upstream of the weir site. - Surface and ground water pollution	- Protection of the catchment area for restraint of sediment load and pollutants
Air Quality	- Impact on air quality due to construction works (excavations, blasting(where applicable)) and construction equipment use	- Keeping dust levels low by watering to temporal roads and access areas
Noise Level	- Noise due to construction works and construction equipment use	- Shorting of construction period - Time restriction of heavy construction equipment use
Protected Area	- The proposed project is not in a protected area, however, the site would be declared a protected zone for security of equipment and reservoir protection. - Restriction of farming and/or fishing activities in both power plant zone and immediate catchment area, which will be declared a protected zone	- Designation of power station site and the catchment area as protected area

Waste	- Pollution caused by construction wastes, liquid wastes, domestic wastes, human wastes, etc	- Reuse of construction wastes and disposal of them in designated areas - Appropriate storage and disposal of wastes in an approved way - Installation of appropriate sanitation facilities - Effluent discharge away from river systems and domestic water intake
Landscape	- The proposed project sites are in a gorge hence not visible from the currently access. However, it is anticipated that the inundation zone spread will be visible from the current access in some sections. - Visual impact due to power distribution line construction	- Placement of distribution network in road reserves where regular bush clearing during road maintenance is common - Restriction of reservoir within the area of inundation - Painting the power house and associated infrastructure with the colors, which harmonize surrounding environment
Biological Environment		
Fauna	- The flooding of the inundation zone upstream of the weir is likely to create condition that may displace some animals. However, the flooding could enhance the development of a wider habitat for animals such as Waterbuck, Duiker, Baboons, Monkey, Hippos and various species of rodents such as cane rats. The expanded water habitat will be good for water fowls such as fish eagles, king fishers and others.	- Protection of the area around reservoir and the entire power plant zone - Sensitization against poaching and general conservation methods - Sensitization of local community for sustainable fishing methods and conservation practices
Flora	- Estimated inundation area is about 1km in length upstream of the weir site. In the inundation zone, vegetation such as palms like *Phoenix reclinata*, and *Raphia farinifera*, ferns such as Royal fern, Bog scaly lady fern, and various types of grasses are likely to be affected. Riverine trees such as *Syzygium cordatum*, *Syzygium guineense ssp afromontanum*, *S. owariense*, *Gardenia imperialis*, *Rothmmania whitfieldii*, *Swatrzia*	- Vegetation establishment around the reservoir - Rehabilitation of construction sites through landscaping, planting of trees and grass, and clearing of any disused materials

	madagascariensis will be affected too. Island vegetation such as soft broomy grass, *Gardenia imperialis* and sedge like plant that produces red fruit locally known as *intungulu* is likely to be affected due to flooding arising from weir construction. - Impacts on specific species of plants due to expanse of inundation area resulting from weir construction - Impacts on vegetation due to bush clearing to ensure way-leave for distribution line	 - Placement of distribution network in road reserves - Restriction of bush clearing area in the way-leave (22m)
Socio-economic Environment		
Population	- Temporal increase in population due to influx of construction workers from outside the project area	- Insulation of location of camps for construction workers from vicinity of the power plant - Employment of local people as temporal workers - Strict screening of workers from outside the project area
Settlements	- The proposed site is located in an isolated area hence there will be no resettlement.	
Agriculture and fisheries	- Encroachment of farmland - Expropriation of farmland due to power plant construction - Decrease in the number of specific fish species by poaching	- Monitoring of access and use of the water resources in the reservoir - Prohibition of all traditional farming activities near the reservoir - Restriction of fishing activities to defined period
Local Economy	- Improvement in the income level and standard of living fostered by creation of employment opportunities (Positive Impact)	- Power supply to load centers, which are expected to contribute to enhancement of economic growth
Mining	- Enhancement of mining activities (Positive Impact)	- Power supply for enhancement of development of mining
Energy	- Improvement in standard of living - More stable and reliable supply of power to social service facilities (Positive Impact)	—
Water and Sanitation	- Pressure on existing water and sanitation facilities during the construction stage - Impacts on safe water supply due to improper treatment of construction wastes, liquid wastes, domestic wastes, and human wastes	- Construction of appropriate sanitation facilities and domestic water supply services

Health	- Rampancy of communicable diseases by construction workers from outside the project area - Injuries of construction workers - Shortage of medicines due to increase in population - Increased incidence of malaria in the area of impoundment due to increase in breeding ground for mosquitoes - Increased incidence of the bilharzias parasites due to creation of reservoir	- Health education on the dangers and prevention of communicable diseases for construction workers during construction period - Provision of First Aid Kits for emergency
Education	- Improvement in learning environment by supply of power to schools and teachers' residents (Positive Impact)	- Power supply to schools
Employment	- Creation of job opportunities for local people as temporal workers during construction and/or way-leave maintenance staff in operation stage (Positive Impact)	- Priority employment of local people as construction workers - Employment of residents in Kanyama village as maintenance staff in operation stage - Considerations for developing skills to ensure that local people benefit from the project
Infrastructure and Social Services	- Improved social service quality by power supply to social service facilities, etc. (Positive Impact) - Deterioration of road condition due to higher volume of traffic during construction	- Adequate compensation to property owners when facing difficulty in avoiding houses and buildings for distribution line construction
Archaeological and cultural	- The study area has no known archeological sites. However, Kanyama village has a cultural site used for the rain festival called "Chidika cha Mvula." - Impacts on archaeological and/or cultural heritage (if excavated)	- Identifying the places of great cultural significance through consultation with residents - Suspension of excavations in the event of any discovery of any artefact - Consultation with NHCC and local community for advice and/or recovery of the artifact
Tourism	- Enhancement of tourist site development (Positive Impact)	—
Land tenure and land use	- Restriction of land tenure and/or land use during construction and/or operation of power plant	- Restriction of use of reservoir and lands under distribution lines
Safety	- Injuries during construction works and attack by wild animals and/or snakes	- Wearing protective gear - Placing road signs and speed limit signs for road accident prevention - Provision of appropriate medicines and First Aid Kits

Table 12-29 Potential Impacts and Mitigation Measures (Chilambwe Falls Mini-Hydropower Station Site and areas along the route of associated 33kV distribution line)

Item	Potential Impacts	Possible Mitigation Measures
Physical Environment		
Location	- The proposed project site is far from settlements and will not significantly disturb the natural environment.	- Necessity of early definition of the power plant zone - Restriction of the distribution lines to road reserves - Protection of the immediate catchment area from land use
Climate	- Because of the small size of weir (2m high), the proposed project will not have significant impacts on the micro climate of the study area during construction and operation of the hydropower plant.	Impact is insignificant since the scale of the weir is small (height is 2m)
Topography	- The project area is not expected to have significant topographical adverse impacts during the construction and operation phases. However, there may be some impacts on the topography of the slopes from the top of the falls to the bottom where power station will be located	- Minimization of excavation, blasting, and vegetation removal area - Protection of slopes from erosion by appropriate vegetation planting and management
Soil and Geology	- Erosion and destabilization of soils, and landslides due to vegetation removal	- Reuse of excavated soils and blasted rocks for backfilling and stone masonry - Introduction of gabions - Rehabilitation of the construction areas through landscaping and planting trees and grass
Hydrology	- Diversion of the river, from its natural route to the proposed reservoir tank, would affect the natural flow regimes of the Kafubu river at the area between the intake and the tailrace, including the falls. - Erosion and siltation due to pole erection near river banks	- Consideration of required minimum environmental water flows for the river ecology and river ecological restoration between the weir and the tailrace - Keeping enough distance from poles to stream banks - Selection of distribution line routes, which avoid river crossing and/or coming close to river banks
Wetlands	- Diversion and construction of the mini-hydropower plant may cause change in the discharge	- Water reservoir tank shall only be of a limited constructed area (50m x 50m).

	and charging times of the wetlands within the project area. These, however, may not be significant since charging and recharging will largely follow the existing natural cycle which is largely influenced by rain patterns.	- Water reservoir tank shall be constructed away from the recharge zone and 10m away from the slope to the power plant.
Water Quality	- Change in water quality parameters due to change in river flow regimes - Temporal degradation of water quality due to excavations during construction	- Water Quality monitoring of the river and constructed reservoir - Treat water before supply for domestic use - Restriction of both construction and human activities around the reservoir
Air Quality	- Impacts on air quality caused by excavations, blastings, and construction equipment use	- Keeping dust levels low by watering to temporal roads and access areas - Shorting of construction period
Noise Level	- Temporal noise level increase arising from traffic movement, heavy machinery use, blasting and excavation works	- Time restriction of heavy construction equipment use - Prohibition of blasting at night and notification of time of blasting works to local people living near the project site
Landscape	- The project site will have minor visual impacts arising from the penstocks and the powerhouse since they will be on the surface. There will be minor visual impacts from the distribution lines.	- Minimization of vegetation removal area - Replanting of local natural trees and grass - Painting the power house and associated infrastructure with the colors, which harmonize surrounding environment
Waste	- Production of construction wastes, liquid wastes, domestic wastes, etc. - Human wastes at the camping site for workers - Soil disposals and rubble by excavation and blasting works	- Sorting of waste according to types - Reuse of the wastes and/or disposal of them in designated area - Appropriate storage and disposal of wastes in an approved way - Installation of appropriate sanitation facilities
Biological Environment		
Flora /Fauna	- Poaching by construction workers - Destruction and displacement of wildlife habitats due to vegetation removal, blastings, excavations, etc. - Impacts on fish species due to degradation of water quality during construction stage - Creation of fire buffer by bush clearing for way-leave (Positive Impact)	- Worker education to prevent poaching from occurring - Rescue of mammals to a safe area with similar ecological conditions when found in the construction areas - Avoidance of heavy machinery use near the river flow as much as possible - Restriction of excess bush clearing

Socio-economic Environment		
Population	- Growing incidence of crimes due to temporal increase in population during construction stage	- Insulation of location of camps for construction workers from vicinity of the power plant - Employment of local people as temporal workers - Strict screening of workers from outside the project area
Settlements	- The mini-hydropower station will be located in an isolated area, hence there will be no resettlement of people.	-
Agriculture and Fisheries	- Some potential agricultural land will be taken up for construction of the mini-hydropower station. However, the construction of the power station will not cause any land shortage as land is abundant in the project area. - Decrease in the number of specific fish species by poaching	- Monitoring of access and use of the water resources in the reservoir - Prohibition of all traditional farming activities near the reservoir - Restriction of fishing activities to defined period
Local Economy	- Improvement in the income level and standard of living fostered by creation of employment opportunities (Positive Impact)	- Power supply to load centers, which are expected to contribute to enhancement of economic growth
Energy	- Improvement in standard of living - More stable and reliable supply of power to social service facilities (Positive Impact)	-
Water and Sanitation	- Pressure on existing water and sanitation facilities during the construction stage - Impacts on safe water supply due to improper treatment of construction wastes, liquid wastes, domestic wastes, and human wastes	- Construction of appropriate sanitation facilities and domestic water supply services
Health	- Rampancy of communicable diseases (dysentery, HIV/AIDS, etc) by construction workers from outside the project area - Injuries of construction workers - Shortage of medicines due to increase in population - Increased incidence of malaria in the area of impoundment due to increase in breeding ground for mosquitoes - Increased incidence of the bilharzias parasites due to creation of reservoir	- Health education on the dangers and prevention of communicable diseases for construction workers during construction period - Provision of First Aid Kits for emergency

Education	- Improvement in learning environment by supply of power to schools and teachers' residents (Positive Impact)	—
Employment	- Creation of job opportunities for local people as temporal workers during construction and/or way-leave maintenance staff in operation stage (Positive Impact)	- Priority employment of local people as construction workers - Employment of local people as maintenance staff in operation stage - Considerations for developing skills to ensure that local people benefit from the project
Infrastructure and Social Services	- Improved social service quality by power supply to social service facilities, etc. (Positive Impact) - Deterioration of road condition due to higher volume of traffic during construction	- Adequate compensation to property owners when facing difficulty in avoiding houses and buildings for distribution line construction
Archaeological and cultural	- Impacts on the place for harvest festival - Impacts on archaeological and/or cultural heritage (if excavated)	- Identifying the places of great cultural significance through consultation with residents - Suspension of excavations in the event of any discovery of any artefact - Consultation with NHCC and local community for advice and/or recovery of the artifact
Tourism	- Enhancement of tourist site development (Positive Impact)	- Help to put poster on the main road giving direction to the waterfall
Land tenure and land use	- Restriction of land tenure and/or land use during construction and/or operation of power plant	- Restriction of use of reservoir and lands under distribution lines
Safety	- Injuries during construction works and attack by wild animals and/or snakes	- Wearing protective gear - Placing road signs and speed limit signs for road accident prevention - Provision of appropriate medicines and First Aid Kits

12.3.6. Alternative Electrification Schemes

Alternative rural electrification schemes to mini-hydropower mini-grid electrification including more diesel power stations, solar home system (SHS), other renewable energy such as wind power and biomass, and the zero option were compared (Table 12-30).

Table 12-30 Alternative Electrification Schemes

	Mujila Falls Lower	Chilambwe Falls
Diesel Power Stations	- Putting up a diesel power station at a Rural Growth Centre like Kanyama, has very high cost implications, such as the running costs of the plant (due to high cost of diesel). - Spare parts are usually difficult to obtain because of changes in machine design and manufacturers stop making spare parts for older designs. - Generation capacities are normally limited hence there are difficulties in local grid extension to outlying areas for activities such as mining, manufacturing etc. - Diesel stations are a source of air pollution by the very nature of using diesel (emission of sulphur dioxides and other pollutants are common). - Extension of the existing 11kV power network to Kanyama's area was not feasible due to the limited generation capacity from the current diesel generator in Mwinilunga town.	- Same as on the left except for the fifth item
Extension of Existing National Grid	- The current power demand (load) at Kanyama and Kakoma is estimated to be about 600kW, hence it would be very costly to construct a dedicated transmission line to the two load centres and surrounding areas. - Extending the current grid from Mwinilunga to Chief Kanyama's center which is about 54km, would not be feasible due to limited power capacity at the Mwinilunga Diesel Power station. Increased load would have led to increased fuel costs and an increase in sulphur emissions into the atmosphere.	- The 66kV power line which supplies power to Mporokoso town runs from Kasama, passing through Luwingu and Kawambwa. The rest of the district has no electricity. - Extending the national electricity grid to Kapatu, Shibwalwa Kapila and the surrounding areas from Mporokoso town or Kasama is very costly because the grid passes far away.
Mini-Hydropower Stations	- The project area is endowed with high rainfall, reliable river flows throughout the year, and suitable sites (two water falls) hence mini-hydro power development is a viable option. - The development of hydropower is envisaged to be cheaper than many other forms of energy. It is considered clean energy since it has under most conditions less	- Same as on the left

	adverse environmental impacts than for instance diesel or long grid extensions.	
Biomass	- Suitably managed biomass resources can be gasified to produce fuel gas, which in turn, can be fed to gas engines to produce power. ・The power demand in the RGCZ around Mujila is about 1.0MW. Several hectares of land would be required to grow and supply woody vegetation to the bio gasifier, creating competition for land use for other activities such as food production, bee keeping, housing, etc.	- Same as on the left
Wind-power	- According to various studies by various organizations, Zambia has limited wind energy resources as it does not have any significant geographic features that accelerate wind and the country is landlocked. The University of Zambia has evaluated and determined that these low wind speeds are not sufficient for power generation and the wind resources are adequate only for water pumping.	- Same as on the left
Solar Power	- The use of solar would have limited application in the event of full development of the potential in mining, tourism and agriculture. - Vandalism (mainly by foreigners) and lack of technical know-how in maintenance would have make sustainable operation difficult.	- Same as on the left
Zero Option	- Zero Option would not be realistic alternative because the rural area has grown and has potential to contribute to national economic growth. The area has potential in agriculture, manufacturing, mining and tourism. - Power supply is one of the key ingredients to economic growth and subsequently poverty alleviation. Doing nothing therefore would go against Government Policy on rural development.	- The area has great potential for commercial farming, mining and manufacturing. Without implementation of the proposed project, these potential will not be exploited and the area will remain undeveloped. - The provision of quality health care, education and other social services will continue to be difficult without electricity. The area's contribution to the national economy will also remain low.

12.3.7. Environmental Management Plan Framework

The Environmental Management Plan (EMP) is normally provided for in the detailed technical and tender document. Therefore, the section outlines the main components of the EMP.

The main components of the EMP shall include:

(1) Awareness and Training

With general code of conduct (for contractors, employees etc), employment procedures, protection and management of cultural, heritage and archeological sites, protection of infrastructure and property (communal and private), anti-poaching (protection of fauna), health, safety, compensation procedures, working hours

(2) Waste Management

General guidelines on project implementation that shall include: camp site selection, temporal works, road signage, plant and equipment service area, explosives and other construction materials storage, fuel storage and workshop area, borrow pits and quarry sites, access roads and road transport, water supply

(3) Environmental Management

Environmental management: slope protection, erosion protection, noise pollution control, air pollution control, water pollution control, vegetation management (bush clearing, plant species protection, cut wood management), landscaping and rehabilitation of construction sites, monitoring and audit program

(4) Work plan and phasing of environmental management plan implementation activities with responsible persons or parties

The project proponents shall have among the staff on the project, a full time Environmental Coordinator. This will enhance the implementation of the mitigation measures through the Environmental Management Plan.

12.3.8. Conclusions and Recommendations

In the Case Study, pre-F/S level environmental and social impact assessment was conducted for two potential mini-hydropower sites. The anticipated adverse environmental impacts are regarded as minimal and are outweighed by the benefits of the project, in other words, improvement in the electrification rate and standard of living, and stimulation of economic activities for both sites at this time. However, in F/S phase, the followings should be carefully examined as well as review of all impact items considered in this study in response to change in the condition of the circumstances:

- Traditional land ownership system of the villages adjacent to Mujila Falls Lower mini-hydropower potential site and accompanying 33kV power distribution lines
- Impacts of compulsory acquisition of lands resulting from implementation of the proposed projects under current Lands Acquisition Act in Zambia
- In the case of implementation of the proposed projects, identifying the culturally important places used for religious services and confirmation of necessary arrangements, including stakeholder meetings
- Review of details of the Environmental Management Plans of similar type of previous mini-hydropower development projects.

Chapter 13

GIS Database Development

Chapter 13. GIS Database Development

13.1. Introduction of GIS

One of the important tasks of this Rural Electrification Master Plan Study is to develop a GIS (Geographical Information System) database to serve as a useful tool for planning rural electrification projects. The GIS system is a digital mapping system that can handle not only numerical data, such as population of the village and the number of commercial and public facilities, but also graphic information on the map. There are some different types of computer software for GIS systems in the world, but since many ministries in GRZ have an experience more or less of using ArcGIS, which is developed by ESRI in USA and the most popular software, the Study Team selected the latest version of ArcView 9.1, the primary package of ArcGIS as the standard GIS system for this Study.

13.2. The GIS Database

13.2.1. Experience of Using GIS System

As of November 2006, DoE has neither GIS software nor a computer in which GIS software is installed, which means that DoE virtually has no professional skills to use GIS.

ZESCO uses GIS system for its business but only modestly and there appears to be no standardization. We found that one/some ZESCO's branch office(s) is/are using GIS system to manage the power system data such as transmission and distribution line routes, but the file format is different from that of ArcGIS and hence it would be difficult to incorporate the database as it is into the Rural Electrification GIS database that is created in Arc format.

REA, in the meanwhile, has GIS system, the latest version of ArcView 9.1, which is installed in their computer. In the beginning of this Study, REA's usage of GIS system is still limited to collecting GIS database from other Governmental organizations and ZESCO, and they have no experience of developing GIS database of its own for planning rural electrification projects. However, REA recruited a GIS expert, who has enough experience of GIS usage in a water service company, and they have started to utilize GIS in the actual planning of rural electrification including data collection of the site using GPS device.

In short, the counterpart organizations that will be responsible for updating the Rural Electrification GIS database needs training of basic operations of GIS during the project period before going into the details of the database excluding one GIS expert.

13.2.2. Existing GIS Data

The Study Team obtained various GIS database from REA during the first mission in April/May 2006, which was originally owned by other related organizations such as Ministries. This database includes basic and necessary geographic information for this project, such as administrative boundaries, roads, and location of public facilities. These data shall be fully or partially incorporated into the Rural Electrification GIS Database.

REA is classifying the database into the "source" organization, which makes us find easily where each database comes from. However, the information regarding the time of data collection, the database updating, and the original map data that each GIS database referred to are not necessarily available. Therefore, we assume that the accuracy of these databases varies. For instance, by combining the topographical database with the village database on a same map, we find that some villages are positioned in a lake, and this kind of strange incidents, i.e. data input errors, occurs occasionally.

During the second field survey in Zambia, JICA study team obtained the Zambia Health Facility

Census Database compiled in October 2006, based on the field study by JICA between 2004 and 2006, on behalf of the Ministry of Health. The database compiled the information of health facilities in whole Zambia based on the same GIS maps that we obtained during the first field survey. The following table shows the GIS database that the Study Team has obtained so far.

Table 13-1 GIS Database Obtained during the First Mission

Ministry	Item	
Agriculture and Cooperatives	Agro region, Farmers block, Resettlement area	
Commerce, Trade and Industry	N.A.	
Community development and Social Services	N.A.	
Education	Basic school (electrified / unelectrified / no water service), Secondary school, Village centre, Roads (Main / Others)、Railway, National parks, River (Major / Others), Wetland, Dam, Drainage, Administrative boundaries (Nation / Province / district)	
Energy and Water development	Energy	Power systems (330kV - 11kV, existing and plan), Hydropower stations (existing and plan), Diesel Power stations (existing and plan), Substations (existing and plan)
	Water affair	Kafue River (river basin, sub basin, stream flow), Kafue Lake, Kafue Wetland, Zambezi River (agro climate, grow day, evaporation, annual rainfall, runoff, temperature in July and November, rapid point), Zambezi Lake, Zambezi Wetland, Luapula River, Environmental impact assessment in 1995, 2005 and 2015, Environmentally sensitive area, Priority management area, Wetland birds
Health	N.A.	
Home Affairs	N.A.	
Land	N.A.	
Local Government and Housing	N.A.	
Mines and Minerals Development	Mines, Minerals	
Tourism, Environment and Natural Resources	Forest, Grassland, Termitary, Administrative boundary, Rivers, Roads, Railways	
Works and Supply	N.A.	
Central Statistics Office	Administrative boundary (Nation, Province, District), Constituency, Roads (Trunk, Major, Others)	

Source: JICA study team

Table 13-2 GIS Database Obtained during the Second Mission

Ministry	Item
Health	Health Facility Census

Source: JICA study team

By scrutinizing each database, we find that some roads and administrative boundaries are recorded in different route and shapes that really have to be identical, and it's difficult to judge which data is the most probable without the information regarding the accuracy of each map. However, these errors are in general minor and acceptable in terms the purpose of this Study to develop a "nation-wide" Master Plan. The most appropriate data shall be selected case by case for the Rural Electrification GIS database.

In general, extension of distribution networks is made along the route of existing roads, thus lack or inaccuracy of road information strongly affects the accuracy of project plans. On top of that, geographic information of GIS system is less reliable than the paper-based maps. Hence the Study Team has improved the quality of GIS road data by comparing the GIS data with the paper-based 1/250,000 maps, which were issued by the Ministry of Lands. A drawback of paper-based maps is that they were originally published in 1986, more than twenty years ago, and they may lack a lot of information on new or reconstructed roads.

Accuracy of the length of distribution lines, which is essential for estimating the construction cost and for optimising the distribution system planning, also depends on the contour data that give the information of each site's elevation, but none of obtained GIS maps provide the information as such. Because it is physically difficult to obtain / make this information and Zambia is a relatively gently rolling land, the length of distribution lines are calculated assuming the plane land.

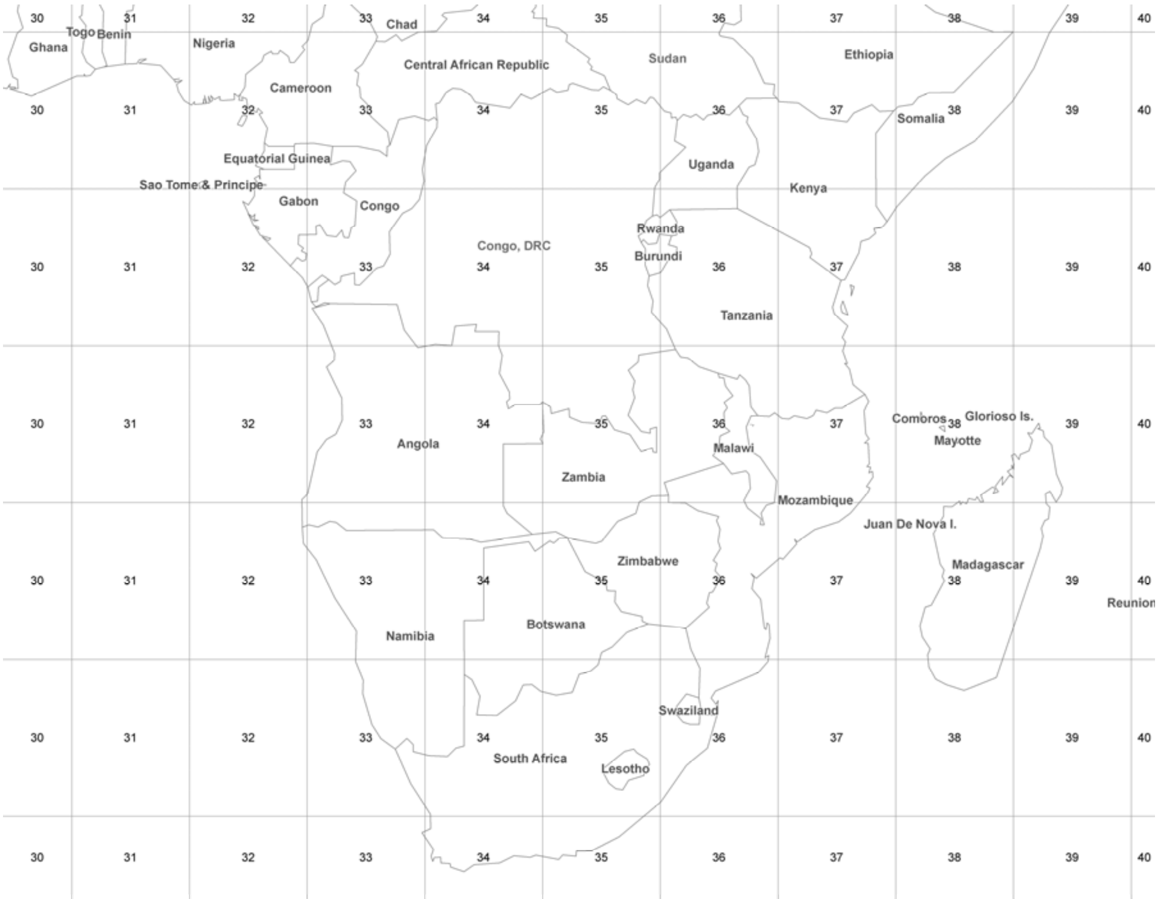
13.2.3. Coordinates System of GIS database

There are a lot of coordinates systems that ArcView can deal with, but the obtained GIS databases do not have the explicit coordinates system. In this case, the ArcView automatically defines the coordinates system as "GCS_Assumed_Geographi", which may cause errors in positioning. Appropriate definition of coordinates is necessary for accurate positioning.

The Study Team combined the GCS_Assumed_Geographic based map and the UTM (Universal Transverse Mercator) based map. These maps are almost consistent with each other. The UTM projection is adopted as the standard in this Study.

The UTM is mainly used for the large scaled map (1/10,000 – 1/200,000) as an international standard. UTM divides longitude into the projection of Zone 1–Zone 60 (longitude of a Zone equals 6 degree = 360 km), and divides latitude into North and South Zone, which makes 120 Zones in total.

The error of one Zone is within 6/10,000 in the UTM projection. Theoretically, the UTM projection displays the map of one Zone seamlessly and it does not display the different Zones simultaneously within the abovementioned margin of error.



Source: JICA study team

Figure 13-1 Southern African UTM Zones

As shown in Figure 13-1, Zambia belongs to the UTM Zones from 34S to 36S, and over half the area of Zambia is positioned in Zone 35S. The Zone 35S is basically used in this study. The ArcView can shift the coordinates to another system without difficulty. To obtain more accurate distance in western Zambia near Angola, and eastern Zambia, near Malawi, UTM 34S or 36S should be used, of course.

13.2.4. Newly Acquired GIS Data

The purpose of this Study to collect existing GIS databases and to develop a new database specialized for planning rural electrification by adding necessary information that has not been recorded as GIS format or even never collected systematically. The following is data are collected through the Provincial Workshops in November 2006 and are incorporated into the database:

- Existing medium-voltage distribution network (33kV – 11kV)
- Candidate Rural Growth Centres (RGCs) for electrification

The existing distribution network, especially medium voltage level, and RGCs data are crucial for developing the Master plan. The power system data in the existing GIS database needs to be improved because of the inaccuracy and incompleteness of some power system information. The Study Team distributed the paper-based 1/250,000 maps to branch office staffs of ZESCO and asked them to trace the power system on it by hand drawing, which was compiled into electronic GIS data. Figure 13-2 shows the updated map of the existing distribution systems.

Information regarding RGCs is also added to the database, including their position, demographic data, and priority order for electrification. The position of RGC is shown in Figure 13-3.

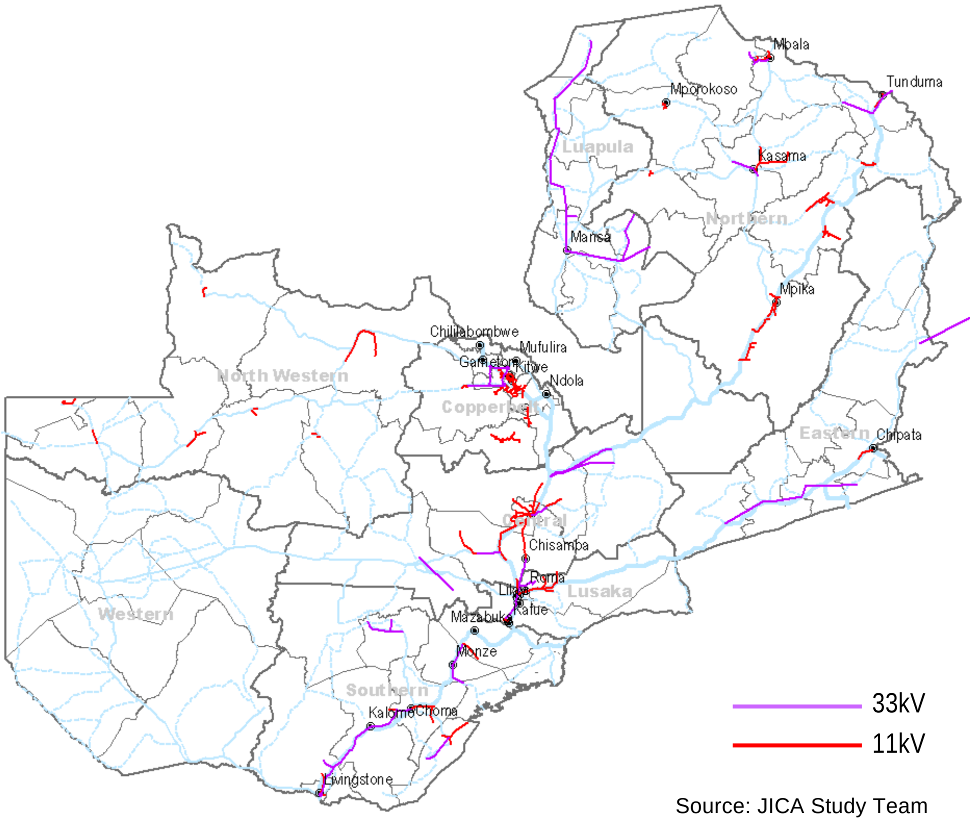


Figure 13-2 Distribution Network in Zambia

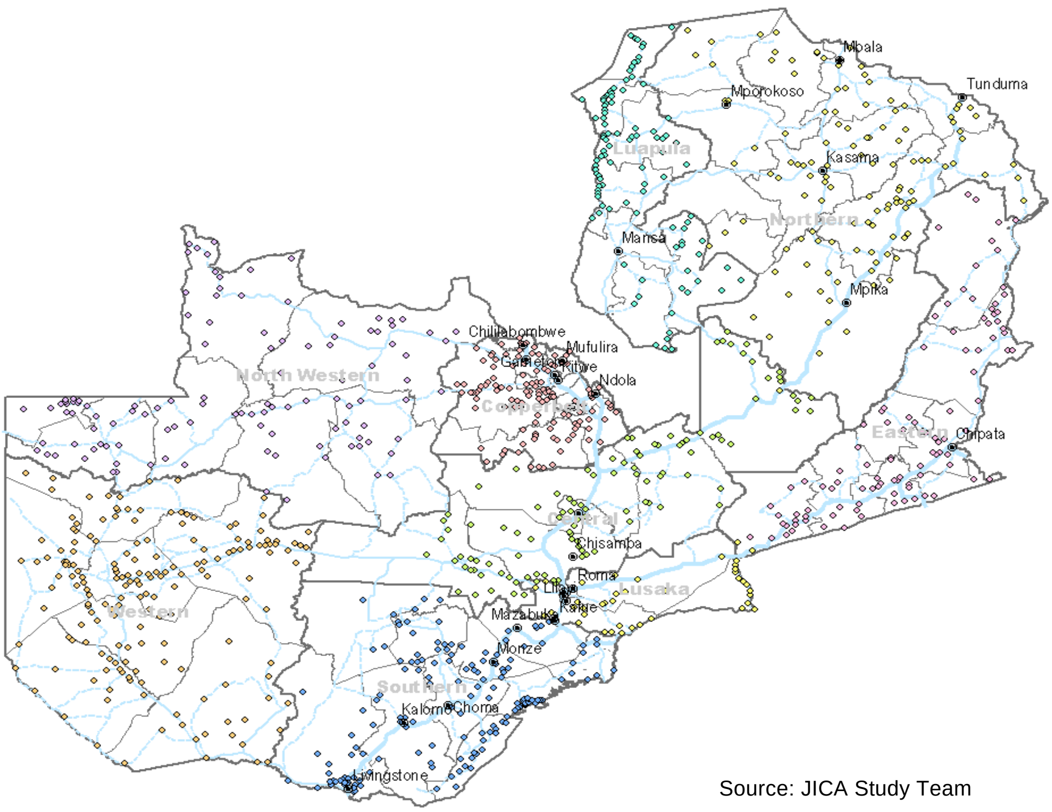
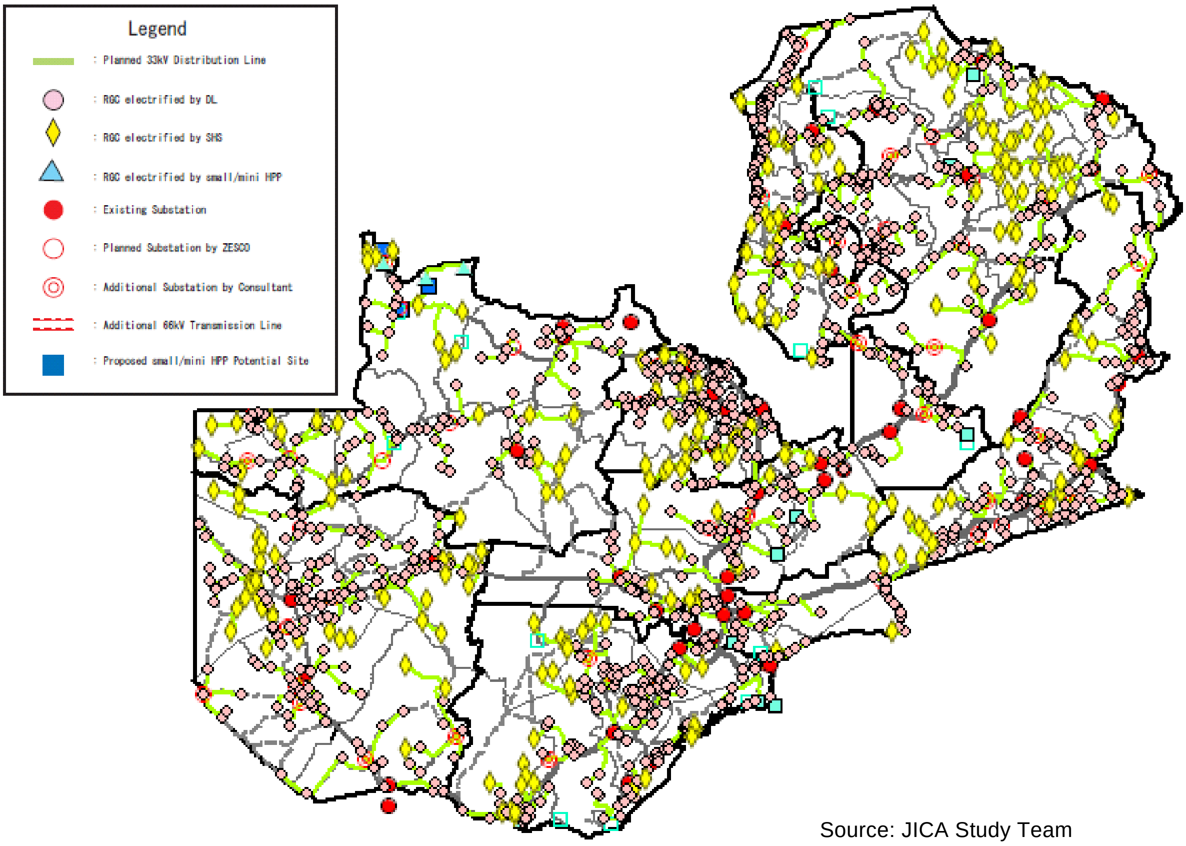


Figure 13-3 Rural Growth Centres Listed in Electrification Candidate

In the last result, this Study developed GIS database including the demand forecast of RGCs, electrification mode and year, and distribution expansion plan etc. as shown in Figure 13-4.



Source: JICA Study Team

Figure 13-4 Example of Final GIS Database

13.2.5. GIS Training

The GIS training was held on 9th and 12th November 2007 at REA with support from GIS expert of REA. The staffs of DOE, REA and ZESCO took this 2-day training course for GIS. This training covered the basic operation of ArcView and how-to utilize GPS device into this Study to improve efficiency of data collection. The tutorial manual was distributed to participants; about 15 people touched the software and became familiar with it. They realized importance of GIS for this kind of project because they need to draw the actual plan on Zambian map. It can manage the map and database with ease. However, the problem is that they don’t have enough license of ArcView. It is better to have at least one license by one organization to share and update the data each other.

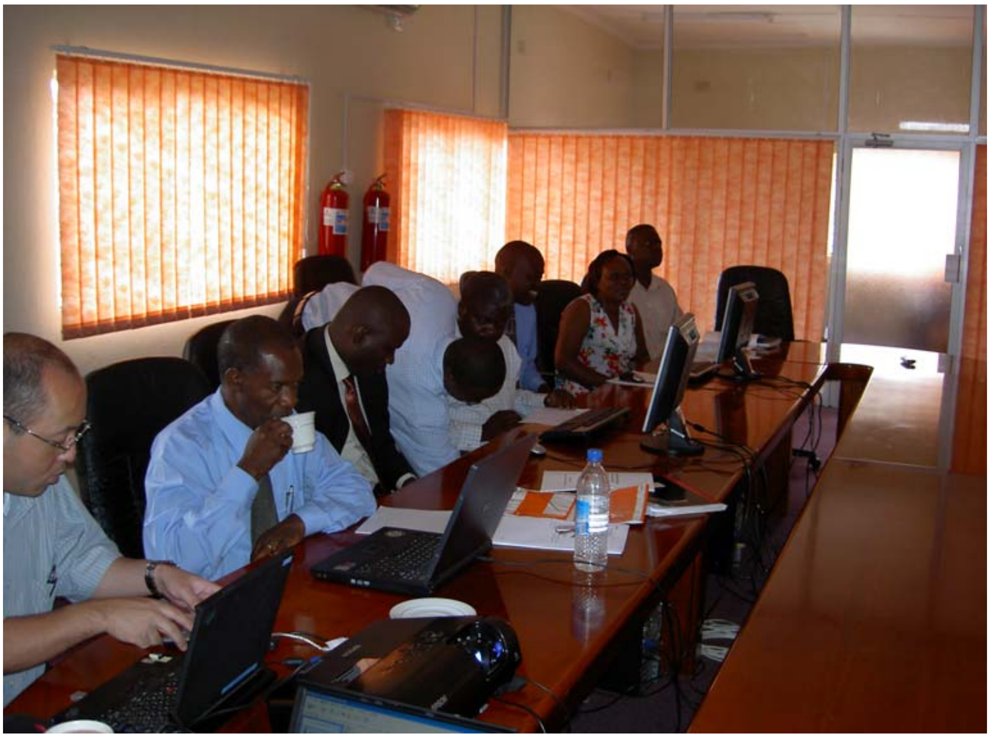


Figure 13-5 GIS Training

Chapter 14

Rural Electrification Master Plan by 2030

Chapter 14. Rural Electrification Master Plan by 2030

14.1. Purpose of Development of Master Plan and Development Flow

To execute rural electrification projects in Zambia, a systematic implementation plan that indicates electrification targets, electrification order, electrification method, time schedule, and required budget is necessary. Therefore, a systematic implementation plan was developed as the Rural Electrification Master Plan (REMP) targeting 2030 along the following principles:

- Develop logical, objective, numerical/quantitative, and convincing Master Plan
- Adopt decentralized planning process
- Provide realistic financial plan to be implemented

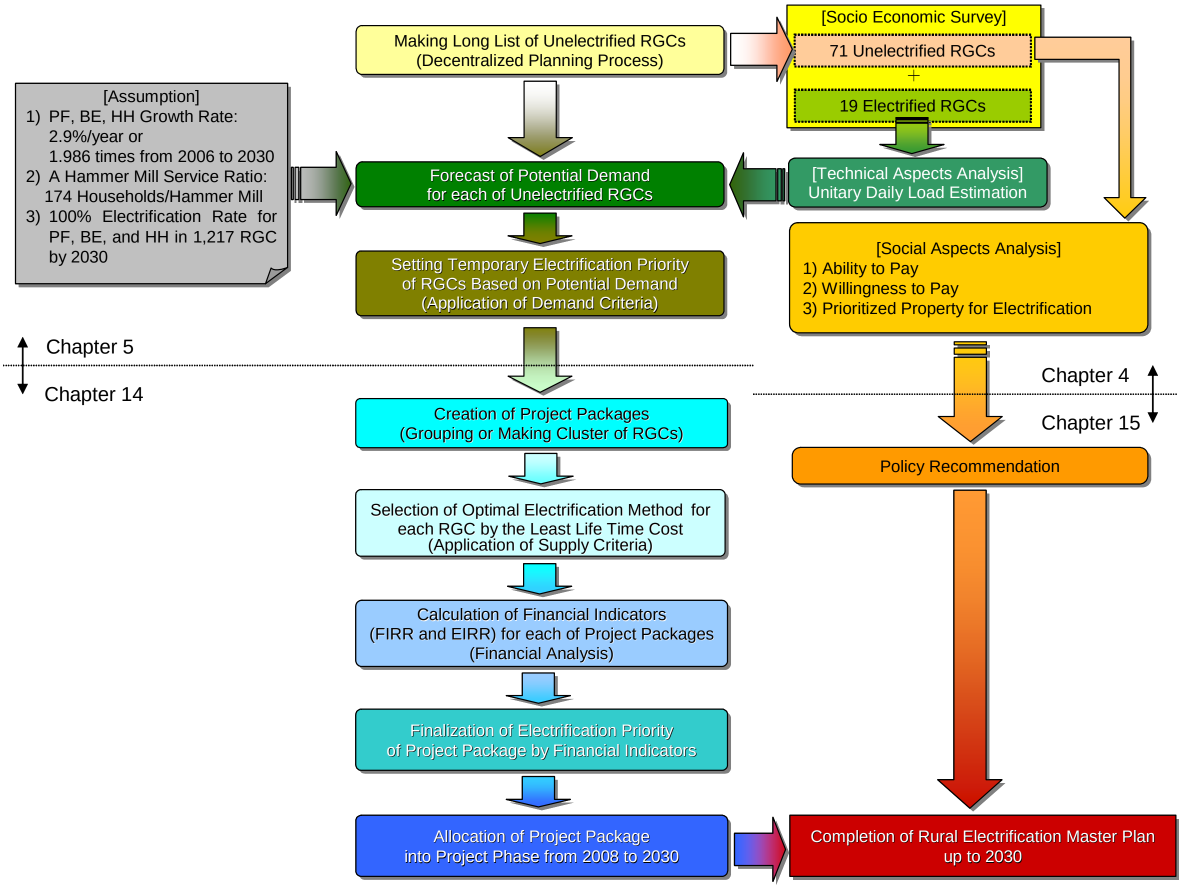


Figure 14-1 Flowchart of Rural Electrification Master Plan Development

The development flow of the REMP is shown in Figure 14-1. As was explained in Chapter 4, a Rural Growth Center (RGC) was selected as the electrification target in the REMP. Based on the information submitted from District Planners in the Workshop held in all the 9 Provincial Centers, 1,217 RGCs were selected as electrification candidates. This is called "Decentralized Planning Process." Then, the potential daily peak demands for the 1,217 unelectrified RGCs were forecasted by using the demographic data of these 1,217 RGCs and analysing the data collected from 19 electrified RGCs in the Socio-Economic Survey. Using the size of the potential peak demand, 1,217

RGCs were given an initial ranking (refer to Table 5-11 in Chapter 5). This process is the application of "Demand Criteria."

Next, the unelectrified RGCs located on a route of a transmission/distribution line extension were grouped to form a Project Package. Each Project Package was then broken down to several Components by shorten the length of the transmission/distribution line extension and introducing stand-alone electrification mode (such as mini-hydro, Solar Home System, or diesel generator) to supply the RGCs where the transmission/distribution line would not reach. For all Components, the Unit Life Time Cost (US$/kWh) of each electrification mode was estimated, and electrification mode having the least Unit Life Time Cost was selected as the optimal Case for each Project Package. This process is the application of "Supply Criteria", which was used to select the optimal electrification method for each of the 1,217 RGCs.

For all Project Packages with the optimal Case, Financial Indicators such as Financial Internal Rate of Return (FIRR) and Economic Internal Rate of Return (EIRR) were calculated, and the final electrification priority of Project Packages was determined by the value of Indicators. Finally, Project Packages were grouped into Annual Project Phases from 2008 to 2030 by the uniform total project cost per year. The process is referred to as "Technical Aspect Analysis."

In addition to the "Technical Aspect Analysis", a "Social Aspect Analysis" (such as for ability to pay, willingness to pay, and prioritized property for electrification) was carried out by using the data collected during the Socio-Economic Survey (refer to Chapter 4).

In this Chapter, applied methods and findings after the process of "Creation of Project packages" in the "Technical Aspect Analysis" are explained. Policy recommendation, elaborated with Stakeholders by taking into account the "Social Aspect Analysis" results, is also introduced in Chapter 15 as a part of conclusion of this Master Plan Study.

14.2. Creation of Project Packages and Subdivided into Project Components

As it was explained in Chapter 5, 1,217 RGCs were initially ranked by the size of potential demand (application of Demand Criteria). Based on this initial ranking, Project Packages or cluster of RGCs electrified by a transmission/distribution line extension were created (refer to Figure 14-2). Process of making Project Package starts from the highest ranked RGC. Along the route to the highest prioritized RGC, some unelectrified RGCs may exist. These RGCs were clustered or grouped into a Project Package as candidates to be electrified by a transmission/distribution line extension project.

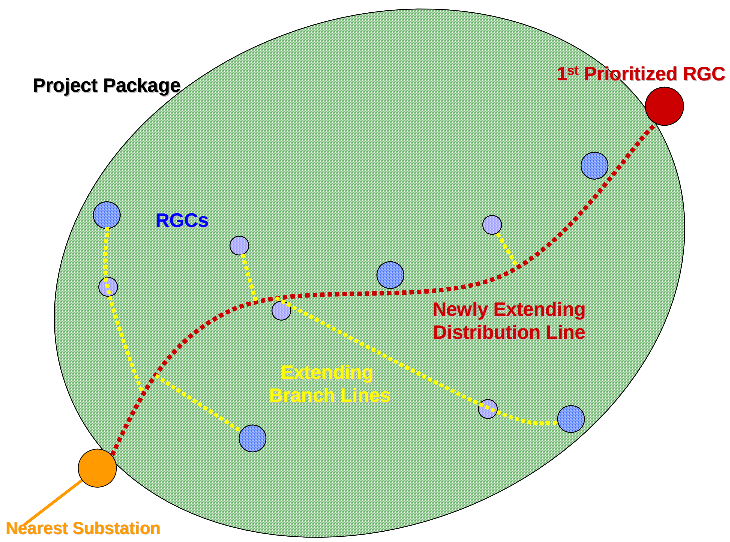


Figure 14-2 Concept of Project Package

Then, each Project Package was subdivided into several Components by shortening the length of transmission/distribution line extension. The process of a Project Package subdivided into Components is shown in Figure 14-3. For example, all the RGCs are connected to transmission/distribution line in Case 1. Then, instead of extending the line to RGC #1, it is electrified by a stand-alone electrification mode (such as Solar Home System, Mini-Hydro, or Diesel Generator) as shown in Case 2. In Case 3, RGC #2 is also isolated and electrified by the stand-alone mode. In Case 4, RGC #3 is additionally isolated. Finally, only RGC #5 is electrified by the line connection, and all other RGCs are electrified by the stand-alone mode as shown in Case 5.

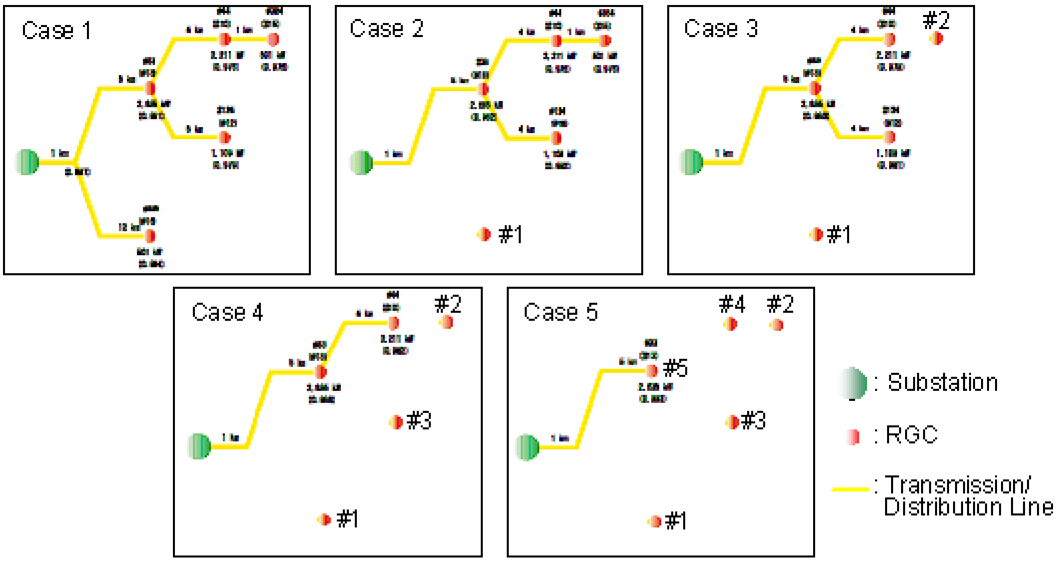


Figure 14-3 Process of a Project Package Broken Down to Cases

This process resulted in grouping the 1,217 unelectrified RGCs into 180 Project Packages subdivided into 835 project Components. In the next step of "Selection of Optimal Electrification Mode for Each RGC", the optimal Case for each Project Package is determined.

14.3. Selection of Optimal Electrification Method for Each RGC

14.3.1. Definition of Unit Life Time Cost

To select the optimal electrification mode for each RGC and define the optimal Case for each Project Package, some criteria were necessary. In general, Financial Indicators (such as FIRR and EIRR) are the most suitable selection criteria. These criteria, however, were not applicable here, since the Financial Indicators for an electrification mode of the Solar Home System (SHS) would always have negative values. This situation would occur under the assumption that SHS equipment would be sold outright to customers and they would operate and maintain (O&M) the equipments. In this situation, there would be no future income from the operation of SHS. Thus, in the calculation of the Financial Indicators, only expenditure for initial cost (equipment cost) and O&M expenses would be appear.

As an alternative criterion of the Financial Indicators, "Unit Life Time Cost in Net Present Value (US$/kWh)" was adopted in this study. The method of calculating the Unit Life Time Cost in Net Present Value is shown in Equation 14-1.

Unit Life Time Cost in Net Present Value (US$/kWh)

$=F_{NPV}$\{[Construction/Initial Cost (US$)＋Total O&M Cost for Life Time (US$)]\}

÷ Total Amount of Electricity Consumable during the Life Time (kWh) (Equation 14-1)

F_{NPV}\{X\}: Function of converting value of X into the Net Present Value (US$)

First, the net present value ("Total Life Time Cost") was calculated from the necessary construction/initial cost and O&M cost for life time of each electrification mode (US$). Next, the total amount of electricity consumable during the life time of each electrification mode (kWh) was worked out ("Life Time Consumable Electricity"). Then, the Unit Life Time Cost in Net Present Value of each electrification mode was estimated by dividing the Total Life Time Cost by the Life Time Consumable Electricity. Finally, electrification mode having the least Unit Life Time Cost in Net Present Value was selected as the optimal electrification mode for each RGC and the optimal Case for each Project Package. The assumed Life Time for each electrification mode is summarized in Table 14-1.

Table 14-1 Assumed Life Time for Each Electrification Mode

Electrification Mode	Life Time
1) Transmission/Distribution Line	30 years
2) Solar Home System	15 years for SHS Panel 5 years for Battery
3) Mini-Hydro	40 years
4) Diesel Generator	20 years

14.3.2. Results of Selecting Optimal Electrification Method

The Unit Life Time Cost in Net Present Value of each electrification mode was calculated for all 835 Project Components made up from 180 Project Packages. The component with the least value was selected as the optimal electrification mode for a Project Package. The number of Project Packages for each combination of electrification mode was summarized in Table 14-2. The majority is either the combination of distribution extension and SHS or that of transmission and distribution extension (56 and 55 Project Packages respectively). It is also found that only three of the mini-hydro power plants, among 29 possible candidate sites considered in this study, are feasible: a Project Package each for the combination of mini-hydro, SHS and distribution extension, for the combination of mini-hydro and SHS, and for the mini-hydro only. The diesel generator option was not selected in any of the Project Package, since the operation cost is too high due to the fuel price (also refer to Appendix-E Current Situation of Diesel Generation in Rural Area).

Table 14-2 Number of Project Packages in Each Combination of Electrification Mode

Combination of Electrification Mode				Project Package
Transmission	Distribution	SHS	Mini-Hydro	
○	○			55 (30.6%)
○	○	○		27 (15.0%)
	○			39 (21.7%)
	○	○		56 (31.1%)
	○	○	○	1 (0.6%)
		○	○	1 (0.6%)
			○	1 (0.6%)
-	-	-	-	180 (100.0%)

The number of RGCs and households for each electrification mode were also summarized in Table 14-3. Approximately 80% of RGCs and 95% of households fall under electrification by transmission/distribution line extension. Only 4 RGCs or 9,702 households will be electrified by three mini-hydro power plants. As the SHS market, 241 RGCs are identified and their names are listed by Province in Table 14-6.

Table 14-3 Number of RGCs and Households Electrified by Each Mode

Electrification Mode	RGC	HH
Transmission/Distribution Line Extension	972 (79.9%)	1,008,622 (94.5%)
Solar Home System Installation	241 (19.8%)	49,405 (4.6%)
Mini-Hydro Power Development	4 (0.3%)	9,702 (0.9%)
Total	1,217 (100.0%)	1,067,729 (100.0%)

14.4. Electrification Priority of Project Package

14.4.1. Calculation of Financial Indicators

For all 180 Project Packages (with each optimal Case), Financial Indicators (namely FIRR and EIRR) were calculated. The assumptions used for the calculation were summarized in Table 14-4. It is important to note that the calculation of the Financial Indicators excluded all SHS in Project Packages. As discussed earlier, it was assumed tat the O&M costs would be borne by the beneficiaries, and that there was no income from the operation of SHS installation.

Table 14-4 Assumptions for Financial Indicator Calculation

Monthly Unit Electricity Consumption (kWh)	
Households	163
Commercial Customers	163
Hammer Mills	5,931
Public Facilities	
1) Basic/Primary School	331
2) High/Secondary School	54
3) Tertiary School	1,609
4) Hospital	12,904
5) Health Center/Clinic	337
6) Police Office	125
7) Post Office	144
8) Church	58
9) Mosque	58
10) Community Center	455
11) Agriculture Depot	215
12) Orphanage	250
13) Central Government Office	181
14) Provincial Government Office	438
15) District Government Office	696
16) Other Local Administration Office	438
17) Court	297
18) Other (Average)	297

	K	US$
Exchange rate	4,000.00	1.00

Standard Conversion Factor	0.892
Conversion Factor for Unskilled Labor	0.70

Current Monthly Average Cost for Alternative Energy	K	US $
Household & Business Entity	65,534	16.38

Willingness to Pay	K / Month	US$ / Month
Households	37,197	9.30

Discount Factor	12.00%

Tariffs		K	US $
Metered Households			
	0-300 kWh	102	0.026
	301-700 kWh	145	0.036
	>700 kWh	236	0.059
	Monthly fixed charge	8,475	2.12
Commercial Tariffs		245	0.061
	Monthly fixed charge	43,841	10.96
Social Tariffs		201	0.050
	Monthly fixed charge	34,839	8.71

Annual Increase Rate	
Households	2.9%
Commercial Consumers	2.9%
Social Consumers	2.9%
A Unit Hammer Mill Service Ratio (HH/HM)	174
Annual Tariff increase	1.0%
Zesco Collection Efficiency	90%

Operation Costs

Percentages of Initial Capital Cost

	DL	SHS	Diesle		Hydro	
Operation & Maintenance	1.00%	1.00%	0.024	US$/kWh	0.024	US$/kWh
Customer care	0.10%	0.00%	0.10%		0.10%	
Overheads	0.10%	0.00%	0.10%		0.10%	
Depreciation	3.3%	6.60%	5.00%		2.50%	
Fuel Cost	-	-	0.27	US$/kWh	-	

Bulk Supply Tariff	K	US $
	65	0.016
Increase pa		1.0%

Infration Rate	
Foreign Currency	2%
Domestic Currency	8%

14.4.2. Final Electrification Priority Order of Project Packages by Financial Indicators

The final electrification priority order of Project Packages in the Master Plan was determined by FIRR (calculated excluding the SHS portion for Project Packages), since it was the most important indicator to evaluate the project's financial viability and the project's capacity to redeem a loan. The final priority order of Project Packages was shown in Table 14-5, together with the Unit Life Time Cost in Net Present Value, project costs with each electrification mode, and EIRR for each of Project Packages (a sample of the financial indicators' calculation process is also shown in Appendix-F).

Project Packages are listed in the order of priority (set by FIRR) for each Province in Table 14-6. In the table, the optimal electrification mode selected for each of RGCs is also indicated. The number of Project Packages and RGCs electrified by each mode are summarized by Province in Table 14-7.

Table 14-7 Number of Project Packages and Electrification Mode for RGCs by Province

Province	# of PP	# of Elec. RGCs by DL	# of Elec. RGCs by SHS	# of Elec. RGCs by Hydro	Total # of RGCs
Central	19	105	19		124
Copperbelt	16	105	24		129
Eastern	25	104	18		122
Luapula	18	98	23		121
Lusaka	5	36	4		40
Northern	32	140	55		195
North-Western	18	94	24	4	122
Southern	21	140	33		173
Western	26	150	41		191
Total	**180**	**972**	**241**	**4**	**1,217**

14.5. Allocation of Project Packages into Annual Project Phases

As summarized in Table 14-8, US$ 1,103 million is needed to implement all 180 Project Packages. This translates to approximately US$ 50 million per year for 22 years from 2008 to 2030.

Table 14-8 Necessary Electrification Project Cost by 2030 in Each Mode

Electrification Mode	Cost in US$
Transmission/Distribution Line Extension	1,022,385,240 (92.7%)
Solar Home System Installation	58,489,689 (5.3%)
Mini-Hydro Power Development	22,210,313 (2.0%)
Total	1,103,085,242 (100.0%)

Then, the prioritized 180 Project Packages are grouped into 22 Annual Project Phases each requiring US$ 50 million, as shown in Table 14-9.

Table 14-5 Final Electrification Priority of Project Packages by 2030 (1/2)

FIRR Ranking	Substation	Province	Feeder & Package	Trans./Dist. Line Cost (US$)	SHS Cost (US$)	Hydro Cost (US$)	Total Project Package Cost	Least Life Time Cost	Project Package FIRR	Project Package EIRR
1	Isoka	Northern	1 - 1	673,272	990,123		1,663,395	0.0092	22.0%	59.9%
2	Azele	Eastern	2 - 2	1,899,936			1,899,936	0.0060	20.5%	57.5%
3	Kapiri Mposhi	Central	2 - 2	2,701,296			2,701,296	0.0064	18.1%	50.2%
4	Kansunswa	Copperbelt	1 - 8	4,522,824			4,522,824	0.0078	13.2%	35.1%
5	Azele 2	Eastern	2 - 1	2,596,212			2,596,212	0.0080	12.1%	34.1%
6	Azele	Eastern	1 - 2	1,608,120			1,608,120	0.0080	12.0%	33.9%
7	Azele 3	Eastern	1 - 2	3,388,392			3,388,392	0.0082	11.5%	32.4%
8	Isoka	Northern	2 - 1	747,576	1,243,873		1,991,449	0.0167	11.0%	29.5%
9	Azele 1	Eastern	1 - 5	3,600,612			3,600,612	0.0085	11.0%	31.1%
10	Ndola 1	Copperbelt	1 - 4	3,675,672			3,675,672	0.0087	10.8%	29.5%
11	Lundazi	Eastern	3 - 2	2,733,588			2,733,588	0.0094	9.5%	26.1%
12	Chipata	Eastern	2 - 2	4,280,904	416,277		4,697,181	0.0100	9.2%	26.3%
13	Mbereshi	Luapula	1 - 3	2,620,728	622,820		3,243,548	0.0116	9.1%	22.2%
14	Azele 5	Eastern	1 - 3	7,189,452			7,189,452	0.0096	8.7%	25.6%
15	Kasama 1	Northern	1 - 2	4,137,372	483,813		4,621,185	0.0105	8.7%	24.9%
16	Senanga	Western	1 - 1	2,146,932			2,146,932	0.0102	8.5%	23.3%
17	Mbereshi	Luapula	2 - 1	1,854,468			1,854,468	0.0100	8.4%	23.9%
18	Kitwe	Copperbelt	1 - 3	2,269,080	368,850		2,637,930	0.0114	8.2%	22.6%
19	Azele 2	Eastern	1 - 3	4,538,160			4,538,160	0.0101	8.2%	23.8%
20	Luwingu	Northern	3 - 3	1,395,468			1,395,468	0.0103	7.7%	23.2%
21	Mponqwe	Copperbelt	3 - 2	2,048,868	80,283		2,129,151	0.0107	7.6%	22.8%
22	Mongu 2	Western	2 - 3	5,644,512	460,417		6,104,929	0.0112	7.5%	22.1%
23	Nchelenge	Luapula	1 - 4	2,087,748	364,872		2,452,620	0.0127	7.5%	19.1%
24	Azele 3	Eastern	2 - 1	2,509,596			2,509,596	0.0105	7.5%	22.6%
25	Azele 1	Eastern	2 - 2	3,545,532	1,139,130		4,684,662	0.0130	7.1%	21.9%
26	Mongu 2	Western	1 - 3	4,102,704	219,028		4,321,732	0.0114	7.1%	20.9%
27	Mumbwa	Central	1 - 3	2,034,072	684,666		2,718,738	0.0133	7.0%	21.3%
28	Nchelenge	Luapula	2 - 4	4,227,552	225,395		4,452,947	0.0121	6.8%	19.1%
29	Nakonde	Northern	1 - 2	3,076,272	1,064,965		4,141,237	0.0154	6.7%	16.6%
30	Mongu	Western	1 - 4	3,890,700			3,890,700	0.0119	5.9%	19.0%
31	Muzuma 2	Southern	2 - 1	3,703,968			3,703,968	0.0125	5.6%	17.7%
32	Luwingu 3	Northern	2 - 5	4,202,496			4,202,496	0.0126	5.5%	17.4%
33	Samfya 2	Luapula	2 - 2	2,752,596			2,752,596	0.0139	5.0%	14.4%
34	Luano	Copperbelt	1 - 3	2,387,772	284,120		2,671,892	0.0148	4.9%	15.5%
35	Mbereshi 1	Luapula	2 - 5	6,313,140	559,897		6,873,037	0.0147	4.9%	15.2%
36	Mbala	Northern	2 - 4	5,112,504	2,547,823		7,660,327	0.0174	4.8%	17.1%
37	Pensulo	Central	1 - 1	599,616			599,616	0.0146	4.6%	13.7%
38	Msoro	Eastern	1 - 1	1,486,296			1,486,296	0.0139	4.6%	14.4%
39	Azele 4	Eastern	2 - 3	5,366,628	341,988		5,708,616	0.0140	4.6%	16.4%
40	Kabwe 1	Central	1 - 3	4,443,228			4,443,228	0.0136	4.5%	16.0%
41	Solwezi	North-Western	1 - 1	3,196,692			3,196,692	0.0134	4.5%	16.3%
42	Senanga	Western	3 - 3	4,424,004			4,424,004	0.0138	4.4%	15.6%
43	Luwingu 2	Northern	2 - 5	6,526,008			6,526,008	0.0135	4.4%	16.3%
44	Victoria Falls	Southern	3 - 1	1,662,120	1,365,257		3,027,377	0.0213	4.4%	16.0%
45	Kabwe 2	Central	1 - 2	5,905,008			5,905,008	0.0137	4.3%	15.9%
46	Luano	Copperbelt	2 - 4	2,782,080	512,429		3,294,509	0.0165	4.3%	13.8%
47	Senanga 3	Western	1 - 2	5,513,508			5,513,508	0.0141	4.2%	15.2%
48	Ndola	Copperbelt	1 - 3	4,725,756			4,725,756	0.0143	4.1%	14.6%
49	Kitwe	Copperbelt	2 - 3	2,922,804	314,531		3,237,335	0.0171	4.0%	11.9%
50	Samfya 1	Luapula	2 - 3	4,234,788			4,234,788	0.0153	3.9%	13.2%
51	Samfya	Luapula	1 - 1	1,286,388	293,925		1,580,313	0.0169	3.7%	14.6%
52	Muzuma 1	Southern	2 - 1	2,582,172	2,251,605		4,833,777	0.0243	3.6%	14.0%
53	Mwinilunga 1	North-Western	1 - 0		3,070,610	2,654,970	5,725,580	0.0195	3.6%	14.5%
54	Mporokoso	Northern	2 - 6	7,404,372			7,404,372	0.0148	3.6%	14.3%
55	Kawambwa Tea	Luapula	1 - 6	4,996,188	401,485		5,397,673	0.0183	3.5%	10.4%
56	Mbereshi 1	Luapula	1 - 3	4,493,664	531,461		5,025,125	0.0170	3.4%	12.7%
57	Samfya 2	Luapula	1 - 3	4,748,220			4,748,220	0.0159	3.3%	12.4%
58	Kaoma	Western	4 - 2	3,370,788	397,632		3,768,420	0.0168	3.2%	13.4%
59	Nampundwe	Central	1 - 5	6,327,072	521,627		6,848,699	0.0166	3.1%	13.2%
60	Luwingu 1	Northern	1 - 5	7,400,916			7,400,916	0.0157	2.9%	13.2%
61	Isoka	Northern	3 - 2	4,738,824			4,738,824	0.0160	2.9%	12.9%
62	Kasama 2	Northern	1 - 4	7,680,960			7,680,960	0.0162	2.8%	12.3%
63	Kalabo	Western	1 - 3	6,112,368	723,406		6,835,774	0.0174	2.7%	13.0%
64	Muzuma 3	Southern	1 - 3	4,332,960			4,332,960	0.0166	2.7%	12.1%
65	Pensulo 1	Central	2 - 5	5,346,756			5,346,756	0.0164	2.7%	12.5%
66	Luwingu 3	Northern	1 - 3	3,819,528			3,819,528	0.0161	2.6%	13.0%
67	Lundazi	Eastern	1 - 2	2,785,860	1,479,405		4,265,265	0.0240	2.3%	11.5%
68	Mongu	Western	2 - 5	7,319,376			7,319,376	0.0167	2.3%	12.3%
69	Nchelenge 1	Luapula	1 - 3	4,821,120			4,821,120	0.0185	2.3%	10.1%
70	Luwingu	Northern	1 - 4	7,722,972			7,722,972	0.0168	2.2%	12.3%
71	Senanga 2	Western	2 - 2	2,739,744			2,739,744	0.0171	2.2%	11.8%
72	Kabwe	Central	2 - 5	6,232,788	225,782		6,458,570	0.0180	2.1%	11.5%
73	Senanga 3	Western	2 - 3	7,618,536			7,618,536	0.0174	2.1%	11.6%
74	Kapiri Mposhi	Central	1 - 6	5,497,848	399,856		5,897,704	0.0189	2.0%	11.0%
75	Kalabo	Western	2 - 1	2,756,268	794,187		3,550,455	0.0216	1.8%	11.4%
76	Senanga 2	Western	1 - 3	3,328,452			3,328,452	0.0187	1.8%	10.2%
77	Mporokoso	Northern	1 - 5	4,094,712			4,094,712	0.0182	1.7%	10.6%
78	Muzuma 1	Southern	1 - 4	6,212,484	1,331,379		7,543,863	0.0220	1.7%	10.1%
79	Mongu 1	Western	1 - 4	6,380,748	2,847,936		9,228,684	0.0241	1.6%	11.1%
80	Lundazi 1	Eastern	1 - 3	4,215,024			4,215,024	0.0184	1.5%	10.8%
81	Kaoma	Western	1 - 2	3,539,376	1,801,008		5,340,384	0.0288	1.5%	8.5%
82	Mazabuka	Southern	1 - 3	3,732,048	738,598		4,470,646	0.0279	1.5%	3.5%
83	Luwingu 2	Northern	1 - 5	7,625,988			7,625,988	0.0182	1.5%	11.0%
84	Mfuwe 1	Eastern	1 - 5	4,821,120	175,869		4,996,989	0.0190	1.5%	10.7%
85	Solwezi	North-Western	2 - 4	2,663,712			2,663,712	0.0188	1.5%	10.4%
86	Kafwe Town	Lusaka	1 - 3	1,582,632			1,582,632	0.0199	1.5%	9.2%
87	Mumbwa	Central	3 - 4	6,012,576			6,012,576	0.0191	1.3%	10.2%
88	Lundazi	Eastern	2 - 7	8,256,276			8,256,276	0.0203	1.2%	9.1%
89	Isoka 1	Northern	1 - 1	4,628,988			4,628,988	0.0199	1.2%	9.5%
90	Muzuma 3	Southern	2 - 6	5,251,284			5,251,284	0.0200	1.1%	9.4%

Table 14-5 Final Electrification Priority of Project Packages by 2030 (2/2)

FIRR Ranking	Substation	Province	Feeder & Package			Trans./Dist. Line Cost (US$)	SHS Cost (US$)	Hydro Cost (US$)	Total Project Package Cost	Least Life Time Cost	Project Package FIRR	Project Package EIRR
91	Luano 2	Copperbelt	1	-	5	6,468,768	109,535		6,578,303	0.0209	1.1%	8.8%
92	Isoka 1	Northern	2	-	1	4,419,792			4,419,792	0.0196	1.1%	9.8%
93	Azele 4	Eastern	1	-	4	11,500,056			11,500,056	0.0193	1.0%	10.1%
94	New SS at Lukulu	Western	1	-	5	8,474,976			8,474,976	0.0228	1.0%	6.9%
95	Mongu 1	Western	2	-	8	10,201,680			10,201,680	0.0193	1.0%	10.2%
96	Mpika	Northern	1	-	1	1,251,288	508,921		1,760,209	0.0260	0.9%	9.5%
97	Mkushi	Central	1	-	7	5,977,476	951,259		6,928,735	0.0257	0.8%	7.1%
98	Nchelenge 1	Luapula	2	-	4	7,155,648			7,155,648	0.0215	0.8%	8.3%
99	Luwingu	Northern	2	-	5	6,742,008	726,748		7,468,756	0.0216	0.7%	9.7%
100	Mfuwe	Eastern	1	-	3	7,515,828			7,515,828	0.0203	0.6%	9.5%
101	Mazabuka 1	Southern	2	-	6	6,055,668			6,055,668	0.0222	0.6%	7.7%
102	Maposa	Copperbelt	2	-	4	3,617,136			3,617,136	0.0221	0.4%	8.1%
103	Chinsali	Northern	2	-	1	1,129,140	1,201,445		2,330,585	0.0438	0.4%	6.3%
104	Senanga	Western	2	-	3	8,819,172			8,819,172	0.0213	0.4%	8.7%
105	Kasama	Northern	2	-	5	7,077,132			7,077,132	0.0217	0.4%	8.5%
106	Kasama	Northern	1	-	3	2,891,484	2,822,026		5,713,510	0.0372	0.3%	8.7%
107	Mpika	Northern	2	-	3	3,820,824	1,316,505		5,137,329	0.0276	0.3%	8.4%
108	Mpika	Northern	3	-	1	2,613,816	1,384,800		3,998,616	0.0311	0.0%	8.2%
109	Azele 6	Eastern	2	-	2	3,756,780			3,756,780	0.0221	0.0%	8.4%
110	Maposa	Copperbelt	1	-	6	9,154,296	37,124		9,191,420	0.0238	-0.3%	7.3%
111	Chipili	Luapula	1	-	4	4,341,060	90,503		4,431,563	0.0255	-0.4%	6.4%
112	Mumbwa	Central	2	-	3	4,442,904			4,442,904	0.0257	-0.5%	5.7%
113	Mpika 1	Northern	1	-	2	7,672,860			7,672,860	0.0240	-0.5%	7.3%
114	Kitwe	Copperbelt	3	-	8	6,919,884	201,447		7,121,331	0.0282	-0.7%	4.7%
115	Sesheke	Western	1	-	4	8,686,008			8,686,008	0.0253	-0.7%	6.4%
116	Chilundu	Southern	1	-	3	3,358,044	296,011		3,654,055	0.0278	-0.8%	6.1%
117	Azele 6	Eastern	1	-	3	7,118,712	142,129		7,260,841	0.0246	-0.8%	7.3%
118	Mkushi Farm Block	Central	1	-	5	7,162,452	665,468		7,827,920	0.0300	-0.8%	5.1%
119	Chipata	Eastern	1	-	4	6,059,016	481,548		6,540,564	0.0267	-0.9%	6.8%
120	Pensulo 1	Central	1	-	4	5,382,180			5,382,180	0.0246	-0.9%	7.1%
121	Mazabuka 1	Southern	3	-	9	6,448,248			6,448,248	0.0262	-1.0%	6.1%
122	Muzuma 2	Southern	1	-	4	7,654,932	254,481		7,909,413	0.0255	-1.0%	7.0%
123	Chinsali	Northern	3	-	1	710,748	813,992		1,524,740	0.0510	-1.0%	5.4%
124	New SS at Kabompo	North-Western	2	-	5	11,671,020			11,671,020	0.0253	-1.1%	6.7%
125	New SS at Lukulu	Western	2	-	2	5,237,244	1,774,905		7,012,149	0.0335	-1.2%	6.1%
126	Sinazongwe	Southern	1	-	8	5,275,908	805,526		6,081,434	0.0320	-1.2%	4.9%
127	Kabwe	Central	1	-	7	6,657,012			6,657,012	0.0265	-1.3%	6.1%
128	New SS at Zambezi	North-Western	2	-	2	5,368,680	334,115		5,702,795	0.0277	-1.6%	6.3%
129	Zambezi 1	North-Western	1	-	4	6,354,180	279,755		6,633,935	0.0275	-1.6%	6.3%
130	New SS at Mwinilunga	North-Western	4	-	0			8,688,211	8,688,211	0.0261	-2.0%	4.6%
131	New SS at Zambezi	North-Western	1	-	6	10,004,364	1,185,245		11,189,609	0.0327	-2.2%	4.7%
132	Luano 1	Copperbelt	1	-	4	4,479,516	134,174		4,613,690	0.0341	-2.4%	3.4%
133	Samfya 1	Luapula	1	-	5	6,764,040			6,764,040	0.0317	-2.4%	4.1%
134	Muzuma 1	Southern	3	-	1	2,671,272	353,962		3,025,234	0.0340	-2.4%	4.6%
135	Pensulo 2	Central	2	-	2	12,876,408	164,406		13,040,814	0.0308	-2.5%	4.8%
136	Mpongwe	Copperbelt	2	-	1	1,717,848	79,938		1,797,786	0.0330	-2.6%	4.1%
137	Senanga 1	Western	1	-	4	17,644,176			17,644,176	0.0308	-2.6%	4.6%
138	Pensulo 2	Central	1	-	5	10,138,284			10,138,284	0.0317	-2.8%	4.4%
139	Luano 1	Copperbelt	2	-	4	6,293,808			6,293,808	0.0347	-2.9%	3.0%
140	New SS at Chilundu	Lusaka	2	-	1	12,229,164	306,618		12,535,782	0.0355	-2.9%	2.9%
141	Coventry	Lusaka	1	-	4	5,448,276	145,637		5,593,913	0.0370	-3.0%	2.2%
142	Mpika 2	Northern	1	-	3	9,631,764			9,631,764	0.0331	-3.1%	4.0%
143	Kaoma	Western	2	-	3	8,182,620	915,627		9,098,247	0.0376	-3.1%	3.4%
144	Mpika 1	Northern	2	-	3	11,886,696			11,886,696	0.0354	-3.4%	3.2%
145	Mazabuka 1	Southern	1	-	4	4,611,924			4,611,924	0.0374	-3.5%	2.4%
146	New SS at Mwinilunga	North-Western	3	-	2	3,620,916			3,620,916	0.0357	-3.5%	3.1%
147	New SS at Mwinilunga	North-Western	2	-	4	9,098,892			9,098,892	0.0360	-3.6%	3.1%
148	New SS at Mwinilunga	North-Western	1	-	1	7,986,492	1,449,173	10,867,131	20,302,796	0.0556	-3.9%	0.4%
149	Fig Tree	Central	1	-	6	7,295,940	262,271		7,558,211	0.0422	-3.9%	1.6%
150	Leopard's Hill	Lusaka	1	-	11	12,860,964			12,860,964	0.0378	-4.0%	2.5%
151	Serenje	Central	1	-	3	7,325,532			7,325,532	0.0388	-4.2%	2.4%
152	Victoria Falls	Southern	2	-	4	5,194,692	287,628		5,482,320	0.0479	-4.2%	0.3%
153	New SS at Mufumbwe	North-Western	1	-	7	13,583,916	342,885		13,926,801	0.0438	-4.5%	1.4%
154	Kalabo	Western	3	-	5	16,060,140	532,911		16,593,051	0.0422	-5.0%	2.1%
155	Kaoma	Western	3	-	3	10,689,516			10,689,516	0.0449	-5.1%	0.8%
156	Mpongwe	Copperbelt	1	-	5	8,589,996	143,027		8,733,023	0.0434	-5.1%	1.7%
157	Muzuma	Southern	2	-	2	4,124,628			4,124,628	0.0434	-5.3%	1.5%
158	Kasempa	North-Western	2	-	4	6,585,084	319,324		6,904,408	0.0499	-5.3%	0.2%
159	Chipili	Luapula	2	-	2	8,145,792	199,099		8,344,891	0.0488	-6.0%	0.7%
160	Solwezi	North-Western	3	-	5	10,115,604			10,115,604	0.0487	-6.0%	0.5%
161	Isoka 1	Northern	3	-	1	5,762,340			5,762,340	0.0482	-6.0%	0.7%
162	Sesheke 1	Western	1	-	5	12,350,988	968,951		13,319,939	0.0531	-6.0%	0.1%
163	Muzuma	Southern	1	-	5	5,281,740			5,281,740	0.0533	-6.1%	-0.7%
164	Mansa	Luapula	2	-	3	1,619,784	203,035		1,822,819	0.0675	-6.1%	-2.5%
165	Chilundu	Southern	2	-	8	8,734,500			8,734,500	0.0525	-6.5%	-0.2%
166	Victoria Falls	Southern	1	-	5	3,954,312			3,954,312	0.0662	-6.6%	-3.1%
167	New SS at Mumbezi	North-Western	1	-	2	6,636,492			6,636,492	0.0523	-6.8%	0.0%
168	New SS at Chavuma	North-Western	1	-	8	6,411,204	357,387		6,768,591	0.0641	-7.0%	-1.7%
169	Muzuma	Southern	3	-	1	2,869,452	213,808		3,083,260	0.0579	-7.0%	-0.5%
170	New SS at Kabompo	North-Western	1	-	4	11,623,500			11,623,500	0.0579	-7.0%	-1.9%
171	New SS at Chama	Eastern	2	-	5	11,377,800			11,377,800	0.0538	-7.0%	-0.1%
172	New SS at Chama	Eastern	1	-	3	14,867,712			14,867,712	0.0609	-7.8%	-1.3%
173	Chinsali	Northern	1	-	4	9,725,076			9,725,076	0.0673	-7.8%	-2.6%
174	New SS at Chilundu	Lusaka	1	-	1	5,460,912	364,872		5,825,784	0.0634	-8.1%	-1.1%
175	New SS at Nyimba	Eastern	1	-	6	6,449,544	421,373		6,870,917	0.0744	-8.2%	-4.4%
176	Kasempa	North-Western	1	-	4	3,180,492	254,357		3,434,849	0.0679	-8.7%	-3.0%
177	Maamba	Southern	1	-	8	15,099,588	71,983		15,171,571	0.0800	-9.8%	-3.8%
178	Sesheke 2	Western	1	-	4	21,945,600			21,945,600	0.0743	-10.2%	-2.7%
179	Mansa	Luapula	1	-	5	7,531,272	738,142		8,269,414	0.1071	-12.6%	-5.6%
180	Mbala	Northern	1	-	2	5,990,868	599,286		6,590,154	0.0964	-13.1%	-4.2%
Total		-	-	-	-	**1,022,385,240**	**58,489,689**	**22,210,313**	**1,103,085,242**	-	-	-

Table 14-6 Electrification Priority of Project Packages by Province (1/12)
Central Province

Provincial Ranking	1	2	3	4	5
Substation	Kapiri Mposhi	Mumbwa	Pensulo	Kabwe 1	Kabwe 2
District	Kapri Mposhi	Mumbwa	Serenje	Kapiri Mposhi	Chibombo
RGCs by DL	KPG Market	Mumba	Mukando	Nchembwe	Palace Chipepo Mukuni-Ngombe
	Lukanda	Maimwene settlement		Kafulu	Chilwa
	Luashimba	Chiwena		Koni Bunda Community	Kaswende
					Waya
RGCs by SHS		Ngabwe			
		Kapopo			
		Chikonkomene			
		Nambwa			

Provincial Ranking	6	7	8	9	10
Substation	Nampundwe	Pensulo 1	Kabwe	Kapiri Mposhi	Mumbwa
District	Mumbwa	Serenje	Kabwe	Kapri Mposhi	Mumbwa
RGCs by DL	Muchabi	Lukulu HC, Sch, Mkt	Lukali Community School	Chilese	Big Concession
	keezwa	Nakatambo	Josias Chiwala Farm	Kaloko	Kaindu
	Shibuyunji	Katikululu	Chilumba	Fikola	Mpusu
	Siachele	Musangashi	Katuntulu Com. School	Chankomo	Kamiliambo
	Myooye	Nsala	Likumbo	Lunchu	
	Nalubanda		Mpima Dairy Scheme Shed	Mubalashi	
	Mukulaikwa		Mubofwa		
RGCs by SHS	Chipeso		Chipepo	Nkole	
	Muchenje				
	Mamvule				

Provincial Ranking	11	12	13	14	15
Substation	Mkushi	Mumbwa	Mkushi Farm Block	Pensulo 1	Kabwe
District	Mkushi	Mumbwa	Mkushi	Serenje	Kabwe
RGCs by DL	Chalata	Matala	Old Mkushi	Mailo	Kangomba Health Centre
	Kasalamakanga	Naluvwi	Masansa	C. Saili	Kafumba
	Ndabala	Chibuluma	Makolongo	Kawama	Munwa Basic School
	Malali	Luili	Lubuto	Masase	Kafulamase Basic School
	Nkumbi	Nakanjoli	Masansa	C. Serenje	Kalwelwe Rail Station
	Nshinso	Chikanda	Kanyenshya Resettlement Scheme		Munyama B. School
	Munsakamba	Nalusanga	Mpale_Tuyu		Kapuku Fish Camp
	Lunsemfwa		Chikupili		
	Chitina				
RGCs by SHS	Fibanga		Chikwasha		
	Musofu		Chingombe		
	Kalombe		Fiwila		

Provincial Ranking	16	17	18	19
Substation	Pensulo 2	Pensulo 2	Fig Tree	Serenje
District	Serenje	Serenje	Chibombo	Serenje
RGCs by DL	Talayi	Mpelembe	Shimukuni	Chibale
	Mushili	Machende	Waya	Nchimishi
	Kasanka	Njelele	Mukulushi	Kofi Kunda
	Sokontwe	Chalilo	Chamuka	Mpande
	Chipe	Gibson	Lifwambula	
	Chipundu	Katongo	Kabangala	
	Kapumbu	Chipundu	Momboshi	
RGCs by SHS	Musolo		Kasosolo	
			Kayosha	

Table 14-6 Electrification Priority of Project Packages by Province (2/12) Copperbelt Province

Provincial Ranking	1	2	3	4	5
Substation	Kansunswa	Ndola 1	Kitwe	Mpongwe	Luano
District	Mufulira	Ndola	Kitwe	Mpongwe	Chililabombwe
RGCs by DL	Kawama East	Twapia	Musakashi	Mulela	Kalilo
	Murundu	George Camp	Luela	St. Anthony	Mimbula Block
	Mupambe	Sakania	Lungo		Kansoka
	Luansobe	Chichele	Council Farm		
	Mutundu North (Conner Bar)				
	Mokambo				
	Mutamba				
	Kafironda				
	Lukoshi				
RGCs by SHS			Minsenga	Kapili	Chisangwa
				Ipumbu	
				Mushine	
				Machiya	
				Luswishi	
				Munkunpa	
				Munsongwe	

Provincial Ranking	6	7	8	9	10
Substation	Luano	Ndola	Kitwe	Luano 2	Maposa
District	Chililabombwe	Masaiti	Kitwe	Chingola	Luanshya
RGCs by DL	Kamiteta	Mutaba	St. Joseph	Mutenda	Kaf Miss
	Fitobaula	Kambowa	Nkana	Muchinshi	Kamifungo
	Kawama	Kanglonga	Emerald Mining Area	Ipafu	Shombe
	Lubansa	Chondwe	Kambila	Milopa	Chilobwe
	Mingomba	Mupapa	Kabombo	Muchinshi	Kawama
	Kasapa	Chikumbi	Chibuluma Mine Area	Kansoka	Kangalati
			Chapula	Milulu Mitambo	Lima
				Milulu Kabamba	
RGCs by SHS	Kanenga		Kandole	Mutenda	
	Chilimina		Chantete		

Provincial Ranking	11	12	13	14	15
Substation	Maposa	Kitwe	Luano 1	Mpongwe	Luano 1
District	Luanshya	Kitwe	Lufwanyama	Mpongwe	Lufwanyama
RGCs by DL	Chifulube	Mukutuma	Mbalango Mine Farm Block	Mukumbo	Kambilombilo
	Maposa	Saw-Mills	Kapilamikwa	Shingwa	Nchakwa
	Kafubu	Kalisha	Kangalati	Kasamba	Lumwana
	Kaf GRZ	Michinka	St. Mary's		Kanyafimbolo
	Kakolo	Kafubu Depot	Kantende		Mushingashi
	Chinondo	Chamanza Resettlement	Fumbwe		Fungulwe
	Kapupulu	Kameme			Funda
	Misaka	Milopa			Mapunga
		Kansoka			Kalweu Kasakalabwe
		Lumpuma			
		Kapimbe			
		Chimoto			
		Kankunko			
RGCs by SHS	Salati	Chikabuke	Chinemu	Chitabale	
				Luela	

Provincial Ranking	16
Substation	Mpongwe
District	Mpongwe
RGCs by DL	Mpongwe
	Lukanga
	Chowa
	Mukubwe
	Mushipushi
	Chisanga
	Musofu
	Ibenga
	Chibuli
	Kotinteden
RGCs by SHS	Chisapa
	Chinwa
	Mikata
	Matete
	Fidashi

Table 14-6 Electrification Priority of Project Packages by Province (3/12) Eastern Province

Provincial Ranking	1	2	3	4	5
Substation	Azele	Azele 2	Azele	Azele 3	Azele 1
District	Katete	Katete	Katete	Petauke	Katete
RGCs by DL	Chindenza School	Mtandaza RHC	Chimutende,	Kapungwe	Chinkhombe
	Chitawe RHC		Kapeya Farms	Chikalawa	Nyembe
					Matunga School
					Chisale
					Kafunka
RGCs by SHS					

Provincial Ranking	6	7	8	9	10
Substation	Lundazi	Chipata	Azele 5	Azele 2	Azele 3
District	Lundazi	Chipata	Petauke	Katete	Petauke
RGCs by DL	Sikatengwa	Kasenengwa Rural Centre	Mwanjawanthu	Kagoro	Nyamphinga
	Mwase	Madimawe Rural Health Centre	Mumbi	Kafumbwe School	
	Mwata	Madzimoyo Sec. Schoo	Matonje	Kapirimphika	
		Chinyaku Palace	Kaulu	Taferansoni	
RGCs by SHS		Maguya			

Provincial Ranking	11	12	13	14	15
Substation	Azele 1	Msoro	Azele 4	Lundazi	Lundazi 1
District	Katete	Mambwe	Petauke	Lundazi	Lundazi
RGCs by DL	Kamphambe	Kasamanda	Nyamphande NSS	Mcherenka	Mwimba
	Chilasa	Nkhoko	Monde	Mphamba	Kazonde
			Misolo	Khulamayen	Phikamalaza
				Chasefu	
RGCs by SHS	Zemba		Kalongo Mwape	ZASP	
	Kalimeta		Mulilo	Mapamba	
	Kenje			Lumimba	

Provincial Ranking	16	17	18	19	20
Substation	Mfuwe 1	Lundazi	Azele 4	Mfuwe	Azele 6
District	Mambwe	Lundazi	Petauke	Mambwe	Chadiza
RGCs by DL	Ncheka_	Emusa	Mng'omba School	Chasela	Naviluri
	Kamphasa_	Kapichila	Sasali	Nsefu	Madziayera
	Kamphasa	Egichakeni	Chikowa	Chilanga	Manje
	Ncheka	Kazembe	Ukwimi	Chilanga	
	Chikowa	Nkhanga			
	Chikowa_	M_Mphanga			
		Chikomem			
		Hoya			
		Mtambali			
RGCs by SHS	Nyamaluma				

Provincial Ranking	21	22	23	24	25
Substation	Azele 6	Chipata	New SS at Chama	New SS at Chama	New SS at Nyimba
District	Chadiza	Chipata	Chama	Chama	Nyimba
RGCs by DL	Zingalume	Chinunda	Kaozi Settlement	Muyombe	Chipembe
	Chikonka	Kmgubudu	Mangwere	Kanselele	Mulira
	Chigwe	Mphomwa	Mabinga	Mnauke	Mtilizi Scheme
	Kapachi	Mphomwa Tse-tse	Sitwe	Bulbe	Vizimumba Central
	Kalemba	Kapara	Kalinkhu		Hofmeyre
	Vubwi	Maguya	Chifunda		Ndake
	Mchenjera	Chiparamba	Manga		Mchimadzi Scheme
		Chisengu			Chambula
					Chimphanje
RGCs by SHS	Chiwaula	Lima Com. School			Mbilisao
		Mwanya			Kachölola
					Kalingindi
					Wilison
					Chalubilo

Table 14-6 Electrification Priority of Project Packages by Province (4/12)

Luapula Province

Provincial Ranking	1	2	3	4	5
Substation	Mbereshi	Mbereshi	Nchelenge	Nchelenge	Samfya 2
District	Nchelenge	Nchelenge	Nchelenge	Nchelenge	Samfa
RGCs by DL	Mwansabombwe	Chipashi Island	Kambwali	Nile Kapambwe	Lubwe
	Chipepa	Shabo (Kapambwe	Mubamba	Kenani	Mbilimamwenge
	Mbereshi	Kanyembo	Kabosha	Mabo Kafutuma	Mundubi
	Mukamba		Nchelenge boma	Mwatishi Farm block 2	
	Salanga		Kashikishi	Kabole	
	Lufubu		Nshinda	Mununga	
	Chipunka		Kampampi (Chipakila)	Kabuta Central	
			Chilongo (Mtepuke)	Kaputa	
RGCs by SHS	Chama		Lukwesa	Kaputo	
	Kalamba				
	Muyembe				

Provincial Ranking	6	7	8	9	10
Substation	Mbereshi 1	Samfya 1	Samfya	Kawambwa Tea	Mbereshi 1
District	Mwense	Samfa	Samfa	Kawambwa	Mwense
RGCs by DL	Mwense	Chinsanka	Mano	Township	Mulundu
	Musangu	Katanhsya		Katungulu	Kashiba
	Lubunda	Mabo-Ninge		Mushota	Mutima
	Mulonga	Twingi		Mukuma	Kanyemba
	Lukwesa			Chama	Chibondo
	Mumpolokoso			Lengwe	Kabila
	Kapala			Mufwaya	
	Mununshi				
RGCs by SHS	Chibwe		Ndoba	Kanengo	Muchinga
			Mibenge	Chibote	Katuta

Provincial Ranking	11	12	13	14	15
Substation	Samfya 2	Nchelenge 1	Nchelenge 1	Chipili	Samfya 1
District	Samfa	Chiengi	Chiengi	Mansa	Samfa
RGCs by DL	Kasaba	Puta	Chienge	Mwenda	Kalimankonde
	Mwansakombe	Kalobwa	Lambwe Chomba	Chipili	Bwalya Mponda
	Mwewa	Kalembwe	Lupiya	Luminu	Kapilibila
	Isandulula Peri-urban C	Mukunta	Kasembe	Mukonshi	Kasomalunga
	Miponda	Kafulwe	Mwabu	Mutipula	Konikalila
		Sambula	Kampinda		Nsamba
RGCs by SHS				Mutwewankoko	

Provincial Ranking	16	17	18
Substation	Chipili	Mansa	Mansa
District	Mansa	Mansa	Mansa
RGCs by DL	Munshinga	Ntoposhi	Mulumbu
	Masonde Farming Bloc	Mutiti	Chintu
	Mano	Kabunda	Mikula
	Kalaba	Kapanda	Kasongwa sub boma
			Milambo
			Kundamfumu
			Mulumbi
RGCs by SHS	Chisunka	Mwanachama	Kasoma lwela
	Mbaso	Bukanda	Lukola
			Kalasa kando
			Mansa Ressetlement Scheme
			Kalyongo
			Chipete

Table 14-6 Electrification Priority of Project Packages by Province (5/12)
Lusaka Province

Provincial Ranking	1	2	3	4	5
Substation	Kafwe Town	New SS at Chilundu	Coventry	Leopard's Hill	New SS at Chilundu
District	Kafue	Luangwa	Lusaka	Chongwe	Luangwa
RGCs by DL	Kabweza	Boma	Mwembeshi_ mano	Nankaga	Rufunsa
	Manyonyo	Kapoche	Ipongo	Kapongo	Luangwa Bridge
	Tukunka	Mwalilia	Kasupe	Lishiko	
		Katondwe	Kamano	Chinkuli	
		Chitope	Chowa	Katoba	
		Kaunga	Chipapa VC	Shantumbu	
		Mphuka	Chinyongola	Chinyunyu	
		Manuele		Nyamanongo	
		Kakaro		Chiyota	
		Chiriwe		Mwalumina	
		Luangwa Sec		Lwimba	
				Mwachilele	
				Nchute	
RGCs by SHS		Kavalamanja	Muswishi		Nyalugwe
					Shikabeta

Table 14-6 Electrification Priority of Project Packages by Province (6/12)
Northern Province (1/2)

Provincial Ranking	1	2	3	4	5
Substation	Isoka	Isoka	Kasama 1	Luwingu	Nakonde
District	Isoka	Isoka	Kasama	Luwingu	Nakonde
RGCs by DL	Ntipo	Kafwimbi	Chisanga	Njeke Basic School	Nyela
			Namakwi	Lupili Market	Chilolwa
			Musa	Chipende Basic School and Chief Chipalo's	Ilendela
				Makolongo Basic School	Wulongo
					Kantongo
RGCs by SHS	Muliro	Musanya	Lwabwe		Chisanzu
	Chibale	Peleti			Senka
		Kalulu			Shemu
		Kalela			Sumbi
		Chunga			Kayambi

Provincial Ranking	6	7	8	9	10
Substation	Luwingu 3	Mbala	Luwingu 2	Mporokoso	Luwingu 1
District	Chilubi	Mbala	Chilubi	Mporokoso	Mporokoso
RGCs by DL	Chiwele	Mpulungu Central	Mwiima	Nsama Sub Boma	Mukupakaoma
	Kashitu	Isoko	Kantanta	Chishamwamba	Chitoshi
	Chilamba	Chilumba	Chichile	Katutwa	Mulenga M
	Kambashi	Musende	Chitupila	Malama	Menga Basic School and Clinic
	Mule	Posa, Muzabuwera, Mupata (Itim	Kawasa	Kambobe	Laurent Chita Basic School and C
	Kapofu	Isunga	Katamba	Mporokoso	
	Mbabala		Chabukasansha	Munwa	
			Maela	Chiwala	
RGCs by SHS		Kasaba Bay			
		Vyamba			
		Tanganyika			
		Mumila			
		Iyendwe			
		Chisha			
		Chitimbwa RHC			

Provincial Ranking	11	12	13	14	15
FIRR Ranking	61	62	66	70	77
Substation	Isoka	Kasama 2	Luwingu 3	Luwingu	Mporokoso
District	Isoka	Mporokoso	Chilubi	Luwingu	Mporokoso
RGCs by DL	Sansamwente	Sikapila	Kawena	Bwalinde	Chalabesa
	Kawngu	Kapatu	Kanama	Tolopa Basic School	Mutotosho
		Malaila	Kanama	Nsanja Basic School	Chewe
		Z Chanda	Nsumbu RH	Chikumanino Market	Kalabwe
			Bukotelo	Chief Tungati s Palace and Scho	Sunkutu
				Kapisha School	
				Ipusukilo Mission	
				Chakungubala Basic School	
				Lwena Basic School and Clinic	
RGCs by SHS					

Provincial Ranking	16	17	18	19	20
Substation	Luwingu 2	Isoka 1	Isoka 1	Mpika	Luwingu
District	Chilubi	Isoka	Isoka	Mpika	Luwingu
RGCs by DL	Matipa	Thendere	Mulekatembo	Mufubushi Resettlement	Kanfinsa
	Mofu R4				Mufili Basic School
	Mubili				Saili Basic School
	Lwata				Chitofwe Basic School
	Isangano				Lwenge Basic School
					Tungati Basic School and Clinic
					Nsombo
RGCs by SHS				Nabwalya	Musungu
					Kalundu

Table 14-6 Electrification Priority of Project Packages by Province (7/12) Northern Province (2/2)

Provincial Ranking	21	22	23	24	25
Substation	Chinsali	Kasama	Kasama	Mpika	Mpika
District	Chinsali	Kasama	Kasama	Mpika	Mpika
RGCs by DL	Ketani	Kachuma	Henry Kapata	Katongo Kapala	Katibunga
	Chilanga	Lukulu RR Scheme	Ngoli	Luoembe	
	Mwalala	Chilubula	Mwamba	Kanchibiya Farm Block	
	Nashinga	Chishimba			
	Masongo	Munkonge			
		Chiombo			
		Lukulu North			
RGCs by SHS	Konja		Rosa	Chikakala	Lwanya
	Malekani		Kapolyo	Kopa	Mukwikile
	Kabanda		Chimbola		Mukungule
	Chifulo		M_Mfino		
	Mumba		Chamfubu		
	Nkulungwe		Ndasa		
			Nsampa		
			C_Weyaya		
			Chimba		
			Makasa		
			Chitimukulu		
			Chisau		

Provincial Ranking	26	27	28	29	30
Substation	Mpika 1	Chinsali	Mpika 2	Mpika 1	Isoka 1
District	Mpika	Chinsali	Mpika	Mpika	Isoka
RGCs by DL	Chalabesa Hospital	Kasomo	Muwele	Mbati	Kampumbu (Kamrinsu)
	Mpepo HC, Sch, Palace		Mupamadzi Farm Block	Chambeshi Sch, Mkt	
	Mansha Farm Block		Chiunda Ponde	Mayuka	
				Kabinga	
				Fube	
RGCs by SHS		Mbesuma area			
		Chungulo			
		Kampemba			
		Shimwalule			

Provincial Ranking	31	32
Substation	Chinsali	Mbala
District	Chinsali	Mpulungu
RGCs by DL	Lundu	Kavumbo
	Chitimba	Uningi
	Chikanda	Chalele
	Chimbwese	Chimula
	Lameck	Kaka
	Chimbele	St-Pauls
	Lufila	Kawimbe
	Musonko	Mwamba
	Kabangama	
	Chilombo	
	Shiwan'gandu area	
	Mulakupikwa	
RGCs by SHS		Kalukanya
		Matanga
		Kaluluzi
		Mwiluzi
		Mpande

Table 14-6 Electrification Priority of Project Packages by Province (8/12)
North-western Province

Provincial Ranking	1	2	3	4	5
Substation	Solwezi	Mwinilunga 1	Solwezi	New SS at Kabompo	New SS at Zambezi
District	Solwezi	Mwinilunga	Solwezi	Kabompo	Zambezi
RGCs by DL	Mushindomo		Kimsala	Kaula	Chinyingi
	Tumva		Kamalamba	Kawanda	Liyovu
			Kangwena	Ndunga	Kashona
			Kibanza	Kashinakazhi	Kakoto
			Chikola	Luson'a	
				Manyinga	
				Chiteve	
RGCs by SHS		Salujinga			Lukunyi
		Jimbe			
		Nyakaseya			
		Kafweku			
RGCs by Mini-Hydro		Ikelenge			

Provincial Ranking	6	7	8	9	10
Substation	Zambezi 1	New SS at Mwinilunga	New SS at Mwinilunga	New SS at Zambezi	New SS at Mwinilunga
District	Zambezi	Mwinilunga	Mwinilunga	Zambezi	Mwinilunga
RGCs by DL	Matondo	Ntambu		Dipalata	Kawiku
	Milomboyi	Samuteba		Likungu	Mukangala
	Muyembe	Chisengisengi		Chitokoloki	Lwakela
	Mwange			Ishima	
				Mpidi	
				Kakeki	
				Nyakulena	
				Lwatembo	
RGCs by SHS	Nguvu	Tomu		Lunyiwe Basic School	
	Kayenge	Lumwana		Chisengi	
				Katontu	
				Chizuzu	
RGCs by Mini-Hydro		Kanyama	Mwinilunga BOMA		
		Kakoma			

Provincial Ranking	11	12	13	14	15
Substation	New SS at Mwinilunga	New SS at Mufumbwe	Kasempa	Solwezi	New SS at Mumbezi
District	Mwinilunga	Mufumbwe	Kasempa	Solwezi	Solwezi
RGCs by DL	Chibwika	Mushima	Mateko	Kapiji	Mukumbi
	Mudunyama	Kikonge	Nselauke	Musaka	Mumbezi
	Kanongesha	Lalafuta	Dengwe	Mulonga	Musele
	Kampenba	Matushi	Kamakuku	Kalilele	Shilenda
	Chiwoma	Kashima W	Kalengwa	Sanda	
	Kamapanda	Kaminzeke	Kashima E	Mujima	
		Munyambala	Kalombe	Mumena	
		Miluji			
		Musonweji			
		Shukwe			
		Kakiakasa			
		Chowwe			
		Kamabuta			
RGCs by SHS		Myamdafuka	Miyombe		
			Lunga		
RGCs by Mini-Hydro					

Provincial Ranking	16	17	18
Substation	New SS at Chavuma	New SS at Kabompo	Kasempa
District	Chavuma	Kabompo	Kasempa
RGCs by DL	Sanjongo	Sakandingo	Kabele
	Kakhoma	Samende	Kantenda
	Kalombo	Mukolo	Shivuma
	Lingundu	Nyangwali	Mpungu
	Lukolwe	Chinkonkwelo	
	Kamisamba	Dongwe	
	Chinwandumba	Chiyengele	
	Kambuya		
	Mandalo		
	Chambi		
RGCs by SHS	Chivombo		Kalongwa
	Mukelangombe		Maako
	Nyathanda		Kamakechi
			Lubofu
			Kanogo
RGCs by Mini-Hydro			

Table 14-6 Electrification Priority of Project Packages by Province (9/12)
Southern Province (1/2)

Provincial Ranking	1	2	3	4	5
Substation	Muzuma 2	Victoria Falls	Muzuma 1	Muzuma 3	Muzuma 1
District	Kalomo	Livingstone	Namwala	Namwala	Namwala
RGCs by DL	Kauwe	Sinde	Baambwe	Mbeza	Moobola
		Mulala	Ngabo	Niko	Namakaka_
		Sakurita		Ichila	Itapa
		Majeledi		Bweengwa	Muchila
		Katubia			Chilala
RGCs by SHS		Smachuma	Kalundu		Namusenga
		Chilizya	Shapopa		Luchena
		Kananga	No.57 (Lubanda)		Mbila
		Inonge	Itumbi		Mabombo
		Zimba Hills Settlements			
		Napenzi			
		Malimba			
		Nyawa Central			
		Simango			

Provincial Ranking	6	7	8	9	10
Substation	Mazabuka	Muzuma 3	Mazabuka 1	Chilundu	Mazabuka 1
District	Mazabuka	Namwala	Monze	Siavonge	Monze
RGCs by DL	Ngwezi	Nakamboma (Namakaka)	Njola Camp	Chiawa Central	Namakube
	Nwanachmgurela	Makaba	Kaumba	Mafungautsi	Bbombo
	Naluama	Simaubi	Ntambo Agricultural Camp	Mugula mano	Hakasenke
	Maggobo	Nalutanga	Mujika	Mulila Nsolo	Namilongwe
	Neganega	Kachenge	Chisuwo Agric Camp	Chisakila	Haatontola
		Mangonza	Manungu A	Mulangwa	Malende
			Manungu B		Kazungula
			Lweeta Agric Camp		Hufwa
			Chiyobola Agricultural Camp		Katimba
			Muzuri (Kamuzya East)		Simeweendengwe
			Namateba Agricultural Camp		Silwili
					Hamusankwa
					Sikalinda Resettlement
					Hamapande
RGCs by SHS	Mbaya Musuma			Kanyangala	
	Upper Kaleya				

Provincial Ranking	11	12	13	14	15
Substation	Muzuma 2	Sinazongwe	Muzuma 1	Mazabuka 1	Victoria Falls
District	Kalomo	Sinazongwe	Namwala	Monze	Livingstone
RGCs by DL	Nkandanzovu	Chipepo	Kantengwa	Kayuni	Makunka
	Darphan	Sinakaimbi		Keemba	Ma Hundred
	Kinnertone	Munyati		Chungu Agric Camp	Sekute
	Bbilili	Siacheka		Nteme	Mubalu
	Simakakata	Chiyabi		Malundu	Mambova
	Mutala	Sinamalima		Bankaila	Mahelituna
	Chikoli	Chabulabwambe			Mandia
		Siabwengo			Mayumbelo
		Siambabala			
		Mudonki			
		Mwalede			
		Nangombe			
		Siamejele			
		Hangoma			
		Siampande			
		Malyango			
		Siangwaze			
RGCs by SHS	Nguba	Mwerya	Muwezwa		Sinde
		Mundoza	Makunku		Ngwezi Mataki
		Simuloongo	Banamwaze		
		Nzala			
		Chaposwa			

Table 14-6 Electrification Priority of Project Packages by Province (10/12)
Southern Province (2/2)

Provincial Ranking	16	17	18	19	20
Substation	Muzuma	Muzuma	Chilundu	Victoria Falls	Muzuma
District	Choma	Choma	Siavonge	Livingstone	Choma
RGCs by DL	Luyaba	Kanchomba	Munyama	Manyemunyemu	Kasukwe
	Kanchele	Moyo	Sikoongo	Siadazya	Kabimba
		Singani	Gwena	Kasiya	
		Mukamunga	Chaanga	Zangala	
		Manyati	Sianyoolo	Siambelele	
		Gamela	Namoomba	Natebe	
			Malengo	Katapazi	
			Ibbwemunyama	Sichilore	
			Syangwemu	Simwizi	
			Dibbwi		
RGCs by SHS					Nachanowe

Provincial Ranking	21
Substation	Maamba
District	Sinazongwe
RGCs by DL	Kabanga
	Napatizya
	Muuka
	Siameja
	Dengera
	Masuku
	Mweemba
	Kafwambila
	Siansalama
	Namafulu
	Siatwiinda
	Chilele
	Sulwegonde
RGCs by SHS	Ngoma

Table 14-6 Electrification Priority of Project Packages by Province (11/12) Western Province (1/2)

Provincial Ranking	1	2	3	4	5
Substation	Senanga	Mongu 2	Mongu 2	Mongu	Senanga
District	Senanga	Senanga	Senanga	Mongu	Senanga
RGCs by DL	Lui-mwemba	Sinunga	Nalolo	Nangula	Ngundi
	Liangati	Liliachi	Nangucha	Ikabako	Silumbi
		Nasilimwe	Kataba	Kaande	Songa
		Nasilimwe	Sianda	Mawawa	
				Mweeke	
				Siwa	
				Namitone	
RGCs by SHS		Sumi	Nangoma		

Provincial Ranking	6	7	8	9	10
Substation	Senanga 3	Kaoma	Kalabo	Mongu	Senanga 2
District	Senanga	Kaoma	Kalabo	Mongu	Shangombo
RGCs by DL	Nande	Kazabami	Makuku	Kasheke	Mulele
	Sitoti	Kalumwange	Sishekanu	Likutwe	Mutomena
	Beshe	Shitwa	Lwanda	Ikwiichi	
	Matebele	Namaloba	Mbanga	Ushaa	
	Namatoya		Nangili	Sitoya	
				Mombo	
				Sikusi	
RGCs by SHS		Kabapupu	Malasha		
			Liuwa		
			Mishuwundu		
			Kuuli		
			Munde		
			Mulinga		
			Likapai		

Provincial Ranking	11	12	13	14	15
Substation	Senanga 3	Kalabo	Senanga 2	Mongu 1	Kaoma
District	Senanga	Kalabo	Shangombo	Mongu	Kaoma
RGCs by DL	Likondwana	Ndau	Nangweshi	Mukangu	Shinono
	Kalengola	Kama	Kaanja	Luandui	Namilaugi
	Kaunga Lueti	Ngangu	Sioma	Nalikwanda	Longe
	Keyana	Tapo	Palace	Nakato	Mukandamina
	Namono	Mulundumano		Kalundwans	Kankwanda
				Lukweta	Nkeyama
				Simulumbe	
RGCs by SHS		Mwandi		Litawa	Shishamba
		Lulambo		Liande	Kalale
				Namengo	Lombelombe
					Chiluli
					Mimpongo
					Kandende
					Njonjolo

Provincial Ranking	16	17	18	19	20
Substation	New SS at Lukulu	Mongu 1	Senanga	Sesheke	New SS at Lukulu
District	Lukulu	Mongu	Senanga	Sesheke	Lukulu
RGCs by DL	Lukulu Township	Kaba Hill	Namabuka	SITULU	Simakumba
	Mwanambuyu	Kaungeta	Mata	Mwandi	Namayula
	Mwito	Lukalanys	Mwanamwalye	Katima	Mitete
	Lishuwa	Miulwe	Sibukali	Mabumbu	Kakulunda
	Winda	Nalwei		Lusinina	
	Muyondoti	Ndondo		Lipumpu	
	Kawaya	Nasange			
	Lukau	Nandombe			
	Naimbu	Loona			
		Ndanda			
RGCs by SHS					Watopa
					Kakwacha
					Lupui
					Chinonwe

Table 14-6 Electrification Priority of Project Packages by Province (12/12)
Western Province (2/2)

Provincial Ranking	21	22	23	24	25
Substation	Senanga 1	Kaoma	Kalabo	Kaoma	Sesheke 1
District	Shangombo	Kaoma	Kalabo	Kaoma	Sesheke
RGCs by DL	Shangombo	Luamba	Tuuwa	Mayukwayukwa	Magumwi
	Kaunga Mashi	Kahokoto	Sikongo	Kapili	Sichili
	Sipuma	Kafunda	Liumba	Mangango	Loazamba
	Natukoma	Mushiwala	Liumena	Naliele	Bwina
	Nambolomoka	Mbanyutu	Siluwe	Lukena	Mulobezi
		Nkenga	Kalumbu	Lyamunale	
		Namasheshe	Loke West	Nyango	
		Mukunkiki	Salunda		
		Lubuka	LULANUNYI		
		Lui	Nyengo		
RGCs by SHS		Nyambi 2	Mbalala		Senamba
		Afumba	Muyumbana		Mushukula
		Nakayembe	Namatindi		Kasompa
		Namando	Kalenga		
		Mulwa	Lutwi		
			Sihole		
			Lueti		

Provincial Ranking	26
Substation	Sesheke 2
District	Sesheke
RGCs by DL	Nawinda
	Luampungu
	Sinjembela
	Lusu
	Imusho
	Ngweze
	Mazaba
	Silumbu
	Kalobolelwa
RGCs by SHS	

Table 14-9 Annual Project Phases by 2030 (1/2)

Annual Project Phase	FIRR Ranking	Substation	Province	Feeder & Package	Project Package Cost (US$)	Cumulative Cost (US$)	Project Package FIRR	Project Package EIRR
	1	Isoka	Northern	1 - 1	1,663,395	1,663,395	22.0%	59.9%
	2	Azele	Eastern	2 - 2	1,899,936	3,563,331	20.5%	57.5%
	3	Kapiri Mposhi	Central	2 - 2	2,701,296	6,264,627	18.1%	50.2%
	4	Kansunswa	Copperbelt	1 - 8	4,522,824	10,787,451	13.2%	35.1%
	5	Azele 2	Eastern	2 - 1	2,596,212	13,383,663	12.1%	34.1%
	6	Azele	Eastern	1 - 2	1,608,120	14,991,783	12.0%	33.9%
	7	Azele 3	Eastern	1 - 2	3,388,392	18,380,175	11.5%	32.4%
2009	8	Isoka	Northern	2 - 1	1,991,449	20,371,624	11.0%	29.5%
	9	Azele 1	Eastern	1 - 5	3,600,612	23,972,236	11.0%	31.1%
	10	Ndola 1	Copperbelt	1 - 4	3,675,672	27,647,908	10.8%	29.5%
	11	Lundazi	Eastern	3 - 2	2,733,588	30,381,496	9.5%	26.1%
	12	Chipata	Eastern	2 - 2	4,697,181	35,078,677	9.2%	26.3%
	13	Mbereshi	Luapula	1 - 3	3,243,548	38,322,225	9.1%	22.2%
	14	Azele 5	Eastern	1 - 3	7,189,452	45,511,677	8.7%	25.6%
	15	Kasama 1	Northern	1 - 2	4,621,185	**50,132,862**	8.7%	24.9%
	16	Senanga	Western	1 - 1	2,146,932	52,279,794	8.5%	23.3%
	17	Mbereshi	Luapula	2 - 1	1,854,468	54,134,262	8.4%	23.9%
	18	Kitwe	Copperbelt	1 - 3	2,637,930	56,772,192	8.2%	22.6%
	19	Azele 2	h	1 - 3	4,538,160	61,310,352	8.2%	23.8%
	20	Luwingu	Northern	3 - 3	1,395,468	62,705,820	7.7%	23.2%
	21	Mpongwe	Copperbelt	3 - 2	2,129,151	64,834,971	7.6%	22.8%
	22	Mongu 2	Western	2 - 3	6,104,929	70,939,900	7.5%	22.1%
2010	23	Nchelenge	Luapula	1 - 4	2,452,620	73,392,520	7.5%	19.1%
	24	Azele 3	Eastern	2 - 1	2,509,596	75,902,116	7.5%	22.6%
	25	Azele 1	Eastern	2 - 2	4,684,662	80,586,778	7.1%	21.9%
	26	Mongu 2	Western	1 - 3	4,321,732	84,908,511	7.1%	20.9%
	27	Mumbwa	Central	1 - 3	2,718,738	87,627,248	7.0%	21.3%
	28	Nchelenge	Luapula	2 - 4	4,452,947	92,080,196	6.8%	19.1%
	29	Nakonde	Northern	1 - 2	4,141,237	96,221,433	6.7%	16.6%
	30	Mongu	Western	1 - 4	3,890,700	**100,112,133**	5.9%	19.0%
	31	Muzuma 2	Southern	2 - 1	3,703,968	103,816,101	5.6%	17.7%
	32	Luwingu 3	Northern	2 - 5	4,202,496	108,018,597	5.5%	17.4%
	33	Samfya 2	Luapula	2 - 2	2,752,596	110,771,193	5.0%	14.4%
	34	Luano	Copperbelt	1 - 3	2,671,892	113,443,084	4.9%	15.5%
	35	Mbereshi 1	Luapula	2 - 5	6,873,037	120,316,122	4.9%	15.2%
2011	36	Mbala	Northern	2 - 4	7,660,327	127,976,449	4.8%	17.1%
	37	Pensulo	Central	1 - 1	599,616	128,576,065	4.6%	13.7%
	38	Msoro	Eastern	1 - 1	1,486,296	130,062,361	4.6%	14.4%
	39	Azele 4	Eastern	2 - 3	5,708,616	135,770,977	4.6%	16.4%
	40	Kabwe 1	Central	1 - 3	4,443,228	140,214,205	4.5%	16.0%
	41	Solwezi	North-Western	1 - 1	3,196,692	143,410,897	4.5%	16.3%
	42	Senanga	Western	3 - 3	4,424,004	**147,834,901**	4.4%	15.6%
	43	Luwingu 2	Northern	2 - 5	6,526,008	154,360,909	4.4%	16.3%
	44	Victoria Falls	Southern	3 - 1	3,027,377	157,388,286	4.4%	16.0%
	45	Kabwe 2	Central	1 - 2	5,905,008	163,293,294	4.3%	15.9%
	46	Luano	Copperbelt	2 - 4	3,294,509	166,587,803	4.3%	13.8%
	47	Senanga 3	Western	1 - 2	5,513,508	172,101,311	4.2%	15.2%
2012	48	Ndola	Copperbelt	1 - 3	4,725,756	176,827,067	4.1%	14.6%
	49	Kitwe	Copperbelt	2 - 3	3,237,335	180,064,402	4.0%	11.9%
	50	Samfya 1	Luapula	2 - 3	4,234,788	184,299,190	3.9%	13.2%
	51	Samfya	Luapula	1 - 1	1,580,313	185,879,504	3.7%	14.6%
	52	Muzuma 1	Southern	2 - 1	4,833,777	190,713,281	3.6%	14.0%
	53	Mwinilunga 1	North-Western	1 - 0	5,725,580	**196,438,861**	3.6%	14.5%
	54	Mporokoso	Northern	2 - 6	7,404,372	203,843,233	3.6%	14.3%
	55	Kawambwa Tea	Luapula	1 - 6	5,397,673	209,240,906	3.5%	10.4%
	56	Mbereshi 1	Luapula	1 - 3	5,025,125	214,266,031	3.4%	12.7%
	57	Samfya 2	Luapula	1 - 3	4,748,220	219,014,251	3.3%	12.4%
2013	58	Kaoma	Western	4 - 2	3,768,420	222,782,671	3.2%	13.4%
	59	Nampundwe	Central	1 - 5	6,848,699	229,631,370	3.1%	13.2%
	60	Luwingu 1	Northern	1 - 5	7,400,916	237,032,286	2.9%	13.2%
	61	Isoka	Northern	3 - 2	4,738,824	241,771,110	2.9%	12.9%
	62	Kasama 2	Northern	1 - 4	7,680,960	**249,452,070**	2.8%	12.3%
	63	Kalabo	Western	1 - 3	6,835,774	256,287,844	2.7%	13.0%
	64	Muzuma 3	Southern	1 - 3	4,332,960	260,620,804	2.7%	12.1%
	65	Pensulo 1	Central	2 - 5	5,346,756	265,967,560	2.7%	12.5%
	66	Luwingu 3	Northern	1 - 3	3,819,528	269,787,088	2.6%	13.0%
2014	67	Lundazi	Eastern	1 - 2	4,265,265	274,052,353	2.3%	11.5%
	68	Mongu	Western	2 - 5	7,319,376	281,371,729	2.3%	12.3%
	69	Nchelenge 1	Luapula	1 - 3	4,821,120	286,192,849	2.3%	10.1%
	70	Luwingu	Northern	1 - 4	7,722,972	293,915,821	2.2%	12.3%
	71	Senanga 2	Western	2 - 2	2,739,744	**296,655,565**	2.2%	11.8%
	72	Kabwe	Central	2 - 5	6,458,570	303,114,135	2.1%	11.5%
	73	Senanga 3	Western	2 - 3	7,618,536	310,732,671	2.1%	11.6%
	74	Kapiri Mposhi	Central	1 - 6	5,897,704	316,630,374	2.0%	11.0%
	75	Kalabo	Western	2 - 1	3,550,455	320,180,829	1.8%	11.4%
2015	76	Senanga 2	Western	1 - 3	3,328,452	323,509,281	1.8%	10.2%
	77	Mporokoso	Northern	1 - 5	4,094,712	327,603,993	1.7%	10.6%
	78	Muzuma 1	Southern	1 - 4	7,543,863	335,147,856	1.7%	10.1%
	79	Mongu 1	Western	1 - 4	9,228,684	344,376,540	1.6%	11.1%
	80	Lundazi 1	Eastern	1 - 3	4,215,024	**348,591,564**	1.5%	10.8%
	81	Kaoma	Western	1 - 2	5,340,384	353,931,948	1.5%	8.5%
	82	Mazabuka	Southern	1 - 3	4,470,646	358,402,594	1.5%	3.5%
	83	Luwingu 2	Northern	1 - 5	7,625,988	366,028,582	1.5%	11.0%
	84	Mfuwe 1	Eastern	1 - 5	4,996,989	371,025,571	1.5%	10.7%
2016	85	Solwezi	North-Western	2 - 4	2,663,712	373,689,283	1.5%	10.4%
	86	Kafwe Town	Lusaka	1 - 3	1,582,632	375,271,915	1.5%	9.2%
	87	Mumbwa	Central	3 - 4	6,012,576	381,284,491	1.3%	10.2%
	88	Lundazi	Eastern	2 - 7	8,256,276	389,540,767	1.2%	9.1%
	89	Isoka 1	Northern	1 - 1	4,628,988	394,169,755	1.2%	9.5%
	90	Muzuma 3	Southern	2 - 6	5,251,284	**399,421,039**	1.1%	9.4%

Table 14-9 Annual Project Phases by 2030 (2/2)

Annual Project Phase	FIRR Ranking	Substation	Province	Feeder & Package	Project Package Cost (US$)	Cumulative Cost (US$)	Project Package FIRR	Project Package EIRR
2017	91	Luano 2	Copperbelt	1 - 5	6,578,303	405,999,342	1.1%	8.8%
	92	Isoka 1	Northern	2 - 1	4,419,792	410,419,134	1.1%	9.8%
	93	Azele 4	Eastern	1 - 4	11,500,056	421,919,190	1.0%	10.1%
	94	New SS at Lukulu	Western	1 - 5	8,474,976	430,394,166	1.0%	6.9%
	95	Mongu 1	Western	2 - 8	10,201,680	440,595,846	1.0%	10.2%
	96	Mpika	Northern	1 - 1	1,760,209	442,356,055	0.9%	9.5%
	97	Mkushi	Central	1 - 7	6,928,735	**449,284,790**	0.8%	7.1%
2018	98	Nchelenge 1	Luapula	2 - 4	7,155,648	456,440,438	0.8%	8.3%
	99	Luwingu	Northern	2 - 5	7,468,756	463,909,194	0.7%	9.7%
	100	Mfuwe	Eastern	1 - 3	7,515,828	471,425,022	0.6%	9.5%
	101	Mazabuka 1	Southern	2 - 6	6,055,668	477,480,690	0.6%	7.7%
	102	Maposa	Copperbelt	2 - 4	3,617,136	481,097,826	0.4%	8.1%
	103	Chinsali	Northern	2 - 1	2,330,585	483,428,411	0.4%	6.3%
	104	Senanga	Western	2 - 3	8,819,172	492,247,583	0.4%	8.7%
	105	Kasama	Northern	2 - 5	7,077,132	**499,324,715**	0.4%	8.5%
2019	106	Kasama	Northern	1 - 3	5,713,510	505,038,225	0.3%	8.7%
	107	Mpika	Northern	2 - 3	5,137,329	510,175,554	0.3%	8.4%
	108	Mpika	Northern	3 - 1	3,998,616	514,174,170	0.0%	8.2%
	109	Azele 6	Eastern	2 - 2	3,756,780	517,930,950	0.0%	8.4%
	110	Maposa	Copperbelt	1 - 6	9,191,420	527,122,370	-0.3%	7.3%
	111	Chipili	Luapula	1 - 4	4,431,563	531,553,933	-0.4%	6.4%
	112	Mumbwa	Central	2 - 3	4,442,904	535,996,837	-0.5%	5.7%
	113	Mpika 1	Northern	1 - 2	7,672,860	543,669,697	-0.5%	7.3%
	114	Kitwe	Copperbelt	3 - 8	7,121,331	**550,791,028**	-0.7%	4.7%
2020	115	Sesheke	Western	1 - 4	8,686,008	559,477,036	-0.7%	6.4%
	116	Chilundu	Southern	1 - 3	3,654,055	563,131,091	-0.8%	6.1%
	117	Azele 6	Eastern	1 - 3	7,260,841	570,391,932	-0.8%	7.3%
	118	Mkushi Farm Block	Central	1 - 5	7,827,920	578,219,852	-0.8%	5.1%
	119	Chipata	Eastern	1 - 4	6,540,564	584,760,416	-0.9%	6.8%
	120	Pensulo 1	Central	1 - 4	5,382,180	590,142,596	-0.9%	7.1%
	121	Mazabuka 1	Southern	3 - 9	6,448,248	**596,590,844**	-1.0%	6.1%
2021	122	Muzuma 2	Southern	1 - 4	7,909,413	604,500,257	-1.0%	7.0%
	123	Chinsali	Northern	3 - 1	1,524,740	606,024,997	-1.0%	5.4%
	124	New SS at Kabompo	North-Western	2 - 5	11,671,020	617,696,017	-1.1%	6.7%
	125	New SS at Lukulu	Western	2 - 2	7,012,149	624,708,166	-1.2%	6.1%
	126	Sinazongwe	Southern	1 - 8	6,081,434	630,789,600	-1.2%	4.9%
	127	Kabwe	Central	1 - 7	6,657,012	637,446,612	-1.3%	6.1%
	128	New SS at Zambezi	North-Western	2 - 2	5,702,795	643,149,407	-1.6%	6.3%
	129	Zambezi 1	North-Western	1 - 4	6,633,935	**649,783,342**	-1.6%	6.3%
2022	130	New SS at Mwinilunga	North-Western	4 - 0	8,688,211	658,471,554	-2.0%	4.6%
	131	New SS at Zambezi	North-Western	1 - 6	11,189,609	669,661,163	-2.2%	4.7%
	132	Luano 1	Copperbelt	1 - 4	4,613,690	674,274,852	-2.4%	3.4%
	133	Samfya 1	Luapula	1 - 5	6,764,040	681,038,892	-2.4%	4.1%
	134	Muzuma 1	Southern	3 - 1	3,025,234	684,064,126	-2.4%	4.6%
	135	Pensulo 2	Central	2 - 2	13,040,814	697,104,940	-2.5%	4.8%
	136	Mpongwe	Copperbelt	2 - 1	1,797,786	**698,902,726**	-2.6%	4.1%
2023	137	Senanga 1	Western	1 - 4	17,644,176	716,546,902	-2.6%	4.6%
	138	Pensulo 2	Central	1 - 5	10,138,284	726,685,186	-2.8%	4.4%
	139	Luano 1	Copperbelt	2 - 4	6,293,808	732,978,994	-2.9%	3.0%
	140	New SS at Chilundu	Lusaka	2 - 1	12,535,782	**745,514,776**	-2.9%	2.9%
2024	141	Coventry	Lusaka	1 - 4	5,593,913	751,108,689	-3.0%	2.2%
	142	Mpika 2	Northern	1 - 3	9,631,764	760,740,453	-3.1%	4.0%
	143	Kaoma	Western	2 - 3	9,098,247	769,838,700	-3.1%	3.4%
	144	Mpika 1	Northern	2 - 3	11,886,696	781,725,396	-3.4%	3.2%
	145	Mazabuka 1	Southern	1 - 4	4,611,924	786,337,320	-3.5%	2.4%
	146	New SS at Mwinilunga	North-Western	3 - 2	3,620,916	789,958,236	-3.5%	3.1%
	147	New SS at Mwinilunga	North-Western	2 - 4	9,098,892	**799,057,128**	-3.6%	3.1%
2025	148	New SS at Mwinilunga	North-Western	1 - 1	20,302,796	819,359,923	-3.9%	0.4%
	149	Fig Tree	Central	1 - 6	7,558,211	826,918,134	-3.9%	1.6%
	150	Leopard's Hill	Lusaka	1 - 11	12,860,964	839,779,098	-4.0%	2.5%
	151	Serenje	Central	1 - 3	7,325,532	**847,104,630**	-4.2%	2.4%
2026	152	Victoria Falls	Southern	2 - 4	5,482,320	852,586,950	-4.2%	0.3%
	153	New SS at Mufumbwe	North-Western	1 - 7	13,926,801	866,513,751	-4.5%	1.4%
	154	Kalabo	Western	3 - 5	16,593,051	883,106,802	-5.0%	2.1%
	155	Kaoma	Western	3 - 3	10,689,516	893,796,318	-5.1%	0.8%
	156	Mpongwe	Copperbelt	1 - 5	8,733,023	**902,529,340**	-5.1%	1.7%
2027	157	Muzuma	Southern	2 - 2	4,124,628	906,653,968	-5.3%	1.5%
	158	Kasempa	North-Western	2 - 4	6,904,408	913,558,376	-5.3%	0.2%
	159	Chipili	Luapula	2 - 2	8,344,891	921,903,267	-6.0%	0.7%
	160	Solwezi	North-Western	3 - 5	10,115,604	932,018,871	-6.0%	0.5%
	161	Isoka 1	Northern	3 - 1	5,762,340	937,781,211	-6.0%	0.7%
	162	Sesheke 1	Western	1 - 5	13,319,939	**951,101,150**	-6.0%	0.1%
2028	163	Muzuma	Southern	1 - 5	5,281,740	956,382,890	-6.1%	-0.7%
	164	Mansa	Luapula	2 - 3	1,822,819	958,205,709	-6.1%	-2.5%
	165	Chilundu	Southern	2 - 8	8,734,500	966,940,209	-6.5%	-0.2%
	166	Victoria Falls	Southern	1 - 5	3,954,312	970,894,521	-6.6%	-3.1%
	167	New SS at Mumbezi	North-Western	1 - 2	6,636,492	977,531,013	-6.8%	0.0%
	168	New SS at Chavuma	North-Western	1 - 8	6,768,591	984,299,604	-7.0%	-1.7%
	169	Muzuma	Southern	3 - 1	3,083,260	987,382,864	-7.0%	-0.5%
	170	New SS at Kabompo	North-Western	1 - 4	11,623,500	**999,006,364**	-7.0%	-1.9%
2029	171	New SS at Chama	Eastern	2 - 5	11,377,800	1,010,384,164	-7.0%	-0.1%
	172	New SS at Chama	Eastern	1 - 3	14,867,712	1,025,251,876	-7.8%	-1.3%
	173	Chinsali	Northern	1 - 4	9,725,076	1,034,976,952	-7.8%	-2.6%
	174	New SS at Chilundu	Lusaka	1 - 1	5,825,784	1,040,802,737	-8.1%	-1.1%
	175	New SS at Nyimba	Eastern	1 - 6	6,870,917	1,047,673,654	-8.2%	-4.4%
	176	Kasempa	North-Western	1 - 4	3,434,849	**1,051,108,503**	-8.7%	-3.0%
2030	177	Maamba	Southern	1 - 8	15,171,571	1,066,280,073	-9.8%	-3.8%
	178	Sesheke 2	Western	1 - 4	21,945,600	1,088,225,673	-10.2%	-2.7%
	179	Mansa	Luapula	1 - 5	8,269,414	1,096,495,087	-12.6%	-5.6%
	180	Mbala	Northern	1 - 2	6.590.154	**1.103.085.242**	-13.1%	-4.2%

14.6. Targeting Electrification Rate in 2030

As shown in Table 14-10, the household electrification rate in 2006 is 20.4% nation-wide, being 47.6% in the urban areas and 3.1% in the rural areas (data from *Living Conditions Monitoring Survey Report 2004, Central Statistical Office, December 2006*). As of 2006, the number of households in 1,217 RGCs targeted in the master plan is 535,717, accounting for 23.4% in the national total, and this will be 1,067,729 in 2030. By 2030, DoE, REA and ZESCO aim to achieve household electrification rate 90% in the urban areas, 100% in 1,217 RGCs in the Master Plan, and 20% in the rural areas outside the 1,217 RGCs. Based on these targets, a household electrification rate of 66.0% in the nation-wide will be achieved in 2030, in which the rural electrification rate will be 50.6%. The growth of household electrification rates in urban areas, rural areas, and nation-wide during the Master Plan period are shown in Figure 14-4. The cumulative number of electrified RGC and rural electrification rate by 2030 are also shown in Figure 14-5. Figure 14-6 shows the rural electrification map of 1,217 RGCs with their electrification modes.

Table 14-10 Targeting Electrification Rate in 2030

	2006				2030		
	# of HH	HH Ratio	# of Elec. HH	Elec. Rate	# of HH	# of Elec. HH	Elec. Rate
Urban	896,234	(39.0%)	426,608	47.6%	1,779,880	1,601,892	90.0%
Rural	1,403,408	(61.0%)	43,506	3.1%	2,787,102	1,411,604	50.6%
a) 1,216RGCs	*535,717*	*(23.4%)*	*0*	*-*	*1,067,729*	*1,067,729*	*100.0%*
b) Others	*867,691*	*(37.6%)*	*43,506*	*3.1%*	*1,719,373*	*343,875*	*20.0%*
Total	**2,299,642**	**(100.0%)**	**470,113**	**20.4%**	**4,566,982**	**3,013,496**	**66.0%**

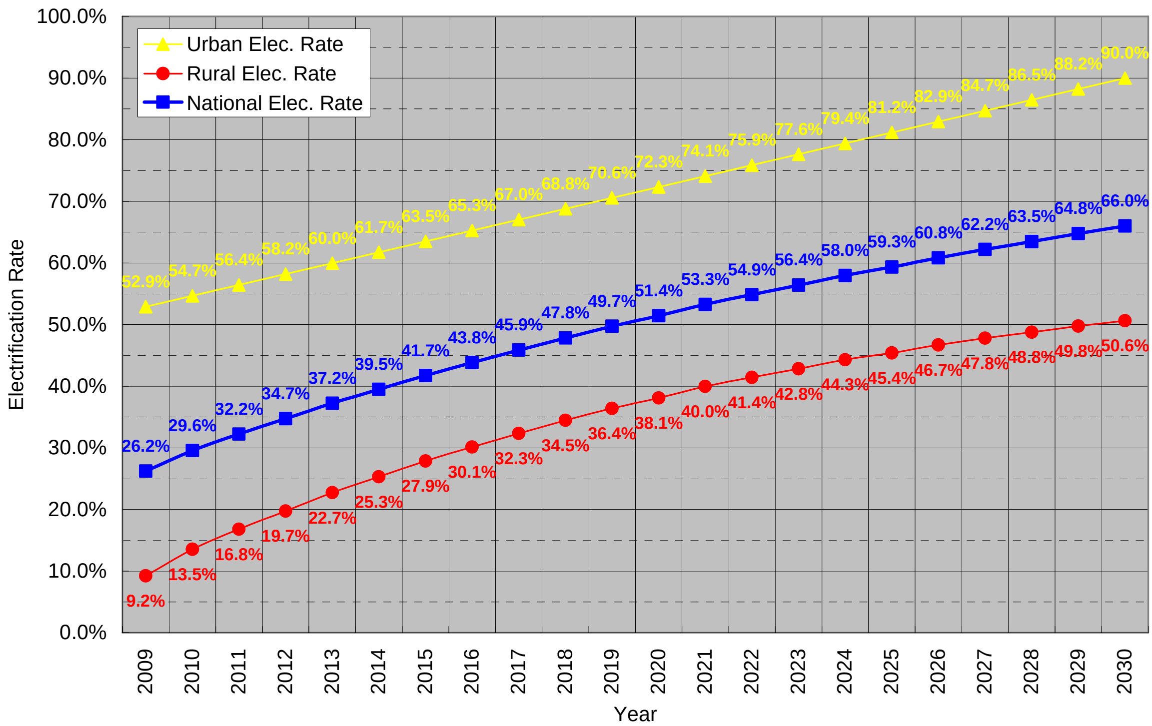


Figure 14-4 Transition of Household Electrification Rates by 2030

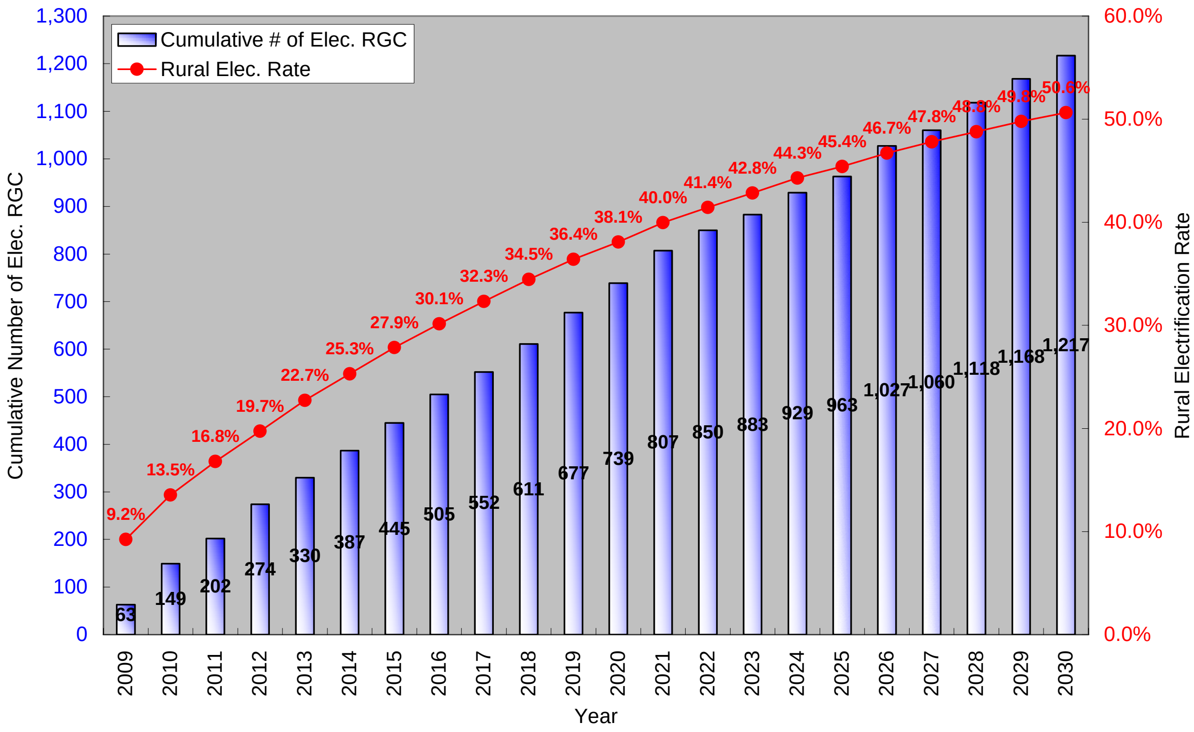


Figure 14-5 Transition of Cumulative Number of Electrified RGCs and Rural Electrification Rate by 2030

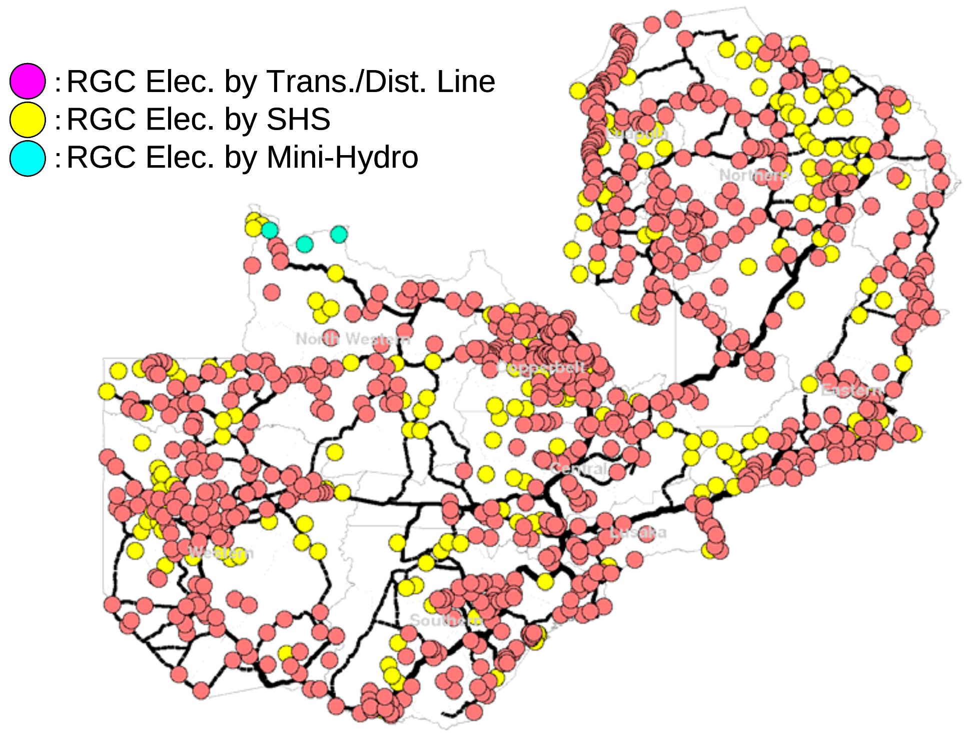


Figure 14-6 Rural Electrification Map in 2030

Chapter 15

Conclusion and Recommendation

Chapter 15. Conclusion and Recommendation

15.1. Conclusion

In this Study, the Rural Electrification Master Plan up to 2030 was developed. In the process of "Technical Aspect Analysis", the "Decentralized Planning Process" was adopted to identify 1,217 RGCs in rural areas as the electrification target. Next, "Demand Criteria (or potential daily maximum demand in each RGC)" and "Supply Criteria (or the "Unit Life Time Cost in Net Present Value")" were used to cluster (or group) 1,217 RGCs into 180 Project Packages, and to select the optimal electrification mode (among transmission/distribution extension, SHS, mini-hydro, and diesel generator) for each of the 1,217 RGCs. Then, based on the estimated cost for each Project Package, the final electrification priority of 1,217 RGCs in 180 Project Packages was determined by Financial Indicator (FIRR). Finally, these 180 Project Packages were grouped into 22 Annual Project Phases up to 2030, by the uniform annual project cost.

As a part of the Technical Aspect Analysis, Case Study (or pre-feasibility study level survey) was carried out. Among 29 potential mini-hydro development sites explored in Northern, Luapula, North-western, and Western Provinces, the Case Studies were executed at 2 sites: Chilanbwe Falls Site in Northern Province and Mujila Falls Lower Site in North-western Province. At these two mini-hydro Case Study sites, Socio Environmental Surveys were also executed and Project Briefs were prepared. The Case Studies for transmission/distribution extension were also executed at 3 sites: Kabwe in Central Province, Luangwa in Lusaka Province, and Mazabuka in Southern Province.

In addition, Socio Economic Survey was carried out, in the process of "Social Aspect Analysis." In the Socio Economic Survey, data were collected more than 1,300 interviewees in 90 RGCs: 71 unelectrified and 19 electrified RGCs. Based on the data collected in the Socio Economic Survey, the ability to pay, willingness to pay, and prioritized property for electrification were analyzed, and these results were used as basic information to elaborate policy recommendation with the involvement of Stakeholders.

The Study combined the outputs from the Technical and the Social Aspect Analysis, to develop a Comprehensive Rural Electrification Program. The development process of the Master Plan was subject of discussion with International Development partners, such as Japanese Bank for International Cooperation (JBIC), African Development Bank (AfDB), Development Bank for Southern Africa (DBSA) and World Bank (WB). As a result, the Development Partners have shown interest in financing the rural electrification projects in Zambia, and JBIC started considering providing Yen-Loan as a co-finance with WB, to realize this Master Plan.

Initial findings, results and outputs of this Study are as follows:

1) 1,217 Unelectrified RGCs were clustered (or grouped) into 180 Project Packages. The electrification priority order of 180 Project Packages, the optimal electrification mode for each of 1,217 RGCs, and the 22 Annual Project Phases up to 2030 are shown in Table 14-5, 14-6, and 14-9 respectively.

2) Although not many Project Packages' FIRR are attractive, considerable number of Project Packages show reasonable EIRR.

3) US$ 1,103 million is required to realize all 180 Project Packages (including 1,217 RGCs) by 2030. This means approximately US$ 50 million per year is needed from 2008 to 2030.

4) The target household electrification rate is set as 66.0% nation-wide, requiring a rate of 50.6% for the rural areas. This is achievable if DoE, REA and ZESCO success to increase the household electrification rate at 90% in the urban areas, 100% in 1,217 RGCs in the Master Plan, and 20% in the rural areas other than 1,217 RGCs by 2030 (refer to Table 14-10). It is essential that the Zambian Government makes appropriate investment to the rural electrification projects in the

Master Plan to meet these targets.

5) Since the annual amount of Rural Electrification Fund (REF) is much less than the required project cost to realize the Master Plan, in addition to making effort to increase the REF, utilization of the low interest loan from the international donors should be necessary.

6) In the nation wide, 241 RGCs are identified as Solar Home System Market.

7) Although a lot of mini-hydro potential sites exist in Zambia, only 3 sites (Mujila Falls Lower, Upper Zambezi, and West Lunga in North-western Province) were financially feasible.

8) Unelectrified households and business entities pay considerable amount of money to meet their needs using alternative energy sources (K59,141 and K75,315 respectively). In 2006, the estimated ability to pay for electricity monthly bill for households and business entities are K35,485 and K60,252 respectively.

9) The connection fee charged in rural areas by ZESCO (K2,873,000 for 1 Phase and K4,887,000 for 3 Phase) was much higher than the rural households' ability to pay (average monthly income by K910,757) and willingness to pay (K2,508,483).

10) Duration (usable daily hours of electricity) was the most important factor for unelectrified residents, compared to Urgency (years until electrified), Monthly Fee, and Connection/Initial Fee. Although 24 hours usage per day was the most preferred, unelectrified residents were eager to use electricity even for 5 hours per day (such as by SHS).

15.2. Recommendation

15.2.1. Practical Use of Master Plan

Although the final electrification priority of Project Packages were determined by Financial Indicator (FIRR) in the Master Plan, the priority should be modified in practice and updated by taking into account the opinions of Zambian Government and Financial Organization, such as in the financial coordination with International Development Partners. For example, Zambian Government may wish to pay attention to the balance of development among areas/Provinces. Some of Financial Organizations may also wish to apply some project selection criteria as their loan conditions. Therefore, the staff members of DoE and REA need skills to merge the new criteria with the original Master Plan in a flexible way. Such skills and techniques could be transferred under the JICA Technical Cooperation Project scheduled to commence in 2008.

Since financial evaluation for SHS portion in each Project Package was excluded in the Master Plan, International Donors may not be willing to provide financial assistance for SHS projects. They may, for instance, wish to finance a Project Package with high priority ranking but excluding RGCs electrified by SHS in a Package. Even in such a case, however, maintaining an electrification priority order of SHS portion according to the priority of a Project Package, by providing subsidy utilising Rural Electrification Fund (REF) for SHS installation to households and business entities, is suggested. Regarding public facilities (such as school and hospital/clinic) in RGCs electrified by SHS, the installation cost is assumed to be provided from the Government Authorities (such as Ministry of Education and Ministry of Health).

15.2.2. Management of Rural Electrification Fund

The REF as currently funded is not sufficient to implement the Master Plan, and thus measures are needed to increase REF and methods of efficient and effective utilization of funds need to be considered. Firstly, the Zambian Government should allocate an adequate budget every year toward the REF as it does for other infrastructures, such as health and road sector. Secondly, the Rural Electrification Levy should be charged to the mining sector (which consumes 50% of the national total) and to the export of electricity. At the time of writing, it was uncertain what percentage of levy should be charged to the mining sector, other industries and electricity export, but the Zambian Government was considering 5% electricity levy for them as a measure towards social responsibility, while the levy by the domestic consumers would remain at 3%. Thirdly, the REF needs to be efficient and effective in its management in order to ensure that the program runs smoothly. Such measures are also likely to attract the interest of Development Partners. Therefore, more transparency, accountability and efficiency are required in the process of electrification project selection and utilization of the REF. Fourthly, the electrification levy should be paid directly to REA, not through the Ministry of Finance and National Planning. Otherwise, the possibility remains that the rural electrification levy will be used for other purposes by the Government (such as a general account budget). Finally, electrification facilities funded by the REF (such as mini-hydro, but exclude SHS) should be owned by either REA or ZESCO, and leased to other private companies or local communities for O&M, if necessary.

15.2.3. Increase of Electricity Access Rate

A high initial connection fee is one of the hindrances to increase electricity access, even in areas where distribution line has been extended. The tariff charged by utility companies should be capital cost reflective and thus reduction of the initial connection fee should be considered. In addition, the payment of initial connection fee by the consumers to the electricity network should be spread over a period of 3 to 5 years.

Setting up a technical standard for appropriate low cost electrification method could also contribute to increase the electrification rate in rural areas. Moreover, exemption of import tax for equipments used for rural electrification gives the advantage of reduced project cost and connection fee.

Finally, to create a price competitive market, supporting capacity development and formation of new companies to undertake rural electrification business, such as construction and operation & maintenance is recommended.

15.2.4. Supporting Sustainable Electrification Business in Rural Area

Development of local capacity in simple operation and maintenance of electricity systems, such as SHS and mini-hydro, through a mobile training program provided by DoE and REA could contribute to making the rural electrification business sustainable. Development of the mobile training programs could be supported by JICA Technical Cooperation Project scheduled to commence in 2008.